CIBA

ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

भा कृ अनु प – केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

ANNUAL REPORT 2020

ICAR

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Outputs from small yard experiments are systematically validated in field conditions before the technology reaches the hands of farmers and other stakeholders

Mangrove red snapper, *Lutjanus argentimaculatus* : a potential premium quality finfish species ideal for farming in brackishwater. ICAR-CIBA has developed the hatchery technology for its seed production in captivity.

Inaguration of the Brackishwater Aquaculture Farmers' Conclave - 2020 (BAFAC-2020) during 19-20 Feb, 2020 at Surat, Gujarat.

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वार्षिक प्रतिवेदन

Annual Report
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भाकृअनुप–केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद)

75, संथोम हाई रोड़, आर.ए.पुरम, चेन्नई–600 028

ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

ISO 9001 : 2015

(Indian Council of Agricultural Research)

75, Santhome High Road, M.R.C Nagar, R.A. Puram

Chennai - 600028, Tamil Nadu, India

PUBLISHED BY

Dr. K.K.Vijayan
Director

ISSN 0976-5536

Citation : CIBA - 2020. Annual Report 2020.
Central Institute of Brackishwater Aquaculture,
Chennai, Tamil Nadu, India, pp. 244.

Layout and Design
Dr C. P. Balasubramanian
Dr K. K. Vijayan

Dr J. Raymond Jani Angel
Mr M.S. Vasanth Christopher

Printed at:
Aparna Graphic Arts, Chennai -600002.

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Preface

One more year has passed, in the shadows of the COVID-19 pandemic, COVID related constrains in the lab as well as field. While looking back at what CIBA has done during the last year makes me happy to see the institute's contributions in aquaculture sector, more particularly in brackishwater aquaculture research, in the country, which is very much tangible and visible. The Annual report 2020 of ICAR-CIBA highlights some of our key achievements over the past year, despite the pandemic related challenges.

The year 2020 started with a remarkable event, having focus on the aquafarmers of the country, the second brackishwater aquaculture conclave 2020 (BAFAC-2020), first of this kind on the west coast of India. The west coast possess abundant brackishwater resources, however these resources are inadequately utilized for the development of aquaculture. In order to bring focus and to formulate a road map for sustainable brackishwater aquaculture development for the west coast, we organized this brackishwater farmers' conclave in collaboration with Society of Aquaculture and Fisheries (SCAFi) and Navsari Agricultural University

(NAU). This event was a unique platform that brought large numbers of brackishwater farmers representing all the coastal states and few inland states of India such as Haryana, Punjab and Rajasthan, and BAFAC-2020 provided an excellent opportunity on a farmer centric mode to exchange scientific information and ideas related to brackishwater aquaculture in particular.

After achieving a breakthrough in captive breeding of grey mullet (*Mugil cephalus*) for the first time in the country, this year CIBA has successfully developed hatchery production of fingerlings of this species. The grey mullet, country has been looking for farming using hatchery produced seeds, is one of the most preferred choice of consumers due to its taste, texture, less spines and nutritive value. Fast growth rate, omnivores feeding habit and amenability of farming in different production systems (e. g. monoculture, poly culture and integrated multi-trophic aquaculture) make this species one of the most sustainable candidate species for diversification of brackishwater aquaculture. We are looking forward to scaling up of grey mullet seed production in partnership with enterprising farmers and state government.

The current COVID 19 scenario that started in late 2019, when international flight and air cargo movement disrupted, again proved that the exclusive reliance on exotic *Penaeus vannamei,* is not a sustainable model. Both logistic and issues in the quality of imported broodstock posed challenges on sustainable farming and production of *P. vannamei*. It is also well acknowledged that a seven billion industry in this country cannot solely rest on a single exotic species. At this context, Indian white shrimp, *P. indicus*, an ideal native shrimp, has been recognized as a national priority for domestication and genetic improvement. Therefore, it is better late than never, to start a national flagship programme on the selective breeding of native *P. indicus*, on private-Public partnership (PPP) mode, with the participation of all the stake holders. The fundamental challenge of any selective breeding program is the closing of complex life cycle of candidate/target species. The slow progress in the domestication and selective breeding of indigenous closed thelycum species such as *P. indicus* and *P. monodon*, are largely attributed to the issues in captive breeding, particularly in issues in the natural mating and less amenability of artificial insemination. Crustacean Culture Division of CIBA was able to resolve these issues in mating in captivity to large extend, and successfully produced three domesticated lines of Indian white shrimp. Further, the growth, production and profitability of domesticated stock in grow out system was found to be comparable with SPF vannamei at size up to 20 g, the present processing size for export.

Taxonomic studies have rarely come out of the boundaries of specialized academic disciplines. A taxonomic revision made in relatively recent past for marine shrimp genus *Penaeus* has

Taxonomic studies have rarely come out of the boundaries of specialized academic disciplines. A taxonomic revision made in relatively recent past for marine shrimp genus *Penaeus* has elicited controversy and sparked outrage protests and criticism among scientific and industrial communities. 'This controversy regarding the genus *Penaeus* may be the first of its particular nature to have arisen in the field of Zoology'. This decadal old controversy has been resolved by the scientists of Genetics and Biology division of the CIBA, using genomic tools with complete mitochondrial genome and robust phylogenetic analysis. This study unequivocally proved the monophyletic status and credibility of the genus Penaeus, and refuted the controversial six-genus classification.

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Aquaculture is progressing with more diversified species, and therefore understanding the species specific nutrient requirement is paramount in optimizing practical feed formulation, as feed is the major 'cost factor' in the aqua farming. Feed is not only just a biological requirement, but also an economic factor which determines the cost of production and thereby the success of aquaculture, . CIBA has been actively involving in various aspects of nutrition of the diversified candidate brackishwater species used in farming, targeting cost effective feeds, in functional feeds (maturation and larval rearing) and farm rearing. Finding a nutritionally appropriate and sustainable alternative to fish meal with possible alternative sources has been an elusive goal of aquaculture industry. The black soldier fly (*Hermetia illucen*) meal has been acknowledged as a candidate species to be used as animal feed. The pilot experiment with black soldier fly meal indicated that it can be included up to 10% level without compromising shrimp growth and survival. Further, development of a cost-effective and sustainable production system would be a boon for the formulated feed sector, where the spiralling fish meal price is an issue to be tackled.

Development and intensification of aquaculture result increased occurrence of disease problems due to conventional pathogenic bacterial diseases, also due to emerging pathogens such as *Enterocytozoon hepatopenaei* (EHP, a microsporidian parasite) white gut etc. The development of new therapeutic solutions is a burning issue in aquaculture health management. Issue of EHP and endemic WSSV in shrimp, and tilapia like virus (TLV) in farmed finfishes are considered as strong cause of economic losses in the aquaculture sector. Currently there are limited therapeutic options available for the controlling of diseases affecting the shrimp rearing systems. At this context, potential of phage therapy is gaining importance, and aquatic animal health division CIBA was able to develop a bacteriophage based product for prophylaxis and therapy of luminescent Vibriosis in shrimp hatcheries. The phage based product was subsequently commercialized. This kind of novel therapeutic approaches would give new options in the tackling the aquatic diseases, which is on the rise due to the intensification and spread of shrimp and fish farming.

During the Last few years, the research output of CIBA in the form of quality publications has averaged 52 research papers per year. I am delighted to note that most papers have been accepted for publication in peer reviewed renowned journals, predominantly in the international journals with high impact factor, although our access is more difficult in comparison with more fundamental research institute owing to our applied field orientation.

Although the past year was extremely challenging due to the pandemic situations, we were able to cope with harsh situations, and able to make significant contributions in all fronts: externally funded research projects, research publications, technology development and commercialisations, public private partnership (PPP) through MOUs, revenue generation, training, societal development initiatives and institution building. In the institution building front, we were able to add about 65 acres of prime land including potential brackishwater farming areas within the city limits near Kovalam, which would provide wings for the future development of CIBA, and it would enable us to establish a regional centre of excellence in brackishwater aquaculture. This year is the last phase of my tenure, and when I look back I feel pride in what ICAR-CIBA has accomplished. More importantly how my colleagues are involved in the research and performing to take their research results to the stake holders. It has been greatly rewarding to serve as the Director of this prestigious institute. My sincerest thanks to my scientific colleagues and all staff of CIBA, and all our stakeholders and farmers who have supported, and their trust in our effort to realise the vision and mission of CIBA.

I am immensely grateful to Dr Trilochan Mohapatra, the Director General of ICAR, Secretary, DARE, without his professional supports 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 passionate support, enthusiasm and timely help in pursuing our goals. I sincerely thank Dr Pravin Puthra, Assistant Director General (Marine Fisheries) for his continued and timely support from SMD, Delhi. Although my new role will be outside the official institutional realm, I will be following and involving in the development of brackish water aquaculture sector, and science of aquaculture, which I have been passionate for several decades, starting from my post-graduation, doctoral, post doctoral work as an ARS scientist, and as a scientific administrator.

Thank you so much, one and all for joining on this journey.

Vijayan, K. K
Director, ICAR-CIBA

कार्यकारी सारांश

पी. वन्नामेय और पी. इंडिकस के नर्सरी पालन और प्रतिपूरक वृद्धि पर भंडारण घनत्व और मौसम का प्रभाव

झींगे की बेहतर उत्तरजीविता और वृद्धि के लिए अब झींगे की खेती में नर्सरी पालन को व्यापक रूप से प्री ग्रो आउट गतिविधि के रूप में अपनाया जा रहा है। संवर्धन प्रोटोकॉल को अनुकूलित करने के लिए, विभिन्न मौसमों (गर्मी, पूर्व-मानसून, मानसून और सर्दियों के मौसम) और विभिन्न संग्रहण घनत्व (2500, 5000, 7500 और 10000 पोस्ट लार्वा/टन) के अंतर्गत एक्वा मिमिक्री के उपयोग से पी. वन्नामेय और पी. इंडिकस का नर्सरी संवर्धन किया गया। संवर्धन के दौरान पी. वन्नामेय और पी. इंडिकस का अधिकतम संग्रहण घनत्व क्रमशः 7500 पोस्ट लार्वा/टन और 5000 पोस्ट लार्वा/टन से बेहतर वृद्धि और उत्तरजीविता प्राप्त हुआ। ऋतुओं के प्रभाव ने ग्रीष्म, पूर्व मानसून, मानसून और सर्दियों के दौरान क्रमिक रूप से उत्पादकता में अवरोही प्रवृत्ति दर्शाया। पी. वन्नामेय और पी. इंडिकस का नर्सरी पालित पोस्ट लार्वा ने ग्रो आउट पालन के दौरान प्रतिपूरक वृद्धि और बेहतर उत्तरजीविता दर्शाया। झींगे की पालन अवधि घटाने और उत्पादकता को बढ़ाने के लिए झींगा बीज के नर्सरी संवर्धन को अपनाया जाएगा।

मिट्टी के तालाबों में पालित पी. वन्नामेय पोस्ट लार्वा की उत्पादन विशेषताओं पर आहार खनिजों और विटामिन सी अनुपूरण के प्रभाव

विशेषकर कम और मध्यम लवणता पर झींगा पालन करते समय झींगे की उत्तरजीविता और विकास में सुधार के लिए वाणिज्यिक आहार के साथ खनिज लवण और विटामिन सी का अनुपूरण झींगा किसानों के बीच एक आम बात है। वाणिज्यिक झींगा आहार में अनुपूरक के रूप में पोटेशियम क्लोराइड (KCL-5g/kg), मैग्नीशियम क्लोराइड (Mgcl 2.5g/Kg), KCL और MgCl2 और विटामिन C (5kg/Kg) का संयोजन शामिल था। प्रायोगिक नियंत्रणों में वाणिज्यिक फ़ीड वाले झींगे और गैर- वाणिज्यिक फ़ीड वाले समूह शामिल था। समग्र रूप से देखा गया है कि, पोटेशियम और विटामिन सी वाले पूरक आहार वाले झींगों में बेहतर एफसीआर, अंतिम उपज और वृद्धि दर प्राप्त हुई है। वांछित उत्तरजीविता, विकास दर और उपज प्राप्त करने के लिए किसान खेत स्थितियों में पोटेशियम और विटामिन सी पूरकता के संयोजन को अपनाएंगे।

सूत्रबद्ध झींगा आहार की तुलना में विशेष रूप से किण्वित सोयाबीन मील खिलाए गए पी. वन्नामेय तरूण झींगों की वृद्धि विशेषताएँ

झींगा पालन में एक्वा मिमिक्री अवधारणा में झींगा के लिए पूरक आहार के रूप में किण्वित सोयाबीन मील (एफएसबीएम) का उपयोग, झींगा पोस्ट लार्वा के आहार के लिए तालाब में जीवित खाद्य जीवों की वृद्धि शामिल है। तीन उपचारों का उपयोग किया गया: खमीर के उपयोग से किण्वित सोयाबीन मील (Y-Saccharomyces cerevisiae), वाणिज्यिक प्रोबायोटिक (बैसिलस एसपी) और खमीर एवं वाणिज्यिक प्रोबायोटिक का 1:1 अनुपात में संयोजन। खमीर से किण्वित सोयाबीन मील, प्रोबायोटिक और दोनों के संयोजन दिए गए झींगों के अंतिम शारीरिक भार में कोई महत्वपूर्ण भिन्नता नहीं थी। पालन के प्रथम 30 से 45 दिनों की अवधि में पी. वन्नामेय पोस्ट लार्वा के लिए किण्वित सोयाबीन मील का उपयोग किया जा सकता है। ये आहार प्रगति जैविक झींगा खेती और भविष्य में उत्पादन लागत को कम करने के लिए खेत में बने चारा तैयार करने में मददगार हैं।

विभिन्न स्तर की लवणीयता में पीनियस वन्नामेय का अनुकूलन और नर्सरी उत्पादन

विभिन्न लवणीय व्यवस्थाओं के तहत पी. वन्नामेय के अनुकूलन

और नर्सरी संवर्धन के प्रभाव का अध्ययन किया गया। पी. वन्नामेय पोस्ट लार्वा का अनुकूलन किया गया और 2, 15, 30, 45 और 65 पीपीटी लवणता में पालन किया गया। जबकि 2, 15 और 30 पीपीटी लवणता में पालित झींगों में उच्चतम उत्तरजीविता, परीक्षण के अंत में 15 और 2 पीपीटी वाले झींगों में उच्चतर शारीरिक भार दर्ज किया गया। निम्न एवं उच्च लवणीय स्थितियों में क्रमश: हाइपर-ऑस्मोरेगूलेटर और हाइपो-ऑस्मोरेगूलेटर व्यवहार देखा गया था।

भारतीय सफेद झींगा पीनियस इंडिकस का नर्सरी पालन : विभिन्न प्रबंधन व्यवस्थाओं के तहत संग्रहण घनत्व का अनुकूलीकरण

किसानों द्वारा उत्पादकता बढ़ाने और फसल अवधि को घटाने के लिए नर्सरी पालन को एक पूर्व ग्रो आउट गतिविधि के रूप में व्यापक रूप से उपयोग किया जाता है। भंडारण घनत्व के तीन स्तरों (1650, 3350, 8350 PL/m3) और तीन प्रबंधन प्रणालियों के साथ एक प्रयोग किया गया; जीरो वाटर एक्सचेंज (जेडडब्ल्यूई), मृदा आधार के साथ जेडडब्ल्यूई (जेडडब्ल्यूई+एसएन) और मृदा आधार के साथ जेडडब्ल्यूई और सब्सट्रेट एकीकरण (जेडडब्ल्यूई+एसएन+एसयूबी)। निम्न (1650 पोस्ट लार्वा/घनमीटर) और मध्यम-घनत्व (3350 पोस्ट लार्वा/घनमीटर) समूहों ने अधिक भार और उत्तरजीविता प्राप्त की। नर्सरी पालन में सब्सट्रेट (जेडडब्ल्यूई+एसएन+एसयूबी) के एकीकरण के परिणामस्वरूप बेहतर वृद्धि विशेषताओं और पानी की गुणवत्ता में सुधार हुआ है। पी. इंडिकस नर्सरी पालन के लिए सब्सट्रेट के साथ 1650-3000 पोस्ट लार्वा/घनमीटर के संग्रहण घनत्व की सिफारिश की जाती है।

पीनाइड श्रिम्प के साथ पर्ल स्पॉट का सह-पालन : वरदान या विनाश

झींगों और मछलियों के सह-पालन की संभावनाएं उद्योग में लंबे समय से एक बहस का मुद्दा है। उद्योग में यह आम धारणा है कि बड़ी पर्ल स्पॉट मछलियां छोटे झींगे का उपभोग करती हैं। विभिन्न आमापों के झींगों (पोस्ट लार्वा 1.5, 5-7 ग्राम) और पर्ल स्पॉट (0.3, 3, 50 और 100 ग्राम) मछलियों के सह-पालन पर एक व्यापक अध्ययन किया गया था। अध्ययन से पता चला कि 3-100 ग्राम आमाप के पर्ल स्पॉट मछलियां बड़े आमाप के झींगों को भी सक्रिय रूप से खा रहे थे और सभी मामलों में 100% मृत्यु दर देखी गई थी। हालांकि 0.2-0.3 ग्राम वाली पर्ल स्पॉट तरूण मछलियां झींगों के पोस्ट लार्वा का उपभोग करने में सक्षम नहीं थीं। पर्ल स्पॉट और झींगे का सह-पालन करते समय किसानों को सावधानी बरतनी चाहिए।

फ़ीड पूरक के रूप में बायोफ्लॉक समृद्ध रोटिफ़र्स के साथ रीसर्क्युलेटिंग एक्वाकल्चर सिस्टम (आरएएस) में पीनियस इंडिकस का नर्सरी पालन

एक्वा मिमिक्री सिस्टम के उपयोग से उच्च घनत्व (पोस्ट लार्वा 10 2000/घनमीटर की दर से) पर पी. इंडिकस की वृद्धि और उत्पादन की तुलना आरएएस, हाइब्रिड आरएएस और बायोफ्लॉक समृद्ध रोटिफ़र के साथ आरएएस में की गई। बायोफ्लॉक समृद्ध रोटिफ़र के साथ आरएएस ने बेहतर विकास और उत्तरजीविता (91%) का प्रदर्शन किया। प्रोफेनोलॉक्सीडेज और लाइसोजाइम गतिविधि भी रोटिफर समृद्ध आरएएस सिस्टम में सामान्य की तुलना में लाभकारी रूप से तेज हुई थी। बायोफ्लॉक समृद्ध रोटिफर के साथ आरएएस में झींगा नर्सरी पालन से वृद्धि, प्रतिरक्षा और उत्तरजीविता में सुधार हो सकता है।^

विभिन्न घनत्वों और लवणीयताओं में भारतीय सफेद झींगा पीनियस इंडिकस की वृद्धि क्षमता और प्रतिरक्षा

विभिन्न लवणीयताओं (3-7, 8-15, 15-25, 25-35, और 40-60 पीपीटी) पर दो अलग-अलग संग्रहण घनत्वों (निम्न और उच्च) के तहत 80-120 दिनों के लिए ऑन फार्म वृद्धि निष्पादन और प्रतिरक्षा स्तर का आकलन किया गया था। 15-25 पीपीटी लवणता में अंतिम उपज प्राप्ति में औसत भार और भार में वृद्धि काफी अधिक थी। उच्च घनत्व की तुलना में निम्न संग्रहण घनत्व वाले उपचार में अधिक औसत भार दर्ज किया गया। लवणीयता स्तर के अनुसार प्रोफेनोलॉक्सिडेज़ गतिविधि में क्रमिक रूप से बढ़ोत्तरी या कमी देखी गई तथा बहुत ही कम (5 पीपीटी) एवं बहुत ही अधिक (60 पीपीटी) लवणीयता में निम्नतम पीपीओ गतिविधि दर्ज की गई।

आहार में प्रोटीन के विभिन्न स्तरों के साथ बायोफ्लॉक-आधारित प्रणाली में पालित पी. इंडिकस का उत्पादन प्रदर्शन और प्रतिरक्षा प्रतिक्रिया

पीनियस इंडिकस का पालन विभिन्न प्रोटीन स्तर (25%, 30% और 35%) वाले आहार के साथ बायोफ्लॉक आधारित पालन प्रणाली में किया गया था। बायोफ्लॉक को विकसित करने के लिए विभिन्न कार्बन स्रोतों (शीरा, गेहूं का आटा, और चावल की भूसी) और एक प्रोबायोटिक कंसोर्टियम (बैसिलस एसपी और सैक्रोमाइसेस एसपी) के संयोजन का उपयोग किया गया था। प्रयोग के अंत में, 30 और 35% प्रोटीनयुक्त आहार दिए गए जीवों में बेहतर वृद्धि प्राचल पाए गए। उच्च प्रोटीन दिए गए जीवों के प्लाज्मा में

एचए गतिविधि, पीओ गतिविधि अधिक पाई गई। उच्च प्रोटीन वाले समूहों में सुपरऑक्साइड डिसम्यूटेज, प्रोफेनोलॉक्सिडेज, पेरोक्सीनेक्टिन और एंटीमाइक्रोबियल पेप्टाइड्स जैसे प्रतिरक्षा जीन अधिक व्यवस्थित थे। बेहतर विकास और झींगे की प्रतिरक्षा प्रतिक्रिया के लिए पीनियस इंडिकस के बायोफ्लॉक पालन को उच्च प्रोटीन (35%) के साथ अनुपूरण किया जाएगा।

तरूण कीचड़ केकड़ों स्काइला सेर्राटा की उत्तरजीविता एवं विकास पर सूत्रबद्ध आहार की प्रभावकारिता

कीचड़ केकड़ों के बीज उत्पादन में कीचड़ केकड़ों के किशोरों का नर्सरी पालन एक महत्वपूर्ण चरण है। केकड़ों के किशोरों की बेहतर वृद्धि और उत्तरजीविता के लिए, आमतौर पर पालन के दौरान जीवंत आहार का उपयोग किया जाता है। वर्तमान अध्ययन में विभिन्न जीवंत आहारों एवं सूत्रबद्ध आहारों का मूल्यांकन किया गया था। जीवंत आहार वाले समूह में वृद्धि और भार का बढ़ना अधिक था। दिलचस्प बात यह है कि सूत्रबद्ध आहार से 95% उत्तरजीविता प्राप्त हुई, जो गीले आहार का स्थान लेने की क्षमता को दर्शाता है।

एकल रूप से संवर्धित कीचड़ केकड़ों की किशोर अवस्थाओं का व्यक्तिगत विकास पैटर्न

अलग-अलग डिब्बे में एकल रूप से केकड़े की खेती ने केकड़े की ऊर्ध्वाधर खेती और साफ्ट शेल क्रैब उद्योग में लोकप्रियता हासिल की है। एकल केकड़ों की वृद्धि और मोल्ट पैटर्न प्राप्त करने के लिए, 1129 दिनों के लिए व्यक्तिगत मोल्ट और ग्रोथ पैटर्न को रिकॉर्ड करते हुए एक अध्ययन किया गया था। विभिन्न चरणों में गीले भार का प्रतिशत 98.05% और 226.48% के बीच था। C6 चरण तक सिंक्रोनस मोल्टिंग देखी गई और बाद में मोल्टिंग फ्रीकवेन्सी कम हो गई।

ग्रे मुलेट का वृद्धि निष्पादन

एक तालाब (2000 वर्गमीटर) में स्थापित नर्सरी हापा (2 x 1 x 1 मी.) में 90 दिनों तक विभिन्न स्तरों (30%, 35%, 40% और 45%) के प्रोटीनयुक्त आहार देते हुए वन्य रूप से प्राप्त ग्रे मुलेट मुगिल सेफालस पोनों (2.0-2.5 सेमी) का वृद्धि निष्पादन एवं आहार उपयोग का मूल्यांकन किया गया। अध्ययन के परिणामों से पता चला तालाब में स्थापित हापा में ग्रे मुलेट, मुगिल सेफालस पोनों के नर्सरी पालन के लिए 35% प्रोटीनयुक्त तैरता हुआ चारा उपयुक्त और किफायती है। कम फीड इनपुट के साथ, हापाओं में मिल्कफिश का परिपादप आधारित नर्सरी पालन से ज्ञात हुआ है कि परिपादप + 50% कम आहार के साथ 60 दिनों तक पालित मिल्कफिश अंगुलिकाओं का आकार प्राप्त किया जिनकी औसत कुल लम्बाई और शारीरिक भार क्रमश: 9.20 ± 0.14 से.मी. एवं 8.24 ± 0.19 ग्रा. तथा 95% उत्तरजीवित दर पाई गई।

मिल्कफिश पालन

भारत के पश्चिमी तट पर मिल्कफिश, चनोस चनोस पालन को बढ़ावा देने के लिए, केरल के एर्नाकुलम जिले के चेल्लानम में किसानों के तालाब में एक पॉलीकल्चर निरूपण आयोजित किया गया था। प्रारंभ में 3000 मिल्कफिश बीजों (tl.2.5 से.मी., 32 डीपीएच) को 30 दिनों के ग्रो आउट पालन के लिए 0.72 हे. क्षेत्र में 05-25 पीपीटी पर पेन आधारित बंद नर्सरी में लगभग 08-12 ग्रा आमाप के 2700 अंगुलिकाओं को मोनोसेक्स तिलापिया (10000 नग) और टाइगर झींगा (50000) के साथ संग्रहीत किया गया था। 30 दिनों की पालन अवधि में देशी आहार (32% प्रोटीन; 6% वसा) दिन में दो बार शारीरिक भार का 3% की दर से खिलाने पर मिल्कफिश और मोनोसेक्स तिलापिया क्रमश: 250-400 ग्रा. तथा 150-200 ग्रा. शारीरिक भार और 85% उत्तरजीविता दर प्राप्त किया।

मिल्कफिश और सफेद झींगों का सह-पालन

दो अलग-अलग 1000 वर्गमीटर वाले तालाबों में कम इनपुट आधारित पॉलीकल्चर सिस्टम के अंतर्गत पी. वन्नामेय और मिल्कफिश की वृद्धि निष्पादन का मूल्यांकन किया गया था। मिल्कफिश (12.61±0.24 से.मी., 15.49±0.54 ग्रा.) को 30 दिनों की पालन अवधि के लिए बाद 2 भिन्न अनुपातों में पी. वन्नामेय, टी1 (मिल्कफिश 0.50 पोना/वर्गमीटर : पी. वन्नामेय 25 पोस्ट लार्वा/वर्गमीटर) और टी2 (मिल्कफिश 0.25 पोना/वर्गमीटर : पी. वन्नामेय 25 पोस्ट लार्वा/वर्गमीटर) के साथ संग्रहीत किया गया था। यह पाया गया कि पी. वन्नामेय के पालन के लिए मिल्कफिश के दोनों संग्रहण घनत्व फायदेमंद हैं। हालांकि, आर्थिक दृष्टिकोण से, कम इनपुट-आधारित पॉलीकल्चर सिस्टम में मिल्कफिश को 0.50 पोना/वर्गमीटर की दर से पी. वन्नामेय के साथ 25 पोस्ट लार्वा/वर्गमीटर की दर से संग्रहीत करना उपयुक्त माना जाता है। एनजीआरसी-सीबा प्रक्षेत्र में उत्पादित झींगा और मिल्कफिश की बिक्री से कुल 1,32,000 रुपये प्राप्त हुए।

पर्ल स्पॉट का नर्सरी पालन

हापा में पर्लस्पॉट के नर्सरी पालन में परिपादप सब्सट्रेट के साथ और सब्सट्रेट के बिना विभिन्न आहारीय क्रूड प्रोटीन स्तर के प्रभाव का मूल्यांकन करने हेतु 90 दिनों का अध्ययन किया गया था। यह पाया गया कि पर्ल स्पॉट बीज के लिए

चारे के साथ-साथ हापा में परिपादप सबस्ट्रेट्स के प्रावधान से न केवल आहार लागत कम हुआ बल्कि बीजों के तेज और उच्च विकास को भी बढ़ावा मिला। मत्स्यपालकों के लिए उच्च आय प्राप्ति एवं हापाओं में पर्ल स्पॉट मछलियों के व्यावसायिक नर्सरी पालन हेतु 30% क्रूड प्रोटीन युक्त फ्लोटिंग फीड के साथ परिपादप सब्सट्रेट यानी गन्ना खोई का प्रावधान, उपयुक्त है। इसके अलावा, हापा (2 x 1 x 1) में 90 दिनों तक नर्सरी संवर्धित पर्लस्पॉट, इट्रोप्लस सुरटेंसिस पोनों (2.0-2.5 सेमी) की वृद्धि और उत्तरजीविता पर विभिन्न संग्रहण घनत्वों (200, 300, 400, 500, 600, 700 और 800 पोना/हापा) के प्रभाव का अध्ययन किया गया था और पाया गया कि तालाब में स्थापित हापा में पर्ल स्पॉट इट्रोप्लस सुरटेंसिस मछलियों के व्यावसायिक नर्सरी पालन के लिए 600/हापा का संग्रहण घनत्व उपयुक्त है।

मैंग्रोव स्नैपर का पिंजरा पालन

महाराष्ट्र में रत्नागिरी के एक तालाब में वन्य रूप से एकत्रित मैंग्रोव रेड स्नैपर तरूण मछलियों का तालाब आधारित पिंजरे में ग्रो-आउट पालन किया गया और अध्ययन से पता चला कि वन्य रूप से एकत्रित मैंग्रोव रेड स्नैपर आसानी से कृत्रिम आहार स्वीकार करती है और तालाब के अतिरिक्त संकरी खाड़ियों में भी मछुआरों के लिए वैकल्पिक आजीविका के रूप में पिंजरा पालन के लिए अच्छी प्रत्याशी प्रजाति है। तटीय रेड स्नैपर (20-40 ग्राम, 1130 नग) 4 x 4 x 1 मीटर वाले पिंजरों में संग्रहीत कर 6-8 महीने की पालन अवधि के भीतर 600-1200 ग्राम प्राप्त किया और 64.75% उत्तरजीविता दर प्राप्त हुई।

मिस्टस गुलियो का नर्सरी पालन

खारा जलीय शिंगटी मछली मिस्टस गुलियो के लिए एक नवीन और लागत प्रभावी नर्सरी पालन विधि विकसित करने के लिए, मिस्टस गुलियो (25 dph पोनों ; 0.30 ± 0.04 ग्राम) को 60 दिनों तक एक सरलीकृत फ्लॉक सिस्टम में पालन किया गया। तीन भिन्न संग्रहण घनत्वों (50, 75 और 100 नग/घनमीटर) का परीक्षण 60 दिनों की पालन अवधि में तीन प्रतियों (ट्रिप्लीकेट) में किया गया था। इस अध्ययन ने सुझाव मिला है कि खारा जलीय सरलीकृत फ्लॉक प्रणाली में, एम. गुलियो के पोनों को अधिकतम उत्तरजीविता और आर्थिक लाभ के लिए बेहतर फ़ीड रूपांतरण प्राप्त करने हेतु 100 नग/घनमीटर के उच्च घनत्व पर पाला जा सकता है।

सिल्वर मूनी का नर्सरी पालन

मुत्तुकाडु के करिकट्टुकुपम गांव के युवा मछुआरों की भागीदारी के साथ सिल्वर मूनी के नर्सरी पालन और बिक्री का निरूपण किया गया। तालाब में स्थापित पिंजरों और हापाओं में नर्सरी पालन किया गया और सूत्रबद्ध आहार दिया गया। युवा मछुआरों ने नर्सरी पालन के 60 दिनों की अवधि में 9 से 10 सेमी वाली मछलियों का उत्पादन किया और बीज 50/- प्रति बीज की दर से बेचे गए थे।

पीनियस इंडिकस की प्रथम पीढ़ी एफ1 सम्पदा का प्रजनन एवं बीज उत्पादन

घरेलूकरण की दिशा में, बंद स्थितियों के अंतर्गत पी. इंडिकस के जीवन चक्र को समाप्त करना हमारा महत्वपूर्ण कार्य क्षेत्र है। इस पहलू पर हमारे निरंतर प्रयासों के परिणामस्वरूप वन्य पी. इंडिकस की संततियों से उत्पादित एफ1 पीढ़ी का सफल प्रजनन सम्पन्न हुआ। एफ1 सम्पदाओं ने 17-18 ग्रा. की अवस्था में सफलतापूर्वक मेटिंग किया और 10-11 महीने की आयु में जननग्रंथियों 70% विकास देखा गया। प्रजनन निष्पादन के अध्ययन करने के लिए एमईएस, सीबा की झींगा हैचरी में एफ1 के 40 प्रजनकों का उपयोग करते हुए 13 प्रजनन चक्र किए गए।

उत्पादक क्षमता 28000-90000 के बीच थी और 20% मादा मछलियों ने बहु-प्रजनन का योगदान दिया जो हमारे पिछले अध्ययनों के एफ0 की तुलना में एफ1 पीढ़ी का बेहतर प्रदर्शन रहा है। इसके अलावा, कैप्टिव स्टॉक के प्रजनन निष्पादन को बढ़ाने के लिए, मादा प्रजनकों को 17 -एस्ट्राडियोल दिया गया था, जिसके परिणामस्वरूप जननग्रंथि विकास और सहज अंडजनन शुरू हुई थी।

मेटिंग प्रयोग: इनडोर और आउटडोर पालन इकाइयों में प्रकाश की तीव्रता की भूमिका

कैप्टिव सिस्टम में मेटिंग बंद थैलीकम झींगा प्रजनन की प्रमुख बाधाओं में से एक है। इस चुनौती का समाधान करने के लिए, दो आकार समूहों (समूह 1 : 15-18 ग्रा. और समूह 2 : 25-35 ग्रा.) का उपयोग करके 60 दिनों का एक मेटिंग प्रयोग किया गया। इनडोर और आउटडोर आरएएस टैंकों में रेतीली तल के साथ और रेतीली तल बिना क्रमश: दो फोटोपीरियड (12L:12D और 18L:6D) और प्राकृतिक फोटोपीरियड के तहत प्रयोग किया गया था। हालांकि इनडोर पालन इकाइयों में मोल्टिंग 100% थी, परन्तु मेटिंग दक्षता केवल 9% थी, और अधिकांश (90%) में मेटिंग नहीं हुआ था (समूह 1)। आउटडोर इकाइयों में, लगभग 90% मादाओं का मेटिंग हुआ था, और 72% प्रीमौल्ट और 9% इंटरमौल्ट अवस्थाओं में थे।

पी.इंडिकस के घरेलूकृत प्रजनकों में ई2 संवर्धन के लिए बायो-वेहीकल के रूप में आर्टीमिया बायोमास

पीनायड झींगों के लिए एक गुणवत्तापूर्ण प्रजनक आहार के रूप में आर्टेमिया बायोमास की संभावित भूमिका का मूल्यांकन 21 दिवसीय ब्रूडस्टॉक फीडिंग परीक्षण में किया गया था। प्रजनकों को एस्ट्राडियोल (17-बीटा एस्ट्राडियोल पीजी / 100 मिलीग्राम) के साथ समृद्ध, जमे हुए, जीवित और जीवित उप वयस्क आर्टेमिया बायोमास के साथ 25% आहार खिलाया गया था। समृद्ध आर्टेमिया खिलाए गए प्रजनकों में 14 दिनों के परीक्षण के बाद 100%, 87% और 44.4% जननग्रंथि विकास दर्ज हुआ। एस्ट्राडियोल समृद्ध आर्टेमिया खिलाए गए समूह में उत्तरजीविता और मोल्टिंग फ्रीकवेन्सी अधिक थी। आर्टेमिया बायोमास, इसकी बायो एनकैप्सुलेशन क्षमता और जीवंत रूप में 100% स्वीकार्यता के कारण एक उपयुक्त लाइव फीड है।

डब्ल्यूएसएसवी वायरस का वर्टिकल ट्रांसमिशन

ब्रूडस्टॉक सोर्सिंग और रोग मुक्त मूल समष्टि बनाना घरेलूकरण का प्रारंभिक चरण है। पी. इंडिकस के वन्य सम्पदा में डब्ल्यूएसएसवी वायरस की मौजूदगी के कारण यह एक बड़ी चुनौती है। संक्रमित प्रजनक झींगों से अक्सर वर्टिकल ट्रांसमिशन के कारण संक्रमित पोस्ट लार्वा उत्पन्न होते हैं। डब्ल्यूएसएसवी नेस्टेड पीसीआर पॉजिटिव झींगा प्रजनकों के प्रजनन अंगों और डेरिवेटिव्स की संक्रमण स्थिति के लिए विश्लेषण किया गया।

इन विट्रो निषेचन के दौरान अंडे की सक्रियता में सुधार

अंडों के अधूरे सक्रियण के कारण असफल और कम निषेचन दर के परिणामस्वरूप झींगों का इन विट्रो निषेचन तकनीक लोकप्रिय नहीं है। निषेचन क्षमता के विश्लेषण करने के लिए दो प्रयोग (दिन और रात) किए गए ताकि इनविट्रो तकनीक के दौरान अंडे की सक्रियता क्षमता और निषेचन का अध्ययन किया जा सके। वन्य रूप से पकड़ी गई परिपक्व पी. इंडिकस मादाओं से शल्य चिकित्सा द्वारा विच्छेदित अंडाशय से अंडाणुओं को अलग किया गया और ग्रेडेड स्पर्म सस्पेंशन (0.5, 1, 2.5, 5 X106 सेल्स/एमएल) के साथ मिलाया गया। समय और शुक्राणुओं की सांद्रता के बावजूद अंडे की सक्रियता का कम प्रतिशत देखा गया। अंडे की सक्रियता को अनुकूलित करने से इनविट्रो फर्टिलाइजेशन तकनीक की व्यवहार्यता में वृद्धि हो सकती है।

ग्रे मुलेट का हैचरी उत्पादन

ग्रे मुलेट मुगिल सेफालस के हैचरी उत्पादन के लिए प्रोटोकॉल को और अधिक परिष्कृत किया गया; कैप्टिव ग्रे मुलेट के लिए वर्ष 2016-19 के दौरान 54 ± 3% परिपक्वता प्रतिशत की तुलना में वर्ष 2020 में परिपक्वता प्रतिशत 81% से अधिक दर्ज किया गया; कैप्टिव ग्रे मुलेट के प्रेरित प्रजनन से 2000 से अधिक अंगुलिकाओं का उत्पादन हुआ। हैचरी उत्पादित ग्रे मुलेट बीजों को पहली बार किसानों में वितरित किया गया और कैप्टिव एफ1 प्रजनकों के विकास के लिए रखरखाव किया जा रहा है।

मिल्कफिश का हैचरी उत्पादन

कोविड-19 परिदृश्य और देशव्यापी तालाबंदी के बावजूद, खारे पानी के किसानों के बीच हैचरी से उत्पादित मिल्कफिश के बीज की लगातार मांग थी। केरल, पश्चिम बंगाल, गुजरात, उड़ीसा, तमिलनाडु के किसानों के बीच कुल 46,837 हैचरी उत्पादित मिल्कफिश पोनों का वितरण किया गया और लगभग 1.5 लाख रुपये प्राप्त हुए। यह मिल्कफिश (चानोस चानोस) की दो घरेलूकृत समष्टियों के सहायक हार्मोन इम्प्लांटेशन के माध्यम से उत्पादित किया गया था जिसके परिणामस्वरूप मार्च से अक्टूबर के दौरान कुल 22 अंडजनन हुए। प्रजनन विकल्प के रूप में क्रोनिक (10 इम्प्लांटेशन / वर्ष- दिसंबर, जनवरी-सितंबर) पर संयुक्त हार्मोन पेलेट (GnRHa और 17 -MT) के सहायक इम्प्लांटेशन (04 आरोपण / वर्ष- दिसंबर, जनवरी, अप्रैल, जुलाई) की प्रभावशीलता का मूल्यांकन से पता चला कि सहायक आरोपण ने परिपक्व अंडाणुओं (650-750 µm) के असमान वितरण के वांछित प्रतिशत को प्राप्त करने में मदद की, जो उच्च स्पॉनिंग आवृत्ति के साथ मादा मिल्कफिश में अंतिम अंडाणु परिपक्वता (FOM) चरण तक पहुचती है, जो क्रोनिक / निरंतर इम्प्लांटेशन (हर महीने) के विपरीत होती है। कम स्पॉनिंग घटनाओं के साथ अंडाशय में बिमोडल वितरण (250.500 µm और 500-600 µm) के साथ वाइटेलोजेनिक अंडाणुओं के बढ़े हुए प्रतिशत का कारण बना।

रेड स्नैपर का कैप्टिव प्रजनन और बीज उत्पादन

कैप्टिव टैंक में पालित सम्पदा के उपयोग से मैंग्रोव रेड स्नैपर लुत्जानस अर्जेंटीमैकुलैटस के कैप्टिव प्रजनन और बीज उत्पादन पर सफलता प्राप्त की गई। अवलोकित प्रजनन अवधि, अगस्त से सितंबर के दौरान 67% की कैप्टिव परिपक्वता दर्ज की गई थी। कुल 6 प्रेरित प्रजनन प्रयोग किए गए। रोटिफर्स, कॉपपोड और आर्टेमिया नुप्ली का उपयोग करके सफल लार्वा पालन किया गया था, स्फुटन के 25 दिनों के बाद कृत्रिम आहार दिया गया था। कुल 500 नगों का उत्पादन किया गया था। भारत में कैप्टिव स्थितियों के अंतर्गत रेड स्नैपर तरूण मछलियों का हैचरी उत्पादन का यह प्रथम रिकार्ड है।

समुद्री बास एशियाई सीबास का रोगज़नक़ मुक्त ब्रूडस्टॉक का विकास

कोविड लॉकडाउन से जुड़ी चुनौतियों के बावजूद एशियाई सीबास लेटस कैल्केरिफ़र का स्वस्थ रोगज़नक़ मुक्त ब्रूडस्टॉक विकास और किसानों के लिए गुणवत्तापूर्ण पोनों का उत्पादन सुनिश्चित किया गया। कुल 22 प्राकृतिक अंडजनन और 8 प्रेरित अंडजनन देखे गए और कुल मिलाकर 1.2 मिलियन बीजों का उत्पादन किया गया। जून से अक्टूबर 2020 की अवधि के दौरान कुल 2,96,000 बीज बेचे गए। तमिलनाडु, आंध्र प्रदेश, केरल और कर्नाटक के 25 किसानों और एनजीआरसी टीएसपी कार्यक्रम एवं कैनरेस एक्वा की नई स्टार्टअप पहल को बीजों की बिक्री से 7,04,000/- रुपये की राशि प्राप्त हुई। खारा जलीय पखमीन मछलियों को प्रभावित करने वाले वायरल नर्वस नेक्रोसिस के खिलाफ टीके को मानकीकृत करने के लिए, एशियाई सीबास में एंटीबॉडी टाइट्रे का आकलन करके पुनः संयोजक टीके की खुराक का अनुकूलन किया गया था। शारीरिक भार के 2.5 माइक्रोग्राम/ग्रा. की खुराक ने 1.5 माइक्रोग्राम/ग्रा. की तुलना में बेहतर प्रतिरक्षा प्रतिक्रिया दी। टीकाकरण के 10 सप्ताह बाद तक सभी तीन खुराकों में प्रतिरक्षा प्रतिक्रिया सुरक्षात्मक स्तर से ऊपर पाई गई।

येल्लो फिन ब्रीम, एकांथोपेग्रस लांगिसपिन्निस

आरएएस और खारा जलीय तालाब में विकसित येल्लो फिन ब्रीम, एकांथोपेग्रस लांगिसपिन्निस ब्रूडस्टॉक ने यौन परिपक्वता प्राप्त की। पूरी तरह से परिपक्व नर और परिपक्व मादा (अंडाणु व्यास 380-420 माइक्रोन) दिसंबर-जनवरी महीने के दौरान कैप्टिव पालन किए गए स्टॉक में देखे गए थे।

गोल्ड स्पॉट मुलेट, एल. पार्सिया

गोल्ड स्पॉट मुलेट, एल. पार्सिया में, अंडजनन ऋतु से पहले एक महीने के अंतराल पर तीन बार पैलेट (एलएचआरएचए, 15 माइक्रोग्राम + मेटोक्लोप्रमाइड, 0.005 माइक्रोग्राम / पैलेट) का आरोपण, यौन परिपक्वता को प्रेरित करता पाया गया था। ऑसमोटिक पंप (ओपी) के माध्यम से hCG और CPE (15 IU +0.12 मिलीग्राम/दिन/मछली) की संयुक्त डिलीवरी, hCG या CPE की तुलना में एल. पार्सिया के जननग्रंथि विकास में अधिक प्रभावी पाया गया। परिपक्व एल. पार्सिया में, hCG (hCG @ 2 IU/g) का प्राथमिक और माध्यमिक खुराक के रूप में इंजेक्ट करने पर अंतिम परिपक्वता, ओव्यूलेशन और अंडजनन को प्रेरित करता है।

पर्ल स्पॉट का बीज उत्पादन

आरएएस में पर्ल स्पॉट मछलियों का पिंजरा आधारित अंडजनन और बीज उत्पादन के परिणामस्वरूप 3 महीने की अवधि में 12 जोड़ी प्रजनकों के साथ 28 अंडजननों से पर्ल स्पॉट के 18,500 पोनों का उत्पादन हुआ। आजीविका उत्पादन के स्रोत के रूप में पर्ल स्पॉट की नर्सरी पालन के निरूपण के लिए अनुसूचित जाति उप योजना लाभार्थियों को पिंजरा आधारित प्रजनन मॉडल से उत्पादित पर्ल स्पॉट बीजों को नियमित अंतराल (अगस्त से अक्टूबर 2020) पर आपूर्ति किया गया। कुल 10,500 पर्ल स्पॉट अंगुलिकाओं (4.5-8 सेमी) का उत्पादन किया गया और 1,57,000/- रुपये का राजस्व अर्जित किया गया।

मोनोएंजेल की वृद्धि एवं उत्तरजीविता पर विभिन्न लवणीय स्तरों का प्रभाव

मोनोएंजेल के कायान्तरण से पहले और बाद में लार्वा की वृद्धि और उत्तरजीविता दर पर लवणता के प्रभाव का अध्ययन करने के लिए प्रयोग को पांच अलग-अलग लवणताओं के साथ डिजाइन किया गया था। अध्ययन के परिणामों से पता चला है कि प्री-लार्वा स्टेनोहेलाइन थे और केवल 20-35% समुद्री जल में ही अच्छी तरह से समायोजित होता है। हालांकि, लार्वा कायान्तरण के तुरंत बाद, मीठे जल में भी जीवित रहे हैं, जिससे प्रजाति की मजबूत यूरीहेलाइन प्रकृति का प्रदर्शन होता है।

पोषण

जबकि जलजीव पालन अधिक विविधिकृत प्रजातियों के साथ प्रगति कर रही है, प्रजाति-विशिष्ट पोषक तत्वों की आवश्यकताओं को समझना, व्यावहारिक आहार सूत्रीकरण को अनुकूलित करना और आहार आदानों से निपटना सतत समुद्री आहार उत्पादन के लिए महत्वपूर्ण है। चारा न केवल एक जैविक आवश्यकता है, बल्कि एक आर्थिक कारक भी है जो जलीय कृषि की सफलता को निर्धारित करता है। सीबा, खारे जल की विविध प्रत्याशी प्रजातियों के पोषण के विभिन्न पहलुओं में सक्रिय रूप से शामिल है, जो लागत प्रभावी फ़ीड और ग्रो-आउट खेती के लिए फ़ीड प्रबंधन, कार्यात्मक फ़ीड, परिपक्वता को लक्षित करने वाले विशेष फ़ीड, लार्वा पालन और अंतिम उत्पाद की गुणवत्ता को लक्षित करता है।

फिशमील के विकल्प के रूप में ब्लैक सोलजर फ्लाई मील

पीनियस वन्नामेय तरूण मछलियों को फिशमील के विकल्प के रूप में बीएसएफ लार्वा मील 0, 5, 10 और 15% (W/W) खिला कर सात सप्ताहों तक एक लम्बा प्रयोग किया गया था। हालांकि झींगे को 5% बीएसएफ मील के साथ आहार देने पर बेहतर प्रदर्शन देखा गया था, परन्तु हम अनुमान लगा सकते हैं कि झींगा वृद्धि और उत्तरजीविता को प्रभावित किए बिना बीएसएफ मील को आहार में 10% तक शामिल किया जा सकता है।

आहार घटक के रूप में लोकस्ट मील

उत्तरी भारत ने हाल ही में कृषि खेतों में रेगिस्तानी टिड्डियों की विनाशकारी हमले को देखा था। प्रतिकूल स्थिति को अवसर में बदलने की रणनीति के रूप में, हमने उचित मूल्यांकन के बाद, एक्वा फीड में इस कीट बायोमास के उपयोग की परिकल्पना की। पोषक तत्वों की प्रचुरता को ध्यान में रखते हुए, टिड्डी मील (लोकस्ट मील) मछली और झींगा आहार में एक बेहतर घटक होगा। हालांकि, सूखे बायोमास के उच्चतर स्तर पर विश्लेषित कीटनाशक सामग्री (>13 पीपीएम मैलाथियान और >38 पीपीएम क्लोरपाइरीफोस) को देखते हुए, हमने झींगा फ़ीड में इस कीट बायोमास का उपयोग करने की संभावनाओं का पता लगाने के लिए एक आहार परीक्षण किया। परिणाम निराशाजनक थे। चारा के साथ 15% कीट बायोमास के समावेशन से झींगों की पूर्ण मार्त्यता देखी गई।

पैसीफिक सफेद झींगे के व्यावहारिक फ़ीड में एक्वाफीड घटक के रूप में कम मूल्य की पौध सामग्री का उपयोग

अजोला (Azolla) एक तैरता हुआ जलीय स्थूल पादप है जिसमें उच्च प्रोटीन सामग्री (>20%) पाई जाती है और इसे मछली के चारे की तैयारी में उपयुक्त बताया गया है। झींगों पर एक आहार परीक्षण किया गया जिसमें पांच आइसोप्रोटीनस (सीपी-35%) और आइसोलिपिडिक (ईई-5%) आहारों का उपयोग किया गया और आहार में 0, 1.35, 2.70, 4.05 और 5.40% सोया प्रोटीन के स्थान पर 0,7,14,21 और 28% अजोला मील के समावेशन से परीक्षण किया गया था। परिणामों से पता चला कि झींगे के निष्पादन को प्रभावित किए बिना 4% सोया प्रोटीन के स्थान पर 21% अजोला मील का उपयोग किया जा सकता है। इसी प्रकार उसी झींगा प्रजाति पर एक अन्य प्रयोग किया गया जिसमें 0%, 25%, 50%, 75% और 100% अनाज के आटे के स्थान पर 0, 8 , 16, 24 और 32% तक आलू के अपशिष्ट मील का समावेशन किया गया। परिणामों से पता चला है कि पी. वन्नामेय आहार में अनाज के आटे के 25% स्रोतों के स्थान पर आलू के अपशिष्ट मील का समावेशन 8% स्तर तक हो सकता है।

झींगा आहार में घटक के रूप में किण्वित सूर्यमुखी खली

खमीर किण्वित सूर्यमुखी की खली को झींगों में प्रोटीन घटक के रूप में परीक्षण किया गया। व्यावहारिक समावेशन स्तर जैसे 0, 2.5, 5.0, 7.5 और 10% का परीक्षण किया गया। परिणामों ने संकेत दिया कि खमीर किण्वित एसएफसी को 7.5% तक शामिल किया जा सकता है जबकि कच्चे एसएफसी को पी. वन्नामेय में केवल 2.5% तक शामिल किया जा सकता है।

झींगे के हेपाटोपैनक्रिएटिक स्वास्थ्य में सुधार के लिए कार्यात्मक सूत्रीकरण

हेपाटोपैनक्रियास का स्वास्थ्य सफल झींगा पालन की कुंजी में से एक है। टौरीन और बाइल साल्ट के कार्यात्मक लाभों का पता लगाने के लिए प्रयोग किए गए। परिणाम प्रदर्शित करते हैं कि स्वस्थ हेपाटोपैनक्रियास के लिए झींगा को उनके आहार में 0.3 से 0.6% टौरीन और 0.3% टॉरोकोलेट की आवश्यकता होती है।

प्लवक और जल की सतत गुणवत्ता को बढ़ाने के लिए हाइड्रोलाइज्ड फिश ट्रिमिंग्स उपयोगी पाया गया

मत्स्य कतरनों को दो मूल्य वर्धित उत्पादों , प्लैंकटनप्लस और हॉर्टीप्लस में बदलने की तकनीक, अपशिष्ट से धन और वृत्ताकार अर्थव्यवस्था की अवधारणा के तहत अत्यधिक सफल रहे हैं। पिछले एक साल में विभिन्न प्रजातियों के झींगे, मछलियों और पॉलीकल्चर मॉडल पर कई फील्ड परीक्षणों के सकारात्मक परिणाम मिले हैं। हाइड्रोलाइज्ड उत्पादों का उपयोग सतत प्लवकों के साथ-साथ जलीय गुणवत्ता और उच्च उत्पादन का समर्थन करते पाए गए हैं।

व्हाइट स्पॉट सिंड्रोम वायरस संक्रमण के जवाब में पीनियस वनामेय में फ्लो साइटोमेट्री आधारित एपोप्टोटिक प्रगति विश्लेषण

विभिन्न समय-बिंदुओं (1.5 hpi, 18 hpi और 56 hpi) पर डब्ल्यूएसएसवी (WSSV) संक्रमित पीनियस वनामेय के हेमोसाइट्स में एपोप्टोसिस की क्रमिक वृद्धि का पता लगाने के लिए फ्लो साइटोमेट्री विश्लेषण किया गया था। हेमोसाइट्स में एपोप्टोसिस संक्रमकता समय के साथ बढ़कर 5.06% से 69.63% हो गया। पी. वन्नामेय के हे मोसाइट्स में एपोप्टोसिस का प्रमाण स्थापित किया गया था, जैसा कि झींगा में डब्ल्यूएसएसवी संक्रमण के कारण लेट एपोप्टोटिक सेल्स (कोशिकाओं) के प्रतिशत में उल्लेखनीय वृद्धि देखा गया था। वर्तमान अध्ययन संक्रमण के दौरान एक डब्ल्यूएसएसवी संक्रमित झींगे में एपोप्टोसिस दर और एपोप्टोसिस से संबंधित जीन की भूमिका के बारे में एक अंतर्दृष्टि देता है।

पीनियस इंडिकस के लिए आईसो-अनुक्रमण आधारित संपूर्ण ट्रांसक्रिप्टोम संसाधन :

सिक्वल II प्लेटफार्म पर नवीनतम पैसीफिक बायोसाईंसेस आईसो-अनुक्रमण दृष्टिकोण के उपयोग से पी. इंडिकस के लिए संपूर्ण ट्रांसक्रिप्ट अनुक्रमण तैयार किए गए हैं। वांछित

आर्थिक गुणों और पी. इंडिकस जीनोम की व्याख्या संबंधी कार्यात्मक अध्ययन करने के लिए संपूर्ण ट्रांसक्रिप्टोम एक मूल्यवान संसाधन होगा।

पीनियस इंडिकस के लिए लंबा गैर-कोडिंग आरएनए डेटाबेस :

पी. इंडिकस के लिए 7,434 ट्रांसक्रिप्ट्स से युक्त एक लंबा नॉन-कोडिंग आरएनए (lncRNA) डाटाबेस तैयार किया गया है। ये lncRNA अनुक्रमण न्यूक्लियस और साइटोप्लाज्म में जीन अभिव्यक्ति रेगुलेशन को समझने के लिए एक मूल्यवान संसाधन होंगे।

मुगिल सेफालस के लिए कॉन्टिग-लेवल जीनोम असेम्बली :

पैसीफिक बायोसाईंसेस सिक्वल II प्लेटफार्म पर लोंग-रीड अनुक्रमण डेटा के उपयोग से ग्रे मुलेट जीनोम की एक कॉन्टिग-लेवल असेम्बली तैयार की गई है। असेम्बली 648 Mb की है और इसमें 1725 कॉन्टिग्स शामिल हैं, जिनमें 10.05 Mb का कॉन्टिग N50 के आंकड़े हैं।

इट्रोप्लस प्रजातियों का तुलनात्मक आंत माइक्रोबायोम विश्लेषण :

जीनस इट्रोप्लस से संबंधित सभी प्रजातियों अर्थात इट्रोप्लस सुराटेन्सिस (ईएस), इट्रोप्लस मैकुलाटस (ईएम) और इट्रोप्लस कैनारेन्सिस (ईसी) के आंत माइक्रोबायोम का अध्ययन किया गया। यूनीक ऑपरेशनल टैक्सानोमी यूनिट्स (ओटीयू) की संख्या ईएम के आंत में सबसे अधिक (106) और ईसी में सबसे कम (42) थी, जबकि ईएस में 80 यूनीक ओटीयू थे, अर्थात अन्य दो मत्स्य प्रजातियों में से किसी में भी मौजूद नहीं थी। ईएस और ईएम की आंत में एंटोबैक्टीरिया और उसके बाद जैंथोमोनाडेसी की अधिकता थी, जबकि ईसी में बैक्टीरियोडेसी और उसके बाद एंटरोबैटीरिया की अधिकता थी।

इट्रोप्लस प्रजातियों पर अंतरविशिष्ट विविधता अध्ययन :

इट्रोप्लस जीनस की प्रजातियों के बीच आनुवंशिक सम्बद्धता का अध्ययन करने के लिए ATPaSe 6/8 एक माइटोकॉन्ड्रियल जीन का उपयोग किया गया था। अंत:स्थ जुड़ाव हैप्लोटाइप नेटवर्क और आनुवांशिक विभेदन अध्ययनों से संकेत मिलता है कि प्रत्येक प्रजाति अलग विशिष्ट क्लैड्स (समूहों) का गठन करती है और कई उत्परिवर्तनीय (म्यूटेशनल) घटनाक्रमों से क्लैड्स को स्पष्ट रूप से अलग किया गया था। नेटवर्क ट्री ने यह भी सूचित किया कि ई. कैनरेन्सिस और ई. मैकुलटस दोनों की सामान्य पूर्वज ई. सुराटेन्सिस हो सकती है।

लैटस कैलकैरीफर, लुट्जानस अर्जेंटीमाकुलाटस, मोनोडैक्टलस अर्जेंटियस और स्काटोफैगस अर्गुस का कार्योटाइपिंग

लैटस कैलकैरीफर, लुट्जानस अर्जेंटीमाकुलाटस, मोनोडैक्टलस अर्जेंटियस और स्काटोफैगस अर्गुस के गुणसूत्र पैटर्न का कार्योटाइपिंग द्वारा अध्ययन किया गया था। सभी मछलियों में 48 डिप्लॉयड क्रोमोसोम (2n=48) थे।

एशियाई सीबास के इम्यूनोग्लोबुलिन Mu (IgM) हैवी चेन जीन का प्रवर्धन और क्लोनिंग

एशियाई सीबास IgM जीन का आंशिक कोडिंग अनुक्रम पीसीआर प्रवर्धित था, जिसे pGEMT-ईजी वेक्टर का उपयोग करके क्लोन और अनुक्रमित किया गया था। प्राप्त अनुक्रम की लंबाई 828bp थी और इसे एनसीबीआई डेटाबेस के साथ ब्लास्ट किया गया था। इस अनुक्रमण में सिनिपर्का चुआत्सी (75.03%) और लाट्रिस लिनिएटा (73.46%) मछलियों के साथ उच्चतम पहचान थी। प्राप्त अनुक्रमण का उपयोग जीन अभिव्यक्ति अध्ययन (qRT-PCR और स्वस्थाने संकरण) के लिए प्राइमर डिजाइन करने के लिए किया गया था।

जीनोम स्केल मेटाबोलिक मॉडलिंग द्वारा विब्रियो हार्वेई पर प्रोबायोटिक प्रजातियों की प्रभावकारिता

जलजीव पालन तालाबों में विब्रियो हार्वेई के विकास को दबाने की क्षमता रखने वाले संभावित प्रोबायोटिक बैक्टीरिया को खोजने के प्रयास में, बाधा आधारित जीनोम स्केल मेटाबोलिक मॉडलिंग दृष्टिकोण का उपयोग करके इन सिलिको सिमुलेशन अध्ययन किया गया था। इस विधि का प्रयोग रोगजनक स्ट्रेन विब्रियो हार्वेई QT520 के साथ तीन जेनेरा नामत: लैक्टोबैसिली, बेसिली और लैक्टोकोकी से 193 स्ट्रेन की युग्मक अंत:क्रिया का अनुमान लगाने के लिए किया गया था। 193 प्रजातियों में से 48 ने 15 पोषक वातावरणों में से कम से कम एक पोषक वातावरण में वि. हार्वेई QT520 के विकास में कमी के साथ विकास लाभ का प्रदर्शन किया। छह प्रजातियों अर्थात् बैसिलस एसपी 1s 1 स्ट्रेन 1s 1, बैसिलस वेहियान्सिस स्ट्रेन Alg07, लैक्टोबेसिलस साकी स्ट्रेन WiKim0063, लैक्टोबेसिलस एसपी कौमिस, लैक्टोबेसिलस लिंडनेरी स्ट्रेन TMW 1.1993, और लैक्टोबेसिलस बुचनेरी NRRL B 30929 को रोगजनक के दमन के साथ-साथ विकास में लाभदायी पाया गया। विब्रियो हार्वेई के विकास को दबाने में पहचानी गई प्रजातियों का खारे जल के जलजीव पालन में संभावित उपयोग हो सकते हैं।

खारा जलजीव पालन के लिए राष्ट्रीय रेफरल प्रयोगशाला

कृषि मंत्रालय के मत्स्य पालन विभाग को रोगों की ओआईई सूचीकरण और हितधारकों द्वारा जलजीव पालन आदानों के आयात के संबंध में विशेषज्ञ सेवाएं प्रदान की गईं। चेन्नई में संचालित जलीय संगरोध सुविधा (एक्यूएफ) को भी विशेषज्ञ सेवाएं प्रदान की गई थीं। प्रयोगशाला को जांच के लिए कुल 185 नमूने प्राप्त हुए और जिनसे 11,240,844 रुपये का राजस्व प्राप्त हुआ है।

झींगा खेती के लिए ईएचपी एक बड़ा खतरा बना हुआ है, आईएमएनवी एक उभरता झींगा रोगजनक

पिछले पांच वर्षों के दौरान लगभग सभी झींगा कृषि राज्यों को कवर करते हुए 801 झींगा फार्मों में रोग निगरानी की गई। वर्ष 2020-2021 में 98 झींगा फार्मों की जांच की गई है और एंटोसाइटोज़ून हेपाटोपेनाई (ईएचपी) की सबसे अधिक व्यापकता (41%) थी जिसके बाद इनफेक्सियस मायोक्रोसिस वायरल रोग (आईएमएनवी) 30% की व्यापकता थी। व्हाइट स्पॉट सिंड्रोम वायरल रोग (डब्ल्यूएसएसवी) की व्यापकता 18% और संक्रामक हाइपोडर्मल हेमेटोपोइटिक नेक्रोसिस रोग 1% व्यापकता पाई गई। रोग की जांच से पता चला कि आईएमएनवी एक उभरता रोगजनक है और यह झींगा किसानों के लिए एक बड़ी चिंता का विषय है।

ल्यूमिनेसेंट विब्रियोसिस के नियंत्रण के लिए फेज थेरेपी

फेज थेरेपी विकसित करने के लिए, लगभग 100 से अधिक ल्यूमिनेसेंट विब्रियो आइसोलेट्स के खिलाफ लगभग 100 फेज के संक्रमित स्पेक्ट्रम किए गए थे। फेज की बड़े पैमाने पर उत्पादन तकनीक को मानकीकृत किया गया था। उत्पादन और विपणन के लिए सलेम माइक्रोस प्राइवेट लिमिटेड, भारत में प्रोफिलैक्सिस और ल्यूमिनेसेंट विब्रियोस के उपचार के लिए एक बैक्टीरियोफेज आधारित उत्पाद का व्यवसायीकरण किया गया था।

वायरल नर्वस नेक्रोसिस के लिए रिकॉम्बिनेंट प्रोटीन आधारित टीके का विकास

वायरल नर्वस नेक्रोसिस (वीएनएन) के खिलाफ एक रीकॉम्बिनेंट कैप्सिड प्रोटीन और निष्क्रिय वायरल वैक्सीन विकसित की गई थी। रिकॉम्बिनेंट कैप्सिड प्रोटीन वैक्सीन ने निष्क्रिय वायरल वैक्सीन की तुलना में बेहतर प्रतिरक्षा प्रतिक्रिया दी। रिकॉम्बिनेंट प्रोटीन को कमर्शियल एडजुवेंट के साथ शुद्ध और पायस किया गया था और मछली के तीन अलग-अलग खुराक अर्थात 1, 2.5 और 5 माइक्रोग्राम प्रति ग्राम शरीर भार पर एशियन सीबास फिंगरलिंग्स को दिया गया था। 2.5 माइक्रोग्राम प्रति ग्राम शरीर भार की खुराक ने अन्य दो खुराकों की तुलना में बेहतर प्रतिरक्षा प्रतिक्रिया दी। प्रतिरक्षण के 10 सप्ताह बाद तक सभी तीन खुराकों में प्रतिरक्षा प्रतिक्रिया सुरक्षात्मक स्तर से ऊपर थी।

आईएचएचएनवी कैप्सिड प्रोटीन से वायरस लाइक पार्टिकल (वीएलपी) का विकास

व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्यूएसएसवी) के नियंत्रण के लिए उपयोग करने के उद्देश्य से आईएचएचएनवी के कैप्सिड प्रोटीन से वायरस लाइक पार्टिकल (वीएलआरपी) को विकसित करने का प्रयास किया गया था। आईएचएचएनवी कैप्सिड जीन को pET16b वेक्टर के लिए प्रवर्धित और क्लोन किया गया था। जीन विशिष्ट कॉलोनी पीसीआर द्वारा रिकॉम्बिनेंट क्लोन की पुष्टि की गई। आईपीटीजी प्रेरित सकारात्मक क्लोन में वांछित 40 kDa प्रोटीन की अभिव्यक्ति देखी गई और इसे और अधिक विशेषता दी जाएगी।

झींगा हैचरी में ल्यूमिनेसेंट विब्रियोसिस के नियंत्रण के लिए एथिलेंडियामाइन टेट्राएसेटिक एसिड (ईडीटीए)

झींगा हैचरियों में ल्यूमिनेसेंट विब्रियोसिस एक बड़ी चुनौती है। जैसे सभी जीवन रूपों के लिए लौह एक आवश्यक तत्व है, लौह के विभिन्न अनुक्रमिक अणुओं जैसे एथिलेंडिमीन टेट्राएसेटिक एसिड (ईडीटीए), नाइट्रिलोएसेटिक एसिड और बाइपिरिडाइल की उपस्थिति में ल्यूमिनसेंट जीवाणु वि. कैंपबेली और वि. हार्वेयी की विकास गतिकी पर प्रयोग किया गया था। उत्साहजनक प्रयोगशाला परिणामों के आधार पर, ईडीटीए को झींगा हैचरियों में ल्यूमिनेसेंट विब्रियोसिस को नियंत्रित करने के लिए अनुप्रयोग किया गया था और रोगनिरोधी और चिकित्सीय रूप में प्रभावी पाया गया था।

खारे जलीय प्रणाली में गैर लक्षित जीवों पर रोगाणुरोधी एजेंटों के प्रभाव का निर्धारण

जलजीव पालन सहित खाद्य पशु उत्पादन में जीवाणु संक्रमण के उपचार के लिए रोगाणुरोधी पदार्थ महत्वपूर्ण हैं। जलजीव पालन में उपयोग की जाने वाली दवाओं और रसायनों की पर्यावरणीय सुरक्षा संकेतक जीवों पर उनके प्रभाव का अध्ययन करके निर्धारित की गई थी। क्लोरेला एसपी से ज्ञात होता है कि फ्लोरफेनिकॉल (आईसी50 666.29 पीपीएम) सर्वाधिक सुरक्षित था उसके बाद का स्थान ऑक्सीटेट्रासाइक्लिन (आईसी50 487.75 पीपीएम) और सल्फाडिमेथॉक्सिन (आईसी50 461.44 पीपीएम) का था।

झींगा के व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्यूएसएसवी) के विरुद्ध एक कीटाणुनाशक के रूप में बेंजालकोनियम क्लोराइड (बीकेसी) का मूल्यांकन

बेंजालकोनियम क्लोराइड (बीकेसी) एक डिटर्जेंट है, जो अपनी कीटाणुशोधन गुणधर्म के लिए जाना जाता है। वर्तमान अध्ययन में, डब्ल्यूएसवी के उपशमन के लिए कीटाणुनाशक के रूप में बीकेसी की प्रभावकारिता का मूल्यांकन करने के प्रयास किए गए थे। कृत्रिम परिवेशी अध्ययन ने 1 घंटे के लिए बीकेसी के 4 पीपीएम के संपर्क में आने पर डब्ल्यूएसएसवी (107 प्रतियां/माइक्रो लीटर) की पूरी निष्क्रियता की पुष्टि की। कृत्रिम तालाब की स्थिति में पानी में वायरस उप-सतह मृदा के अभाव में बीकेसी के 4 पीपीएम के साथ निष्क्रिय पाया गया था, जबकि बीकेसी का 18 पीपीएम मृदा की उपस्थिति में प्रभावी था।

आर्थिक रूप से महत्वपूर्ण मत्स्य प्रजातियों में परजीवी संक्रमण को नियंत्रित करने के लिए एमेमेक्टिन बेंजोएट (ईएमबी) का प्रक्षेत्र मूल्यांकन

विभिन्न पालन प्रणालियों (तालाब, टैंक, पिंजरे, झील और मछलीघर), मछली प्रजातियों (एशियन सीबास, ग्रे मुलेट, पर्लस्पॉट, भारतीय मेजर कार्प, गोल्ड फिश और कोई कार्प) में और विभिन्न परजीवियों (कैलिगस एसपीपी., अर्गुलस एसपीपी., लेर्नानथ्रोप्सिस एसपीपी और लेर्नाई एसपीपी) के विरुद्ध एक परजीवी रोधी दवा, एमेमेक्टिन बेंजोएट (ईएमबी) की क्षेत्र प्रभावकारिता के अध्ययन के लिए आहार में प्रति दिन प्रति कि.ग्रा. मछली शरीर भार (बीडब्ल्यू) में 50 माइक्रोग्राम का चिकित्सकीय उपचार किया गया। परिणामों से ज्ञात हुआ है कि उपचार के 7वें दिन अर्गुलस एसपीपी., कैलिगस एसपीपी. और लेर्नानथ्रोप्सिस एसपीपी के खिलाफ और लेर्नाई एसपीपी के खिलाफ उपचार के 10वें दिन 100% प्रभावकारिता थी। दवा दिए जाने के 60 दिनों के बाद तक परजीवी के किसी भी पुनः संक्रमण की सूचना नहीं दी गई थी।

समुद्री जूँ, पर्लस्पॉट, इट्रोप्लस सुराटेन्सिस में कैलिगस मिनीमस के विरुद्ध कीटाणुनाशक की प्रभावकारिता

पर्लस्पॉट, इट्रोप्लस सुराटेन्सिस में कैलिगस मिनीमस के विरुद्ध विभिन्न कीटाणुनाशकों की प्रभावकारिता का परीक्षण किया गया था। परिणामों से संकेत मिलता है कि क्रमशः 200 पीपीएम, 10 पीपीएम, 0.1 पीपीएम और 5 पीपीएम की एक खुराक दर पर फॉर्मेलिन (एचचो), पोटेशियम पर्मगनेट (केएमएनओ 4), कॉपर सल्फेट (CuSO4) और बेंजाल्कोनियम क्लोराइड (बीकेसी) जैसे कीटाणुनाशकों का उपयोग जल में समुद्री जूँ को नियंत्रित करने के लिए किया जा सकता है।

भारत के झींगा प्रक्षेत्रों में औषधियों के उपयोग के पैटर्न का विश्लेषण

भारतीय जलजीव पालन में स्वास्थ्य देखभाल उत्पादों के उपयोग पैटर्न को समझना आवश्यक है ताकि उनके वैज्ञानिक अनुप्रयोग की निगरानी और उन्हें विनियमित किया जा सके। देश के प्रमुख जलजीव पालन राज्यों में किए गए सर्वेक्षण से पता चला है कि पर्यावरण संशोधक कुल उत्पादों का 44% है, जिसके बाद प्रोबायोटिक्स (20%), कीटाणुनाशक (7%) और पोषण पूरक (6%) का स्थान है।

फार्म में ईएचपी का पता लगाने के लिए एलएएमपी परीक्षण विकसित

एंटोसाइटोज़ोन हेपाटोपेनेई (ईएचपी) का पता लगाने के लिए एक रैपिड, ऑन-फार्म विजुअल लूप मिडिएटेड आइसोथर्मल एम्पलिफिकेशन (एलएएमपी) परीक्षण विकसित किया गया था। हाइड्रोक्सी नैफथोल ब्लू और फिनोल रेड जैसे रंगों का उपयोग करके दृष्यमान पहचान को मानकीकृत किया गया।

रोगजनक विब्रियो एसपीपी. के परिमाणीकरण के लिए रियल टाइम पीसीआर आधारित निदान विकसित

विब्रियो की 100 से अधिक प्रजातियों में, वि. हार्वेयी, वि. ओवेन्सी, वि. रोटिफेरियनुस जैसी कुछ प्रजातियों में रोगजनक मार्कर होते हैं जो उन्हें जलजीव पालन की स्थिति में विषाक्त बनाते हैं। इन विषाक्त प्रजातियों के अंतर परिमाणीकरण के लिए मात्रात्मक पीसीआर आधारित निदान परीक्षण विकसित किए जा रहे हैं।

मिल्क फिश के लिए ब्रेन सेल लाइनें एमएफबी-1 विकसित

मिल्क फिश (चनोस चनोस) के ब्रेन टिश्यू से ब्रेन सेल लाइन एमएफबी-1 को विकसित किया गया। तीन वर्षों की अवधि में 65 से अधिक पैसेजों के लिए स्थिर वृद्धि देखी गई।

वन्य रूप से पकड़े गए और पालित भारतीय सफेद झींगा (पीनियस इंडिकस) में गट माइक्रोबायोटा का तुलनात्मक विश्लेषण

पी. इंडिकस के गट माइक्रोबायोटा को समझने के लिए, वन्य रूप से पकड़े गए और पालित पी. इंडिकस ब्रूडस्टॉक में 16S rRNA जीन के V3-V4 हाइपरवेरिएबल क्षेत्रों की जांच की गई। दोनों समूहों ने समुदाय (फाइलम) स्तर पर समान कोर माइक्रोबायोटा प्रदर्शित किया, जिसमें मुख्य रूप से प्रोटोबैक्टीरिया, फ्यूसोबैक्टीरिया, टेनेरिक्यूट्स और

फर्मीक्यूट्स शामिल थे, हालांकि उनके सापेक्ष बहुतायत में महत्वपूर्ण अंतर पाए गए। वन्य के मामले में प्रमुख जेनेरा फोटोबैक्टीरियम (29.5%) था जिसके बाद प्रोपियोनिजेनियम (13.9%), हाइपोसाइक्लिकस (13.7%) और विब्रियो (11.1%) का स्थान था; जलजीव पालन के मामले में इसमें विब्रियो (46.5%) का प्रभुत्व था और इसके बाद कैटेनोकोकस (14%), प्रोपियोनिजेनियम (10.3%) और फोटोबैक्टीरियम (8.7%) का स्थान था।

उच्च और निम्न लवणीय वातावरण से माइक्रोबियल संवर्धन को नाइट्राइंग करने का तुलनात्मक विश्लेषण

अध्ययन में कम (0.5-5‰) और उच्च (18-35‰) खारे जलीय वातावरण से माइक्रोबियल संवर्धन को नाइट्राइंग करने में विविधता सूचित की गई है। दोनों वातावरणों से एओबी और एनओबी संवर्धन ने दोनों समूहों में क्रमशः 38 और 34 फ़ाइला के साथ कम खारा और 53 और 40 फ़ाइला उच्च खारा स्रोतों में वितरित किए गए फ़ाइलम के विविध वंशक्रम प्रदर्शित किया। प्रोटोबैक्टीरिया, क्लोरोफ्लेक्सी, बैक्टेरोएडेट, वेरुकोमाइक्रोबिया, अवर्गीकृत जीवाणु समूह, नाइट्रोसपिरा, ऐक्टिनोबैक्टीरिया, प्लैंक्टोमाइसेट्स, एसिडोबैक्टीरिया, आर्माटिमोनाडेसी दोनों वातावरणों से एओबी और एनओबी संवर्धन के बीच वितरित सबसे प्रमुख फाइलम पाए गए।

भारतीय सफेद झींगा (पीनियस इंडिकस) के आंत माइक्रोबायोटा पर प्रोबायोटिक्स का प्रभाव

प्रोबायोटिक उत्पाद युक्त, बैसिलस सबटिलिस, बी. लिचिनिफॉर्मिस और बी. प्यूमिलस (5×1010 cfu/gram) के अनुप्रयोग ने आंत में माइक्रोबियल समुदायों में परिवर्तन दर्शाया। 16S rRNA आधारित इलुमिना अनुक्रमण का उपयोग करते हुए किए गए विश्लेषण ने प्रोबायोटिक उपचारित समूह (94.85%) में और जीनस स्तर पर विब्रियो (44.17%) द्वारा प्रोटियोबैक्टीरिया की प्रचुरता दिखाई और इसके बाद रोडोबैक्टीरिया_ अनक्लासिफाइड (25.22%), कैटेनोकोकस (12.89%) का स्थान था।

जलजीव पालन तालाबों में विषाक्त सल्फर मेटाबोलाइट के शमन के लिए सल्फर ऑक्सीडाइजिंग बैक्टीरिया का संवर्धन

सल्फर ऑक्सीडाइजिंग बैक्टीरिया (एसओबी) तालाब के तल में बनने वाले अत्यधिक विषैले हाइड्रोजन सल्फाइड से कम/हानिरहित सल्फेट या सल्फर के ऑक्सीकरण में महत्वपूर्ण भूमिका निभाता है। एसओबी का संवर्धन (n = 6) खारे जल के वातावरण से विकसित किया गया था। डीजीजीई विश्लेषण से 6 संवर्धन में 25 विभिन्न उपभेदों के अस्तित्व का पता चला। सभी संवर्धन पीएच को 7 से घटाकर 1 करने में सक्षम थे और 3-5 महीने तक स्थिर पाए गए। 16s rDNA के मेटाजिनोमिक विश्लेषण परिवार स्यूडोमोनाडेसी, प्रीवोटेलैसी और बेसिलेसी के वर्चस्व का पता चला।

झींगा फार्म में अमोनिया विषाक्तता के प्रभावी शमन के लिए डीनाइट्रीफाइंग बैक्टीरिया के कंसोर्टिया का विकास

डीनाइट्रिफाइंग बैक्टीरिया (डीएनबी) हेट्रोट्रोफिक बैक्टीरिया हैं जो नाइट्रेट को फ्री नाइट्रोजन में बदलने या संरचनात्मक अणुओं में आत्मसात करने में कुशल होते हैं। कुल 31 डीएनबी उपभेदों को अलग किया गया। जोबेला एसपी और मैरिनोबैकर एसपी को नाइट्राइट/नाइट्रेट रूपांतरण में दक्ष के रूप में पाया गया और एक डीएनबी को nirK जीन को सहन करने वाला पाया गया जो डीनाइट्रिफिकेशन प्रक्रिया के लिए जिम्मेदार है।

मिल्कफिश लार्वा का माइक्रोबियल प्रोफाइलिंग

मिल्क फिश पालन में माइक्रोबियल प्रोफाइलिंग किया गया। पालन पर निर्भर विधि ने वी. अल्ग्नोलाइटिकस, वी. लिटोरलिस, वी. प्रोटियोलाइटिकस, वी. रूबर, वी. नैट्रिजींस, वी. नियोकैलेडोनिकस, वी. पैराहेमोलिटिकस जैसे विब्रियो एसपीपी. के प्रभुत्व का खुलासा किया। पालन पर निर्भर डीजीजीई पीसीआर ने फ्यूसिबेक्टर, एक्रोमोबैक्टर, कैंडिडा कॉर्सेला, कैटेनोकोकस जैसे अवायवीय बैक्टीरिया के प्रभुत्व का खुलासा किया।

रोगजनक विब्रियो कैंपबेली द्वारा मेटालोप्रोटीज उत्पादन

रोगजनक विब्रियो कैंपबेली में प्रोटीज उत्पादन का विश्लेषण किया गया था। सहसंबंध मैट्रिक्स ने संकेत दिया कि प्रोटीज सकारात्मक रूप से रोगजनकता (पी>0.05) और ऑटोइंड्यूसर-2 और ऑटोइंड्यूसर-1 सिग्नल के साथ नकारात्मक सहसंबद्ध (पी<0.05) के साथ सहसंबद्ध था। प्रोटीज गतिविधि पूरी तरह से 1,10-फेनथ्रोलिन द्वारा बाधित की गई थी जो यह दर्शाता है कि एंजाइम मेटालोप्रोटीज है।

ToxR विब्रियो कैंपबेली की विषाक्तता के विनियमन में महत्वपूर्ण भूमिका

ToxR वि. कॉलेरेई का एक प्रमुख विषाक्तता नियामक है। जलीय रोगजनकों में इसकी भूमिका को समझने के लिए, 30 वि. कैंपबेली आइसोलेटो के ToxR जीन को आंशिक रूप से अनुक्रमित किया गया था। घटाए गए अमीनो एसिड

अनुक्रम के कई अनुक्रम संरेखण 120 से 170 ए. ए. के क्षेत्र में एक चर क्षेत्र का सुझाव दिया जिसमें दो महत्वपूर्ण अमीनो एसिड प्रतिस्थापन के साथ 123वें (एलेनिन के लिए प्रोलाइन) और 150वें स्थान (ग्लूटामाइन से प्रोलाइन) पर हैं। 150वें स्थान (P150) पर प्रोलाइन के साथ आइसोलेटों ने विषाक्तता में महत्वपूर्ण कमी के साथ प्रोटीज गतिविधि को पूरी तरह से समाप्त कर दिया था।

पॉलीकीट्स में ईएचपी संक्रमण

हैचरी में आहार के रूप में इस्तेमाल होने वाले पॉलीचेट्स के जीवित नमूनों में झींगा माइक्रोस्पोरिडियोसिस के कारक एजेंट एंटोसाइटोजोन हेपेटोपेनेई (ईएचपी) के निम्न स्तर का संक्रमण पाया गया। अध्ययन ईएचपी के संचरण में जीवित-आहार पॉलीचेट्स कीड़े की निष्क्रिय भूमिका को हैचरी में ब्रूडस्टॉक झींगा तक समाप्त करता है। हालांकि, माइक्रोस्पोरिडियन परजीवी के लिए एक प्रतिकृति मेजबान होने की संभावना नहीं है।

ईएचपी संक्रमण के बाद सफेद मलीय लडियों को प्रयोगात्मक रूप से पुनरूत्पादन

डब्ल्यूएफएस के साथ ईएचपी के जुड़ाव का अध्ययन करने के लिए, पीसीआर परीक्षण किया गया झींगे को दो दिनों के लिए ईएचपी संक्रमित हेपाटोपैनक्रियास ऊतक खिलाया गया था। प्रायोगिक संक्रमण के 15 दिनों के बाद, सफेद मलीय लडियां पुन: उत्पन्न हुए जिनमें ईएचपी बीजाणुओं मौजूद थे।

झींगा प्रजनकों के लिए चारे के रूप में पॉलीकीट्स के जैव सुरक्षा जोखिम का आकलन

मात्रात्मक पीसीआर द्वारा पॉलीकीट में ईएचपी के प्रसार की जांच करने के लिए, ईएचपी-संक्रमित झींगा ऊतकों को खिलाकर चुनौती संक्रमण द्वारा एक प्रयोग किया गया था। मात्रात्मक पीसीआर और हिस्टोपैथोलॉजी द्वारा निर्धारित ईएचपी के संक्रमण ने समय के साथ उच्च स्तर तक नहीं पहुंचा। इसने संक्रमण की खराब स्थापना और पॉलीकीट के ऊतकों में दोहराने में असमर्थता का संकेत दिया।

पर्लस्पॉट, इट्रोप्लस सुराटेंसिस में एन्सीरोसेफालिड संक्रमण

पालित पर्लस्पॉट, इट्रोप्लस सुराटेंसिस के गलफड़ों में मोनोजीनियन ट्रैमेटोड्स (फ्लूक) एन्सीरोसेफालिड संक्रमण देखा गया था। एन्सीरोसेफालिड परजीवी को आंखों के धब्बे और एंकर (हमुली) जोड़े की संख्या, ट्रांसवर्स बार्स् और उनके हाप्टरों पर सीमांत हुक जैसे विशिष्ट लक्षणों के साथ देखा गया था।

स्ट्रीक्ड स्पाइनफुट रैबिट फिश (सिगनस जावस) में एमाइलोडिनियम का संक्रमण

डाइनोफ्लैगेलेट (फाइटोमास्टिगोफोरा) परजीवी, एमाइलोडिनियम का संक्रमण स्पाइनफुट रैबिट फिश (सिगनस जावस) के गलफड़ों और त्वचा में देखा गया। मछलियों को 14 दिनों के लिए कम लवणता (लगभग 5 पीपीटी तक) में स्थानांतरित करना एमाइलोडिनम ओसेलेटम संक्रमण को खत्म करने का एक व्यवहार्य विकल्प है। बाहरी परजीवी संक्रमण से बचने के लिए अनिश्चितकालीन स्नान के रूप में 15-25 पीपीएम की दर से फॉर्मेलिन का उपयोग रोगनिरोधी उपाय के रूप में किया जा सकता है।

आजीविका सुरक्षा

एससी/एसपी, टीएसपी और सीएसआर वित्तीय सहायता के साथ कांचीपुरम, तिरुवल्लूर, नागपट्टिनम जिलों के गांवों में जलीय कृषि और संबद्ध प्रौद्योगिकी हस्तक्षेपों के साथ तटीय ग्रामीण गांवों में छोटे जोत वाले जलीय कृषि के लिए आजीविका सुरक्षा सुनिश्चित करने हेतु निरूपण किया गया था। अग्रपंक्ति निरूपणों से मछुआरों ने प्रति व्यक्ति प्रति माह 3000 से 12000 रुपये अतिरिक्त आय अर्जित की।

आर्थिकी एवं व्यापार

ईएचपी और डब्ल्यूएसएसवी के कारण होने वाले आर्थिक नुकसान का विस्तार से अध्ययन किया गया। हालांकि WSSV को झींगा पालन में सबसे घातक संक्रमण माना जाता था, विश्लेषण से पता चला कि EHP के कारण प्रति वर्ष राष्ट्रीय नुकसान 0.77 मिलियन टन (3977 करोड़ रुपये) था, जबकि WWSV के कारण होने वाली हानि केवल 0.33 मिलियन टन (रु. 1670 करोड़) था। यह किसानों द्वारा बेहतर जैव सुरक्षा प्रोटोकॉल को अपनाने और ईएचपी की रोकथाम और उपचार में कठिनाई के कारण हो सकता है।

जलजीव पालन पर कोविड-19 का प्रभाव

कोविड-19 संबंधित लॉकडाउन ने जलीय कृषि की पूरी मूल्य श्रृंखला को प्रभावित किया। तालाबंदी के कारण खारे पानी के जलीय कृषि क्षेत्र से कुल राष्ट्रीय नुकसान लगभग 11,265/- करोड़ रुपये था। जबकि किसान सबसे अधिक प्रभावित थे, जिन्हें अनुमानित कुल नुकसान का लगभग 60% का नुकसान हुआ, हैचरी और फीड मिल उद्यम भी प्रभावित हुए।

विविधिकरण की आर्थिकी

एशियाई सीबास के नर्सरी पालन की तकनीकी और आर्थिक दक्षता का मूल्यांकन किया गया। अध्ययन में पाया गया कि खारा जल और कम

लवणीय क्षेत्रों में एशियाई सीबास नर्सरी पालन से किसानों को आय का एक स्तर लाभ लागत अनुपात 1.96 से 2.76 प्रतिशत और क्रमशः 130 और 300% आईआरआर के साथ प्राप्त हुआ।

पीनियस वनामेय पर लवणता और अमोनिया तनाव का एकल एवं संयुक्त प्रभाव

झींगों को एकल लवणता (पीपीटी) में एक्सपोज किया गया था: S1-3; S2-20; S3-35; एकल TAN (मिलीग्राम/एल): TAN1, TAN3, और TAN6; संयुक्त उपचार - TAN1S1, TAN1S2, TAN1S3; TAN3S1, TAN3S2, TAN3S3; TAN6S1, TAN6S2, TAN6S3 और नियंत्रण (लवणता: 10 पीपीटी; TAN : 0.0112 मिलीग्राम / एल)। एकल उपचारों में TAN सांद्रता बढ़ने और लवणता में कमी के साथ मृत्यु का जोखिम बढ़ गया। संयोजन उपचारों में लवणता घटने के साथ जोखिम कारक बढ़ गया। नियंत्रण की तुलना में TAN6S1 (29.6) और TAN6S2 (24.7) में मार्त्यता का सबसे अधिक जोखिम देखा गया। कुल मिलाकर, THC, PO और SOD के संदर्भ में प्रतिरक्षात्मक गतिविधि TAN बढ़ने और लवणता में कमी के साथ घट गई।

झींगा विकास पर एडाप्टोजेन फीड का प्रभाव

जैविक और शारीरिक तनाव के अनुकूलन के लिए एडाप्टोजेन्स निकाल कर उनका विशेषीकरण किया गया। चार अलग-अलग सांद्रणताओं में उपयुक्त फ़ीड पर लेपित एडाप्टोजेन समूहों को उनकी एक्वा स्टेबिल्टी के लिए परीक्षण किया गया था। 500 मिलीग्राम/किलोग्राम की दर से लेपित फ़ीड ने विकास मानकों में तुलनात्मक रूप से बेहतर निष्पादन दर्शाया।^

झींगा तालाब की जलीय गुणवत्ता पर कार्बन : नाइट्रोजन के अनुपात का प्रभाव

भंडारण घनत्व 80 नग/वर्गमीटर की दर से संग्रहीत पी. वन्नामेय के छह सप्ताहों के पालन में कार्बन : नाइट्रोजन के अनुपात (20:1, 15:1 और 10:1) का जलीय गुणवत्ता पर प्रभाव के अध्ययन ने दर्शाया कि सी:एन अनुपात बढ़ने से जल में टैन (TAN) घटता है और झींगे का अधिकतम भार 15:1 अनुपात में दर्ज किया गया तत्पश्चात 20:1 और 10:1 अनुपातों में दर्ज किया गया।

जलीय कृषि तालाब की मिट्टी के लिए चूने की आवश्यकता अनुमान लगाने की प्रक्रियाओं की पुन: जांच

तीन पद्धतियां नामत: मिट्टी-पानी पीएच (1:2.5), मिट्टी-बफर पीएच (शूमेकर-मैकलीन-प्रैट बफर) और अनुमापन द्वारा विनिमेय अम्लता का परीक्षण मिट्टी के पीएच को 5.5 से 7.0 तक बढ़ाने के लिए चार चूना सामग्रियों अर्थात कृषि चूना, डोलोमाइट, शेल लाइम और सी-शेल की चूने की आवश्यकता की गणना के लिए किया गया। विनिमेय अम्लता विधि मिट्टी की चूने की आवश्यकता का सटीक अनुमान लगाती है, जबकि मिट्टी-पानी पीएच और एसएमपी बफर विधियाँ क्रमशः चूने की आवश्यकता को थोड़ा कम और अधिक अनुमान लगाती है।

गुडूर मंडल, आंध्र प्रदेश के झींगा पालन स्रोत जल और तालाब की मिट्टी का विशेषीकरण

आंध्र प्रदेश में गुडूर के चिल्लाकुर मंडल में झींगा पालन तालाबों के स्रोत जल और मिट्टी की गुणवत्ता की जांच की गई। लगभग 40% मिट्टी चिकनी दोमट बनावट की थी और अधिकांश मिट्टी क्षारीय श्रेणी में थीं। लगभग 93% मिट्टी में 0.25% से कम जैविक कार्बन था। सभी मृदाओं में इष्टतम उपलब्ध नाइट्रोजन कम था और लगभग 58% मिट्टी में इष्टतम उपलब्ध फास्फोरस था। खाड़ी (क्रीक) के पानी की लवणता 5 पीपीटी से कम थी जबकि बोरवेल के पानी में व्यापक लवणता सीमा थी। तुलनात्मक रूप से, खाड़ी के पानी की तुलना में बोरवेल के पानी में खनिजों की सांद्रता बहुत अधिक थी।

अंतर्स्थलीय लवणीय मृदाओं की उर्वरता स्तर

राजस्थान, हरियाणा और पंजाब की अंतर्स्थलीय लवणीय मिट्टी में नाइट्रोजन की कमी होती है और उपलब्ध फास्फोरस के साथ-साथ उपलब्ध पोटेशियम भी प्रचुर मात्रा में होता है। अंतर्स्थलीय खारे भूजल के आयनिक प्रोफाइल असंतुलन को कम करने के लिए मृदाएं जलीय कृषि के लिए पोटेशियम की संभावित आपूर्तिकर्ता हो सकती हैं।

विभिन्न आयु के तालाब तलछटों का विशेषीकरण

विभिन्न आयु वाले तालाब तलछटों के अध्ययन हेतु इन्हें 10 वर्ष से कम, 10-20 वर्ष और 20 वर्ष से अधिक आयु में वर्गीकृत किया गया और यह देखा गया कि आयु बढ़ने के साथ लेबाइल कार्बन कम हो गया, जबकि पानी में घुलनशील कार्बन बड़ी आयु वाले तालाबों में अधिक हो गया। विभिन्न कार्बन अंशों में, कम आयु के तालाबों में कुल अकार्बनिक कार्बन अंश अधिक था और अधिक आयु वाले तालाबों में कुल कार्बन अंश अधिक था। अधिक आयु वाले तालाबों में कुल कार्बन बड़ा भाग गैर-लेबाइल रूप में था जिससे कार्बन भंडारण और सीक्वेसट्रेशन में वृद्धि हुई।

चक्रवात निवार के कारण झींगा जलीय कृषि को नुकसान

आंध्र प्रदेश के नेल्लोर जिले में नवंबर 2020 के दौरान गंभीर चक्रवाती तूफान 'निवार' के कारण झींगा जलीय कृषि को हुए नुकसान के आकलन से संकेत मिलता है कि लगभग 5000 एकड़ झींगा पालन तालाब प्रभावित हुए और अनुमानत: 34 करोड़ की क्षति हुई। चक्रवात के बाद भारी वर्षा से प्रेरित बाढ़ से निचले इलाकों में झींगा पालन तालाबों में पानी भर गया, जिससे झींगे बाहर बह गए और तालाब के तल पर 5 सेमी तक नरम तलछट जमा हो गया। बाढ़ के बाद विश्लेषण में देखा गया कि जल की लवणता, खनिजों की संरचना और आयनिक अनुपात में भारी कमी, तालाब जल में गंदलापन और पोषक तत्वों में वृद्धि, जिसने पालन तालाबों में झींगों में तनाव उत्पन्न किया।

जल गुणवत्ता मानकों और झींगा वृद्धि मानकों पर तीव्र वृष्टि का प्रभाव

वर्ष 2020 के दौरान नवसारी जिला, गुजरात में तीव्र वृष्टि के प्रभाव की निगरानी, वर्षा से पहले और वर्षा के दौरान पानी की गुणवत्ता में बदलाव और झींगा तालाबों के उत्पादन संबंधी निष्पादन पर की गई थी। 75 से 100 मिमी की तीव्र वर्षा के परिणामस्वरूप 1 एकड़ के तालाब में एक ही दिन में 2.5 पीपीटी की लवणता कम हो गई। वर्षा के कारण तालाब जल में लवणता की गिरावट, तालाब के पानी की लवणता पर निर्भर करती है। कम और मध्यम लवणता वाले जल की तुलना में उच्च लवणीय जल में अधिक परिवर्तन होगा।

मुत्तुकाडु ज्वारनदमुख और अडयार क्रीक का जलीय गुणवत्ता सूचकांक

मुत्तुकाडु ज्वारनदमुख में मानसून के मौसम (1.98 से 3.14) के दौरान उच्च जल प्रदूषण सूचकांक (WPI) अपवाह के परिणामस्वरूप नाइट्रेट और फॉस्फेट जैसे पोषक तत्वों की उच्च सांद्रता के कारण था। इसी तरह, अडयार क्रीक में मौसम के अनुसार जल प्रदूषण सूचकांक के मान में काफी भिन्नता है और स्रोत जल एवं पेन पालन स्थल पर क्रमशः 0.56 से 1.1 और 1.9 से 2.2 तक है।

दैनिक तापमान नियंत्रित झींगा आवास प्रणाली

दैनिक तापमान नियंत्रित झींगा आवास प्रणाली 20-45 डिग्री सेल्सियस की वांछित तापमान सीमा को बनाए रखते हुए झींगा में रोग की घटना पर जल के तापमान में बदलाव के प्रभाव का अध्ययन करने के लिए तैयार की गई थी। अनुकूलतम सीमा में जल की गुणवत्ता बनाए रखने के लिए इकाई में पुनर्चक्रण प्रणाली है।

Executive Summary

Breeding and seed production of first-generation, F1 stock of *Penaeus indicus*

Closing the life cycle of the *P. indicus* in captivity has been one of our major thrust areas towards the domestication. Our constant efforts on this aspect has produced successful reproduction of the F1 generation produced from the progeny of wild *P. indicus*. F1 stock attained successful mating at 17-18g and 70% gonadal development was observed at 8-11 months of age. 13 reproduction cycles using 40 broodstock of F1 were carried out in the shrimp hatchery of MES, CIBA to study the reproductive performance. Fecundity ranged from 28,000-90,000 and 20% of the females contributed to the multiple breeding leading to better performance of F1 generation compared to the F0 stock in our previous studies. Further, to enhance reproductive performance of captive stock, 17 β-estradiol was administered to the female broodstock resulting in triggered gonadal development and spontaneous spawning.

Mating experiment: role of light intensity in indoor and outdoor rearing units

Mating in captive systems is one of the major constraints breeding of closed thelycum shrimp. To address this challenge, a 60 days mating experiment trial was carried out using two size groups (Group 1: 15-18g and Group 2: 25-35 g). The experimental was conducted in indoor and outdoor RAS tanks with and without sand bottom under two photoperiod (12L:12D and 18L:6D) and natural photoperiod respectively. Though molting was 100% in indoor rearing units, mating efficiency was only 9%, and the majority (90%) were not mated (Group 1). In outdoor units, about 90% of females were mated, and 72% were in premoult and 9% in intermoult stages.

Artemia biomass as a bio-vehicle for E2 enrichment in domesticated broodstock of *P. indicus*

The potential role of *Artemia* biomass as a quality broodstock diet for penaeid shrimps was assessed in a 21-day broodstock feeding trial. The brood stocks were fed 25% of the diet with frozen, live, and live sub adult Artemia biomass enrich with estradiol (17-beta estradiol pg/100 mg). Broodstock fed with enriched Artemia, live and frozen recorded 100%, 87% and 44.4% gonad development after 14 day trial. Survival and molting frequency was higher in the estradiol enriched Artemia fed group. Artemia biomass is a suitable live feed and due to its bio encapsulation ability and 100% acceptability as a live form.

Vertical transmission of WSSV virus

Broodstock sourcing and creating disease-free base population is the initial step of domestication. This is a major challenge due to the presence of WSSV virus in the wild stock of *P. indicus.* Infected brood shrimps often results in infected post larvae through vertical transmission. WSSV nested PCR positive shrimp brooders were subjected to analysis for infection status of the reproductive organs and derivatives.

Improving Egg activation during in vitro fertilization

In vitro fertilization technique for shrimps are not popular due to unsuccessful and lower fertilization rates due to the incomplete activation of eggs. To analyze the fertilization potential two experiments (day and night) were done to study the egg activation capacity and fertilization during the invitro technique. Oocytes were separated by macerating the surgically dissected out ovary from wild caught ripe *P. indicus* females and mixed with graded sperm suspension (0.5, 1, 2.5, 5 $X10^6$ cells/ml). Low percentage of egg

activation was observed irrespective of the time and the concentration of the sperms. Optimizing the egg activation may increase the viability of the invitro fertilization technique.

Hatchery production of grey mullet

Further refinement in protocols for hatchery production of grey mullet *Mugil cephalus*, was carried out; a maturation percentage of over 81% was recorded for captive grey mullet in 2020 as compared to 54±3% in 2016-19; induced breeding of captive grey mullet resulted in production of over 2000 fingerlings. Hatchery produced grey mullet seeds were distributed to farmers for the first time and are also being maintained for captive F1 broodstock development.

Hatchery production of Milkfish

Despite the COVID 19 scenario and nationwide lockdown, there was a steady demand for hatchery produced milkfish seed among brackishwater farmers. A total 46,837 hatchery produced milkfish fry were distributed among farmers from Kerala, West Bengal, Gujarat, Orissa, Tamil Nadu and almost 1. 5 lakh rupees was generated. This was produced through assisted hormone implantation of two domesticated population of milkfish (*Chanos chanos*) which resulted in a total of 22 spawning from March to October. Evaluation of the effectiveness of assisted (04 implantation/year- Dec, Jan, April, July) implantation of combined hormone pellet (GnRHa and 17 α–MT) over chronic (10 implantations/ year- December, January-September) as breeding option revealed that assisted implantation helped to achieve desired percentage of unimodal distribution of mature oocytes (650-750 µm) reaching final oocyte maturation (FOM) stage in female milkfish along with higher spawning frequency, in contrast with chronic/ continuous implantation (every month) which caused an increased percentage of vitellogenic oocytes with bimodal distribution (250 - 500 µm and 500-600 µm) in ovary with reduced spawning events.

Captive breeding and seed production of red snapper

Breakthrough on captive breeding and seed production of Mangrove Red snapper *Lutjanus argentimaculatus* was achieved using captive tank reared stocks. A captive maturity of 67% was recorded during the observed reproductive period, August to September. A total of 6 induced breeding experiments were conducted. Successful larval rearing was carried using rotifers, copepod and *Artemia* nauplii followed by artificial feed at 25 days post hatch. A total 500 numbers were produced. This is the first record of hatchery production of red snapper juveniles under captive conditions from India.

Pathogen free broodstock development of Asian seabass

Healthy pathogen free broodstock development of Asian seabass *Lates calcarifer* and quality fry production for farmers was ensured despite the challenges associated with covid lockdown. A total of 22 natural spawning and 8 induced spawning was observed and an overall production of 1.2 million seed were produced. A total of 2,96,000 seeds were sold during the period from June to October 2020. An amount of Rs.7,04,000/- was realised from the sale of seed to 25 farmers belonging to Tamil Nadu, Andhra Pradesh, Kerala and Karnataka, NGRC TSP programme and new the startup initiative of CANARES Aqua. In order to standardize the vaccine against viral nervous necrosis affecting brackishwater finfishes, dose optimization of recombinant vaccine was done by assessing the antibody titre in Asian sea bass. A dose of 2.5 µg/g body weight dose gave better immune response compared to 1.5 µg/g[1] body weight. The immune response was found to be above the protective levels in all the three doses up to 10 weeks post-immunization.

Yellow fin bream, *Acanthopagrus longispinnis*

Yellow fin bream, *Acanthopagrus longispinnis* brood stock developed in RAS and brackishwater pond attained sexual maturation. Fully mature oozing male and mature female (oocyte diameter 380-420 µm) was observed during month of December-January in captive reared stock.

Gold spot mullet, *L. parsia,*

In gold spot mullet, *L. parsia,* prior to spawning season three time implantation of pellet (LHRHa, 15µg+metoclopramide, 0.005µg/ pellet) at one month interval was found to induce sexual maturation. Combined delivery of hCG and CPE (15 IU+0.12 mg/day/fish) through osmotic pump (OP) was found to be more effective in gonad development of *L. parsia* than either hCG or CPE.In mature *L. parsia,* administration of hCG (hCG @2 IU/g) as primary and secondary dose triggered final maturation, ovulation and spawning.

Seed production of Pearl spot

Cage based spawning and seed production of pearl spot in RAS resulted in production of 18,500

nos pearl spot early fry from 28 spawning with 12 pair of brooders in a span of 3 months. Pearl spot seeds produced from cage based breeding model supplied to scheduled castes sub plan beneficiaries at regular intervals (August to October 2020) for demonstration of nursery rearing of pearl spot as source of livelihood generation. A total of 10,500 pearl spot fingerlings (4.5 – 8 cm) were produced and generated a revenue of Rs 1,57,000/-

Effect of growth and survival of monoangel at various salinities

The experiment was designed with five different salinities to study the effect of salinity on growth and survival rate of larvae before and after metamorphosis. Results of the study demonstrated that pre-larvae were stenohaline and to adjust well to only around 20–35‰ seawater. However, immediately after larval metamorphosis, larvae survived even in fresh water, demonstrating the strong euryhaline nature of the species.

Effect of stocking density and season on nursery rearing and compensatory growth in *P. vannamei* and *P. indicus*

Nursery rearing is now widely adopted as pre grow out activity in shrimp farming for better survival and growth of shrimp. To optimize the rearing protocols, nursery rearing of *P. vannamei* and *P. indicus* was done using aqua mimicry during different seasons (summer, pre-monsoon, monsoon and winter season) and different stocking densities (2500, 5000, 7500 and 10000 PL/ton). Maximum stocking densities of 7500 PL/tons and 5000PL/ton during nursery rearing provided better results in terms of growth and survival for *P. vannamei* and *P. indicus* respectively. Effect of seasons showed descending trend on productivity in the order summer, pre monsoon, monsoon and winter. *P. vannamei* and *P. indicus* showed compensatory growth and better survival during grow out of nursery reared post larvae. Nursery rearing of shrimp seed shall be adopted to reduce the culture period and Increase the productivity.

Effects of dietary minerals and vitamin C supplementation on production characteristics of *P. vannamei* post larvae reared in earthen ponds

Supplementation of commercial diets with mineral salts and vitamin C is a common practice among shrimp farmers to improve survival and growth of the shrimp especially when rearing shrimp at low and intermediate salinities. Commercial shrimp diets were supplemented with Potassium chloride (KCL-5g/kg), Magnesium chloride (Mgcl 2.5g/Kg), Combination of KCL and $MgCl_2$ and Vitamin C (5kg/Kg). Experimental controls comprised shrimps fed with commercial feed and a non-fed group. Overall, superior FCR, final yield and growth rates were observed in the case of shrimp fed using diets supplemented with potassium and vitamin C. Farmers shall adopt a combination of potassium and vitamin C supplementation in field conditions to obtain the desired survival, growth rates and yields.

Growth characteristics of *P. vannamei* juveniles exclusively fed using fermented soya bean meal in comparison to formulated shrimp diet

Aqua mimicry concept in shrimp farming involves enhancement of live food organisms in the pond for shrimp post larvae to feed, using fermented soya bean meal (FSBM) as the soul supplementary diet for shrimp. Three treatments were used: soya bean meal fermented using yeast (Y-*Saccharomyces cerevisiae*) commercial probiotic (Bacillus sp.) and combination of yeast and commercial probiotic at 1:1. The final weight of shrimp fed using SBM fermented using yeast, probiotic and combination of both, did not vary significantly at the end of the trial. Fermented soya bean meal can be used as the soul supplementary diet for *P. vannamei* PL for the first 30 to 45 days of culture. These dietary advancements are helpful for organic shrimp farming and preparation of farm made feeds to reduce production costs in the future.

Acclimatization of *Penaeus vannamei* at different salinity and nursery production

Effect of acclimatization and nursery rearing of *P. vannamei* under different salinity regime was studied. Post larvae of *P. vannamei* were acclimated and reared in salinities 2, 15, 30, 45 and 65 ppt. While shrimp reared at 2, 15 and 30 ppt recorded highest survival, shrimps at 15 and 2 ppt had final higher body weight at the end of the trial. Hyper-osmoregulator and hypo-osmoregulator behavior was observed in lower and higher salinities respectively.

Nursery rearing of Indian white shrimp, *Penaeus indicus*: Optimization of stocking densities under different management regimes

Nursery rearing as a pre grow out activity is widely used by the farmers for enhancing productivity and reducing crop duration. An experiment was carried out with

three levels of stocking density (1650, 3350, 8350 PL/m^3) and three management systems; zero water exchange (ZWE), ZWE with soil base (ZWE+SN), and ZWE with soil base and substrate integration (ZWE+SN+SUB). Low (1650 PL/m^3) and medium-density (3350 PL m^{-3}) groups yielded higher weight and survival. Integration of substrate (ZWE+SN+SUB) in nursery rearing resulted in better growth characteristics and water quality. Stocking density (1650-3000 PL/m^3) with substrate is recommended for *P. indicus* nursery rearing.

Co-culture of Pearl spot with penaeid shrimp: Boon or Bane

Possibilities of the co culture of the shrimps and fishes is a debatable issue in the industry for long time. The common belief in the industry is that the larger Pearl spot consumes smaller shrimps. An extensive study was conducted co-culturing shrimps (PL, 1.5, 5-7g) and Pearl spot (0.3, 3, 50 and 100g) of different sizes. The study revealed that Pearl spot of sizes 3-100g were actively consuming even the bigger sized shrimps and 100% mortality was observed in all the cases. However the 0.2-0.3g Pearl spot were not able to consume the post larvae of shrimp. Farmers must be at caution while co culturing Pearl spot and shrimps.

Nursery rearing of *Penaeus indicus* in a Recirculating Aquaculture System (RAS) blended with Biofloc enriched rotifers as feed supplement

Comparison of growth and production of *P. indicus* at high density (PL10 @ 2000 m^{-3}) was conducted between RAS, Hybrid RAS and RAS with biofloc enriched rotifer using aqua mimicry system. RAS with biofloc enriched rotifer produced better growth and survival (91%). The prophenoloxidase and lysozyme activity was also beneficially enhanced in the rotifer enriched RAS systems than the controls. Nursery rearing of shrimp in RAS with biofloc enriched rotifer can improve the growth, immunity and survival.

Growth potential and immunity of the Indian White shrimp, *Penaeus indicus* at varying densities and salinities

On farm growth performance and immunity status were assessed under two different stocking densities (low and high) at different salinity regime (3-7, 8-15, 15-25, 25-35, and 40- 60 ppt) for a period of 80-120 days. The mean final harvest weight and weight-gain was significantly higher in salinities 15-25ppt. Treatment with lower stocking densities recorded higher mean weight compared to higher densities. The prophenoloxidase activity gradually increased or decreased correspondingly to the salinity level with lowest PPO activity recorded at very low (5ppt) and very high salinities (60ppt).

Production performance and immune response of *P. indicus* reared in a biofloc-based system with different protein levels of feed

Penaeus indicus was cultured in a biofloc based rearing system by providing diets with various protein levels (25%, 30%, and 35%). A combination of different carbon sources (molasses, wheat flour, and rice bran) and a probiotic consortium (*Bacillus* sp. and *Saccharomyces* sp.) was used for developing the biofloc. At the end of the experiment, animals fed with 30 and 35% protein had better growth parameters. The HA activity, PO activity in plasma was found to be higher in high protein fed animals. Immune genes like superoxide dismutase, prophenoloxidase, peroxinectin and antimicrobial peptides were upregulated in high protein groups. Biofloc culture of *Penaeus indicus* shall be supplemented with high protein (35%) for better growth and immune response of shrimps.

Efficacy of the formulated feed on survival and growth of mud crab, *Scylla serrata* juveniles.

Nursery rearing of mud crab juveniles is a crucial part in mud crab seed production. For better growth and survival of crab juveniles, live feeds are commonly used for rearing. Different live feeds and formulated feeds were evaluated in the present study. Growth and weight gain was higher in live feed group. Interestingly the formulated feed produced 95% survival indicating the potential for replacing the wet feeds.

Individual growth pattern of juvenile stages of the mud crab (*Scylla serrata*) reared individually

Cultivation of individual crab in separate compartment has gained popularity in the vertical crab farming and soft shell crab industry. In order to obtain growth and molt pattern of individual crabs, a study was carried out recording the individual molt and growth pattern for 1129 days. Percentage of wet weight gain ranged between 98.05% and 226.48% among different stages. Synchronous molting was observed up to the C6 stage and subsequently molting frequency diminished.

Growth performance of grey mullet

Growth performance and feed utilization of wild collected grey mullet, *Mugil cephalus* fry (2.0-2.5 cm) fed with different levels of protein formulated feed (30%, 35%, 40% and 45%) was evaluated in a nursery hapa (2x 1x 1 m) in a pond system (2000 sq.m) for 90 days. The results of the study revealed that formulated floating feed containing 35% protein is ideal and economical for the nursery rearing of grey mullet, *Mugil Cephalus* fry in hapa in pond. Periphyton based nursery rearing of milkfish in hapas with reduced feed inputs showed that milkfish fingerlings reared with (periphyton + 50% feed reduction) attained fingerling size with mean total length and body weight (9.20±0.14 cm & 8.24±0.19 g) with 95% survival rate in 60 days of rearing.

Farming of milk fish

To promote milkfish, *Chanos chanos* farming in west coast of India, a polyculture demonstration was conducted in farmers' pond at Chellanam, Ernakulam District, Kerala. Initially 3000 milkfish seed (tl.2.5 cm, 32 dph) were stocked in pen based enclosed nursery for 30 DOC and around 2700 number,08-12g size fingerlings were stocked along with monosex tilapia (10000 number) and tiger shrimp (50000) for grow out farming in 0.72 ha area having salinity 05-25 ppt. After culture of 3 months, milkfish and monosex tilapia attained 250 – 400g and 150 – 200g respectively with 85% survival and fed with indigenous feed (32% protein; 6% fat) @ 3% body weight twice a day.

Co culture of milk fish and white shrimp

Growth performance of *P. vannamei* and milkfish was evaluated in a low input based polyculture system in two different 1000 m^2 pond. The milkfish (12.61±0.24 cm, 15.49 ±0.54 g) were stocked after 30 doc in 2 different ratio along with *P. vannamei* i.e T1 (0.50 fry/m^2 milkfish : 25 PL/ m^2 *P. vannamei*) and T2 (0.25 fry/m^2 milkfish : 25 PL/ m^2 *P. vannam*ei). It was found that both stocking densities of milkfish was found to be beneficial for culture of *P. vannamei*. However, from an economical point of view, stocking milkfish 0.50 fry/ m^2 with *P. vannamei* at 25 PL/m^2 considered ideal for low input-based polyculture system. A toral of Rs 1,32,000 was generated from sale of farm produced shrimp and milkfish at NGRC-CIBA.

Nursery culture of Pearl spot

A 90 days study was undertaken to evaluate the effect of feeding different dietary crude protein levels feed provided with and without periphyton substrate on nursery culture of pearlspot in hapa. It was found that provision of periphyton substrates in hapa along with feed for pearlspot seed not only reduced the cost of feed but also promoted faster and higher growth of the seed. Floating feed containing 30% crude protein with provision of periphyton substrate i.e sugarcane bagasses is economical suitable for commercial nursery culture of pearlspot in hapa (2 x 1 x 1 m) for obtaining higher benefits returns to fish farmers. Further, effect of different stocking densities (200, 300, 400, 500, 600, 700 and 800 fry/ hapa) on growth and survival of nursery cultured pearlspot, *Etroplus suratensis* fry (2.0-2.5 cm) was studied in hapa (2 x 1 x 1m) in pond for 90 days and it was found stocking density of 600/hapa was ideal for commercial nursery culture of pearlspot, *Etroplus suratensis* fry in hapa in ponds.

Cage culture of mangrove snapper

Pond based cage grow-out culture of wild collected Mangrove red snapper juveniles was conducted in pond at Ratnagiri, Maharashtra and study revealed that wild collected mangrove red snapper easily accepts the artificial feed and is good candidate species for cage culture in pond as well in creeks as an alternative livelihood for coastal fishfolks. Red snapper (20-40g, 1130 no) stocked in 4 x 4 x 1 m cages attained 600-1200g within period of 6-8 months with survival ranging from 64.75%.

Nursery culture of *Mystus gulio*

To develop an innovative and cost-effective nursery rearing method for brackishwater catfish, *Mystus gulio* (25 dph fry; 0.30±0.04 g) were reared for 60 days in a simplified floc system. Varied stocking density at three levels (50, 75 and 100 no./ m^3) were tested in triplicates in 60 day culture. This study suggested that in brackishwater simplified floc system, *M. gulio* fry can be reared at higher density of 100 no./m^3 to achieve maximum survival and better feed conversion for economic benefit.

Nursery rearing of silver moony

Nursery rearing and sale of silver moony was demonstrated with participation of fishermen youth in Karikattukupam village, Muttukadu. Nursery rearing were conducted in cages and hapas in the pond system and fed with formulated diet. Fishermen youth was able to produce 9 to 10 cm within a 60 days period of nursery rearing and the seeds were sold at Rs. 50/- per seed.

Nutrition of diversified candidate species

While aquaculture is progressing with more diversified species, understanding the species-specific nutrient requirements, optimizing practical feed formulations and dealing with feed inputs are critical for sustainable seafood production. Feed is not only just a biological requirement, but also an economical factor which determines the success of aquaculture. CIBA is actively involved in various aspects of nutrition of the diversified candidate brackishwater species targeting cost-effective feeds and feed management for grow-out farming, functional feeds, speciality feeds targeting maturation, larval rearing and final product quality.

Black Soldier Fly meal as substitute for fishmeal

A seven week long feeding experiment was conducted with juvenile *Penaeus vannamei* by replacing fish meal with BSF larval meal at 0,5,10 and 15% (W/W). Though the better performance was observed with the shrimp fed 5% BSF inclusion, we could infer that BSF meal can be included up to 10% without affecting shrimp growth and survival.

Locust meal as feed ingredient

Northern India had recently witnessed the devasting attack of the desert locust in agriculture farms. As a strategy to convert adverse situation into an opportunistic one, we hypothesized the use of this insect biomass in aquafeed, after proper evaluation. Considering the nutritive richness, locust meal would be an ideal ingredient in fish and shrimp feed. However, considering the higher analysed pesticide content (>13 ppm malathion and >38 ppm of chlorpyrifos) of the dry biomass, we did a feeding trial to explore the chances of using this insect biomass in shrimp feed. The results were disappointing. Complete mortality of shrimp was observed with the feed with 15% insect meal inclusion.

Use of low value plant materials as aquafeed ingredient in practical feeds of pacific white shrimp

Azolla is a floating aquatic macrophyte found to contain high protein content (>20%) and has been reported to be ideal for fish feed formulations. A feeding trial was conducted in shrimp using five isoproteinous (CP-35%) and isolipidic (EE-5%) diet to contain 0,7,14,21 and 28% Azolla meal by replacing 0, 1.35, 2.70, 4.05 and 5.40% of the soya protein. Results showed that 4% of the soy protein can be replaced using 21% Azolla meal without affecting the shrimp performance. Similarly, an another experiment in same shrimp species tested inclusion of potato waste meal inclusion at 0, 8, 16, 24 and 32% level by replacing 0%, 25%, 50%, 75% and 100% of cereal flour. Results shown that potato waste meal can be 8% level with replacement of 25% of cereal flour sources in *P. vannamei* diet.

Fermented sunflower oil cake as ingredient in shrimp feed

Yeast fermented sunflower oil cake were tested as protein ingredient in shrimp. Practical inclusion levels such as, 0, 2.5, 5.0, 7.5 and 10% were tested. The results indicated that yeast fermented SFC can be included up to 7.5% whereas raw SFC could be included up to only 2.5% in *P. vannamei.*

Functional formulations to improve the shrimp hepatopancreatic health

The health of hepatopancreas is one of the keys to successful shrimp farming. Experiments were conducted to explore functional benefits of taurine and bile salts. The results demonstrate that shrimp needs 0.3 to 0.6% of taurine and 0.3% taurocholate in their diets to have healthy hepatopancreas.

Hydrolysed fish trimmings found to be potential for boosting plankton and stable water quality

The technology for conversion of fish trimmings in to two a value-added products, Plankton^{Plus} and Horti^{Plus} under the concept of waste to wealth and circular economy, were highly successful. Several field trials in the last one year in different species shrimp, fish and polyculture models were given positive outcomes. Use of hydrolysed products found to support stable plankton bloom as well as water quality and higher production.

Flow cytometry based apoptotic progression analysis in *Penaeus vannamei* in response to white spot syndrome virus infection

Flow cytometry analysis was carried out to detect the progression of apoptosis in haemocytes of WSSV infected *Penaeus vannamei* at different time-points (1.5 hpi, 18 hpi and 56 hpi). Apoptosis in haemocytes was found to increase with time of infectivity from 5.06% to 69.63%. The evidence of apoptosis in haemocytes of *P. vannamei* was established as shown by significant increase in the percentage of late apoptotic cells due to WSSV infection in

shrimp. The present study gives an insight to the apoptosis rate in a WSSV infected shrimp during the course of infection and the role of apoptosis related genes.

Iso-Seq based full-length transcriptome resource for *Penaeus indicus*:

A full-length transcript sequences resource has been generated for *P. indicus* using the latest Pacific Biosciences Iso-Sequencing approach on Sequel II platform. The full-length trasncriptome would be a valuable resource for conducting functional studies involving desired economic traits and in annotation of *P. indicus* genome.

Long non-coding RNA database for *Penaeus indicus*

A long non-coding RNA (lncRNA) database consisting of 7,434 transcripts has been generated for *P. indicus*. These lncRNA sequences would be a valuable resource to understand gene expression regulation in the nucleus and the cytoplasm.

Contig-level genome assembly for *Mugil cephlus*

A contig-level assembly of the grey mullet genome has been generated using the long-read sequence data generated on Pacific Biosciences Sequel II platform. The assembly is of 648 Mb and contains 1725 contigs with a contig N50 statistic of 10.05 Mb.

Comparative gut microbiome analysis of Etroplus sp.

The gut microbiome of all the species belonging to genus *Etroplus* namely, *Etroplus suratensis* (ES), *Etroplus maculatus* (EM) and *Etroplus canarensis* (EC) were studied. The gut of EM had the highest (106) and EC had the lowest (42) number of unique Operational Taxonomic Units (OTUs), whereas ES had 80 unique OTUs, i.e. not extant in any of the other two fish species. The guts of ES and EM were dominated by *Enterobacteriaceae* followed by *Xanthomonadaceae*, whereas that of EC was dominated by *Bacteriodaceae* followed by *Enterobacteriaceae*.

Interspecific diversity study on *Etroplus* species

ATPaSe 6/8 a mitochondrial gene was utilised to study the genetic relatedness between the species of genus *Etroplus*. Median joining Haplotype network and genetic differentiation studies indicated that each species formed separate distinct clades and the clades were distinctly separated by several mutational events. The network tree also explained that both the *E.canarensis* and *E.maculatus* might have had *E.suratensis* as their common ancestor.

Karyotyping of *Lates calcarifer, Lutjanus argentimaculatus, Monodactylus argenteus and Scatophagus argus*

The chromosome pattern of *Lates calcarifer, Lutjanus argentimaculatus*, *Monodactylus argenteus and Scatophagus argus* were studied by karyotyping. All the fishes had 48 diploid chromosomes (2n=48).

Amplification and cloning of Immunoglobulin Mu (IgM) heavy chain gene of Asian seabass

The partial coding sequence of Asian seabass IgM gene was PCR amplified, cloned using pGEMT-easy vector and was sequenced. The obtained sequence was 828bp in length and was blasted with NCBI database. The sequence had highest identity with *Siniperca chuatsi* (75.03%) and *Latris lineata* (73.46%) fishes. The obtained sequence was utilized to design primers for gene expression studies (qRT-PCR and In-Situ Hybridization).

Efficacy of probiotic species on *Vibrio harveyii* revealed by Genome scale metabolic modeling

In an attempt to find candidate probiotic bacteria having potential to suppress the growth of *Vibrio harveyi* in aquaculture ponds, *in silico* simulation study was conducted using constraint-based Genome scale metabolic modeling approach. This method was applied to predict the pairwise interactions of 193 strains from three genera namely *Lactobacilli, Bacilli and, Lactococci* with the pathogenic strain *Vibrio harveyi* QT520. Forty-eight out of 193 species exhibited growth benefit accompanied with decrease in growth of *V. harveyi* QT520 in at least one of the nutrient environments out of 15 nutrient environments. Six species namely *Bacillus* sp 1s 1 strain 1s 1, *Bacillus weihaiensis* strain Alg07, *Lactobacillus sakei* strain WiKim0063, *Lactobacillus sp Koumiss*, *Lactobacillus lindneri* strain TMW 1.1993, and *Lactobacillus buchneri* NRRL B 30929 were found to have growth benefit along with suppression of the pathogen. The identified species may have potential uses in brackishwater aquaculture in suppressing the growth of *Vibrio harveyi*.

EHP continues to be a major threat to shrimp farming, IMNV an emerging shrimp pathogen

During the past five years disease surveillance was carried out almost all the shrimp farming states. In the year 2020-2021, 98 shrimp farms have been investigated and Enterocytozoon hepatopenaei (EHP) had the highest prevalence (41%) followed by Infectious myonecrosis viral disease (IMNV) prevalence of 30%. The prevalence of White spot syndrome viral disease (WSSV) was found to be 18% and Infectious hypodermal hematopoietic necrosis disease at 1%. The disease investigation revealed that IMNV is an emerging pathogen and a great concern for the shrimp farmers.

Phage therapy for control of luminescent vibriosis

For developing phage therapy, infectivity spectrum of about 100 phages was carried out against over 100 luminescent Vibrio isolates. The mass production technology of phages was standardized. A bacteriophage based product for prophylaxis and therapy of luminescent vibrios in shrimp hatcheries was commercialized to Salem Microbes Pvt Ltd, India for production and marketing.

Recombinant protein based vaccine developed for viral nervous necrosis

A recombinant capsid protein and inactivated viral vaccine was developed against viral nervous necrosis (VNN). The recombinant capsid protein vaccine gave better immune response compared to inactivated viral vaccine. The recombinant protein was purified and emulsified with commercial adjuvants and administered to Asian seabass fingerlings at three different doses viz., 1, 2.5 and 5 µg g^{-1} body weight of fish. The 2.5 µg g^{-1} body weight dose gave better immune response compared to the other two doses. The immune response was above the protective levels in all the three doses up to 10 weeks post-immunization.

Development of Virus Like Particle (VLP) from IHHNV capsid protein

Attempt was made to develop Virus like particles (VLPs) from the capsid protein of IHHNV with an aim to use it for the control of white spot syndrome virus (WSSV). The IHHNV capsid gene was amplified and cloned to pET16b vector. Recombinant clones were confirmed by gene specific colony PCR. Expression of desired 40 kDa protein was observed in IPTG induced positive clones and this will be further characterized.

Ethylenediamine tetraacetic acid (EDTA) for control of luminescent vibriosis in shrimp hatcheries

Luminescent vibriosis is a major challenge in shrimp hatcheries. As iron in an essential element for all the life forms, a growth kinetics experiment of lumiesncent bacterium *V. campbellii* and *V. harveyi* was carried out in presence of different iron sequestering molecules such as Ethylenediamine tetraacetic acid (EDTA), nitriloacetic acid and bipyridyl. Based upon the encouraging lab results, EDTA was applied to control luminescent vibriosis in shrimp hatcheries and found effective as prophylactic and therapeutics.

Determination of impact of antimicrobial agents on non-targeted organisms in brackishwater system

Antimicrobial substances are important for treatment of bacterial infections in food animal production including aquaculture. Environmental safety of the medicines and chemicals used in aquaculture was determined by studying their effect on indicator organisms *Chlorella* spp suggests that the florfenicol (IC50 666.29 ppm) was most safe followed by oxytetracycline (IC50 487.75 ppm) and Sulphadimethoxine (IC50 461.44 ppm).

Evaluation of benzalkonium chloride (BKC) as a disinfectant against shrimp white spot syndrome virus (WSSV)

Benzalkonium chloride (BKC) is a detergent, well known for its disinfection property. In the present study, efforts were made to evaluate efficacy of BKC as a disinfectant for WSSV neutralization. In vitro study confirmed the complete inactivation of WSSV (107 copies/µl) when exposed to 4 ppm of BKC for 1 h. In simulated pond conditions the virus in water was found to get inactivated with 4 ppm of BKC in the absence of subsurface soil while 18 ppm of the BKC was effective in the presence of soil.

Field evaluation of emamectin benzoate (EMB) to control parasitic infection in economically important fish species

Field efficacy of an anti-parasitic drug, emamectin benzoate (EMB) at the therapeutic treatment regimen of 50 µg of EMB kg^{-1} fish body weight (BW) day^{-1} was conducted in different culture systems (pond, tank, cage, lake and aquarium), fish species (Asian Seabass, Grey Mullet, Pearlspot, Indian Major Carps, Gold Fish and Koi Carp) and against various parasites (Caligus spp.,

Argulus spp., Lernanthropsis spp. and Lernaea spp.). Results showed that there was 100% efficacy against Argulus spp., *Caligus* spp. and *Lernanthropsis* spp. on 7th day, and against *Lernaea* spp. on 10th day of treatment. No re-infestation of parasites was reported for a period of 60 days post medication.

Efficacy of disinfectants against Sea lice, *Caligus minimus* in Pearlspot, *Etroplus suratensis*

Efficacy of different disinfectants against Caligus minimus was tested in Pearlspot, *Etroplus suratensis.* The results indicated that disinfectants such as formalin (HCHO), potassium permanganate (KMnO4), copper sulphate (CuSO4) and benzalkonium chloride (BKC) can be used to control the sea lice in water at a single dose rate of 200 ppm, 10 ppm, 0.1 ppm and 5 ppm, respectively.

Analysis of drug usage pattern in shrimp farms of India

It is essential to understand the usage pattern of healthcare products in Indian aquaculture to monitor and regulate their scientific application. The survey conducted in the major aquaculture states of the country revealed that, environmental modifiers constitute 44% of the total products followed by probiotics (20%), disinfectants (7%) and nutritional supplements (6%).

LAMP test developed for on farm detection of EHP

A rapid, on-farm visual loop mediated isothermal amplification (LAMP) test was developed for detection of Enterocytozoon hepatopenaei (EHP). The visual detection was standardized using the dyes such as hydroxy naphthol blue and phenol red.

Brain cell lines MFB-1 developed for milk fish

The Brain cell line MFB-1 was developed from the brain tissue of milk fish *(Chanos chanos).* A stable growth for more than 65 passages was observed for over a period of three years.

Comparative analysis of gut microbiota in wild caught and cultured Indian white shrimp (*Penaeus indicus*)

To understand the gut microbiota of *P. indicus,* V3-V4 hypervariable regions of 16S rRNA gene was examined in wild-caught and cultured *P. indicus* broodstock. Both groups showed similar core microbiota at the phylum level, which consisted mainly of *Proteobacteria, Fusobacteria, Tenericutes* and *Firmicutes,* although significant differences were found in their relative abundances. The dominant genera in case of wild was *Photobacterium* (29.5%) followed by *Propionigenium* (13.9%), *Hypnocyclicus* (13.7%) and *Vibrio* (11.1%); in case of aquacultured it was dominated by Vibrio (46.5%) followed by *Catenococcus* (14%), *Propionigenium* (10.3%) and *Photobacterium* (8.7%).

Comparative analysis of nitrifying microbial enrichments from high and low saline environments

The study reports diversity in nitrifying microbial enrichments from low (0.5-5‰) and high (18-35‰) saline brackishwater environments. The AOB and NOB enrichments from both the environments showed diverse lineage of phylum distributed in both groups with 38 and 34 phyla from low saline and 53 and 40 phyla in high saline sources respectively. *Proteobacteria, Chloroflexi, Bacteroidetes, Verurucomicrobia,* Unclassifed bacterial group, *Nitrospira, Actinobacteria, Planctomycetes, Acidobacteria, Armatimonadaeceae* were found to be most dominant phylum distributed among the AOB and NOB enrichments from both environments.

Effect of probiotics on gut microbiota of Indian white shrimp *(Penaeus indicus)*

Application of probiotic product containing, *Bacillus subtilis, B. lichiniformis* and *B. pumilus* (5×1010 cfu/gram) showed altered microbial communities in the gut. Analysis using 16S rRNA-based Illumina sequencing showed the abundance of Proteobacteria in probiotic treated group (94.85%) and at the genus level by Vibrio (44.17%) followed by Rhodobacteraceae_unclassified (25.22%), Catenococcus (12.89%).

Enrichment of sulphur oxidizing bacteria for mitigation of toxic sulphur metabolite in aquaculture ponds

Sulphur oxidizing bacteria (SOB) play critical role in oxidation of highly toxic hydrogen sulphide formed in the pond bottom to less/ no harmful sulphate or sulphur. Enrichment of SOB (n=6) was developed from brackishwater environment. The DGGE analysis revealed existence of 25 different strains in the 6 enrichment. All the enrichments were capable of reducing the pH from 7 to 1 and found to be stable for 3-5 months. Metagenomic analysis of 16s rDNA revealed domination of family

Pseudomonadaceae, Prevotellaceae and Bacillaceae.

Development of consortia of denitrifying bacteria for efficient mitigation of ammonia toxicity in shrimp farm

Denitrifying bacteria (DNB) are heterotrophic bacteria that are efficient in conversion of nitrate to free nitrogen or assimilate into structural molecules. A total of 31 DNB strains were isolated. Zobella sp and Marinobacter sp were noticed for efficient in nitrite/nitrate conversion and a DNB was observed to bear nirK gene that is responsible for the denitrification process.

Microbial profiling of milkfish larvae

Microbial profiling was carried out in milk fish culture. The culture-dependent method revealed dominance of Vibrio spp such as *V.alginolyticus, V .littoralis, V. proteolyticus, V. ruber, V. natriegenes, V. neocaledonicus, V. parahemolyticus.* The culture-independent DGGE PCR revealed the dominance of anaerobic bacteria such as Fusibacter, Achromobacter, Candida corsella, Catenococcus.

Metalloprotease production by pathogenic *Vibrio campbellii*

Protease production was analysed in pathogenic *Vibrio campbellii.* The correlation matrix suggested that protease was positively correlated with pathogenicity ($p>0.05$) and negatively correlated ($p<0.05$) with autoinducer-2 and autoinducer-1 signal. The protease activity was completely inhibited by 1,10-phenanthroline indicating that the enzyme is metalloprotease.

ToxR play pivotal role in virulence regulation of Vibrio campbellii

ToxR is a major virulence regulator of *V. cholerae.* To understand its role in aquatic pathogens, toxR gene of 30 *V. campbellii* isolates were partially sequenced. The multiple sequence alignment of deduced amino acid sequence suggested a variable zone in the region of 120 to 170 AA with two critical amino acid substitutions at 123rd (proline to alanine) and 150th positions (glutamine to proline). The isolates with proline at 150th position (P150) had completely abolished protease activity with significant reduction in virulence.

EHP infection in polychetes

Live samples of polychaetes used as feed in hatcheries were found to have low level infection of *Enterocytozoon hepatopenaei* (EHP), the causative agent of shrimp microsporidiosis. The study concludes the passive role of live-feed polychete worms in the transmission of EHP to broodstock shrimps in hatcheries. However, it is unlikely to be a replicating host for the microsporidian parasite.

White fecal threads was experimentally reproduced after EHP infection

To study the association of EHP with WFS, the PCR tested shrimp was fed with EHP infected hepatopancreas tissues for two days. After 15 days post experimental infection, the white faecal threads were reproduced which harboured EHP spores.

An assessment of the biosecurity risk of polychaetes as feed for shrimp broodstock

To check the propagation of EHP in polychaete by quantitative PCR, an experiment was conducted by challenge infection by feeding EHP-infected shrimp tissues. The infection of EHP did not led to higher level over time as determined by quantitative PCR and histopathology. This indicated poor establishment of infection and inability to replicate in polychaete tissues.

Ancyrocephalid infestation in Pearlspot, Etroplus suratensis

Monogenean trematodes (fluke) Ancyrocephalid infestation was observed in the gills of the cultured Pearlspot, *Etroplus suratensis.* Ancyrocephalid parasite was noticed with the distinguishing characteristics of having eye spots, and the number of pairs of anchors (hamuli), transverse bars, and marginal hooks on their haptors.

Amyloodinium infestation in streaked spinefoot Rabbit fish *(Siganus javus)*

Amyloodinium infestation was observed in the gills and skin of spinefoot Rabbit fish *(Siganus javus).* Shifting of fishes to lower salinities (up to about 5 ppt) for 14 days is a viable option of eliminating *Amyloodinum ocellatum* infection. Use of formalin at the rate of 15-25 ppm as an indefinite bath could be used as a prophylactic measure to avoid external parasitic infection.

Livelihood security

Ensuring livelihood security for small holding aquaculture in coastal rural villages with aquaculture and allied technology interventions were demonstrated in villages in Kanchipuram, Tiruvallur, Nagapattinam districts with SC/

SP, TSP and CSR funding support. Fishers earned Rs 3000 to 12000 per head per month as additional income from the first line demonstrations undertaken.

Economics and Trade

Economic losses due to EHP and WSSV were studied in detail. Although WSSV was considered as most lethal infection in shrimp farming, the analysis revealed national losses per annum due to EHP were to the tune of 0.77 Million tonnes (Rs. 3977 crores) while losses reported due to WWSV were only 0.33 million tonnes (Rs.1670 crores). This may be due to farmers' adoption of better bio security protocols and difficulty in prophylaxes and treatment of EHP.

Impact of Covid-19 on aquaculture

Covid-10 related lockdown affected complete value chain of aquaculture. The total national losses in brackishwater aquaculture sector due to lockdown summed up about Rs.11,265/- crores. While farmers were the most affected, with a loss of about 60% of estimated total, hatchery and feed mill enterprises also were affected.

Economics of diversification

The technical and economic efficiency of Asian seabass nursery rearing were evaluated. The study found Asian seabass nursery rearing in brackishwater and low saline areas returned a level of income to farmers with a benefit cost ratio of 1.96 to 2.76 percent and 130 and 300% IRR respectively.

Individual and combined effect of salinity and ammonia stressors on *Penaeus vannamei*

Shrimps were exposed to individual salinity (ppt): S1-3; S2-20; S3-35; individual TAN (mg/L): TAN1, TAN3, and TAN6; combined treatments - TAN1S1, TAN1S2, TAN1S3; TAN3S1, TAN3S2, TAN3S3; TAN6S1, TAN6S2, TAN6S3 and control (salinity: 10 ppt; TAN: 0.0112 mg/L). In individual treatments the risk of dying increased with increasing TAN concentration and decreasing salinity. Among the combination treatments risk factor increased with decreasing salinity. The highest risk of dying was observed in TAN6S1 (29.6) and TAN6S2 (24.7) compared to control. Overall, the immunological activity in terms of THC, PO and SOD decreased with increasing TAN and decreasing salinity.

Effect of adaptogen feed on shrimp growth

Adaptogens were extracted and characterized to adapt to biological and physiological stress. The adaptogen groups coated on suitable feed with four different concentrations were tested for their aqua stability. The feed coated with 500 mg/kg showed comparatively better performance in growth parameters.

Effect of Carbon : Nitrogen ratio on shrimp pond water quality

Study on the effect of C:N ratio (20:1, 15:1 and 10:1) on water quality of *P.vannamei* culture with a stocking density of 80 m^2 for six weeks showed that TAN in the water decreased with increasing C:N ratio and the highest shrimp weight was recorded in 15:1 ratio and followed by 20:1 and 10:1.

Re-examining the lime requirement estimation procedures for aquaculture pond soils

Three methods: soil-water pH (1:2.5), soil-buffer pH (Shoemaker-McLean-Pratt buffer) and exchangeable acidity by titration were tested for calculating the lime requirement of four lime materials viz., agricultural lime, dolomite, shell lime and sea shell to raise the soil pH from 5.5 to 7. Exchangeable acidity method exactly estimates the lime requirement of soil, whereas soil-water pH and SMP buffer methods slightly lower and over estimates the lime requirement, respectively.

Characterization of shrimp culture source waters and pond soils of Gudur Mandal, Andhra Pradesh

Source waters and soil quality of shrimp culture ponds were investigated in Chillakur Mandal of Gudur, Andhra Pradesh. About 40% soils were of clay loam texture and most of the soils were in alkaline range. About 93% soils had less than 0.25% organic carbon. All soils had less than the optimum available N and about 58% soils had optimum available phosphorus. The salinity of creek waters was less than 5 ppt whereas bore well water had wider salinity range. Comparatively, the concentrations of minerals were much higher in bore well water than creek water.

Fertility status of Inland saline soils

Inland saline soils of Rajasthan, Haryana and Punjab are deficient in nitrogen and rich in available phosphorus and available potassium. The soils could be potential suppliers of potassium for aquaculture to mitigate the ionic profile imbalances of the inland saline ground waters.

Characterization of pond sediments of varying age

The pond sediments of different age: less than 10 yrs, 10 -20 yrs and more than 20 yrs were studied and it was observed that the labile carbon decreased with ageing, whereas the water soluble carbon higher in aged ponds. Among the different carbon fractions, total inorganic carbon fraction was higher in the younger ponds and the total carbon content was higher in the latter ponds. The non-labile form of carbon constituted the major portion of the total carbon in the older ponds, which thereby enhanced carbon storage and sequestration.

Damage to shrimp aquaculture due to Cyclone Nivar

Assessment of damage to shrimp aquaculture due to severe cyclonic storm 'Nivar' during November 2020 in Nellore District, Andhra Pradesh indicated that about 5000 acres of shrimp culture ponds were affected with an estimated loss of 34 crores. The flood induced by post-cyclone heavy rainfall inundated shrimp culture ponds in low lying areas led to escape of shrimp and, soft sediment deposition up to 5 cm on the pond bottom. A drastic reduction in salinity, minerals composition, and ionic ratios in water, an increase in pond water turbidity and nutrients which created stress to the shrimp in the culture ponds was observed post flood upon analysis.

Effect of intensive spells of rainfall on water quality parameters and shrimp growth parameters

The effect of intensive rainfall spells during 2020 was monitored on the changes in water quality before and during rains and production performance in shrimp cultured ponds, Navsari District, Gujarat. Intense rainfall of 75 to 100 mm resulted in a salinity drop of 2.5 ppt within a single day in a 1 Acre pond. The salinity drop in pond water due to rainfall is depending on the pond water salinity. High saline water would be subjected to a greater change compared to a medium at lower salinities.

Water quality index of Muttukkadu Estuary and Adyar Creek

The higher water pollution index (WPI) during monsoon season (1.98 to 3.14) in Muttukadu estuary was due to higher concentration of nutrients such as nitrate and phospahte as a result of runoff. Similarly, WPI values significantly varied among the seasons in Adyar creek and ranged from 0.56 to 1.1 and 1.9 to 2.2 in the source water and pen culture site, respectively.

Diurnal temperature controlled shrimp housing system

Diurnal temperature controlled shrimp housing system was fabricated for studying the influence of variations in rearing water temperature on disease occurrence in shrimp by maintaining the desired temperature range of 20-45°C. The unit has recirculatory system to maintain water quality in the optimum range.

Introduction

Central Institute of Brackishwater Aquaculture (CIBA) is one of the one hundred and one research institutes under the Indian Council of Agricultural Research (ICAR). Appreciating the significance of this sector in food production and considering the potential of brackishwater resources, the Indian Council of Agricultural Research (ICAR, New Delhi) established the Central Institute of Brackishwater Aquaculture as a national institute at Chennai by restructuring the fishery institutes like CMFRI and CIFRI.

The institute was established on April 1, 1987, and serves as the nodal agency for research and development of brackishwater aquaculture in the country. CIBA is an organization of international repute with a vision of environmentally sustainable, economically viable and socially acceptable brackishwater aquaculture. This institute is involved in R&D related to the production of seeds in finfishes and shellfishes, genetic improvement, cost-effective feeds, environment monitoring, farm and hatchery management, disease diagnosis, disease monitoring, and capacity enhancement and technology transfer. The headquarters of the Institute is located at Chennai with an Experimental Field Station at Muttukadu, about 35 km south of the city and two Regional Research Centres, one (KRC) at Kakdwip (West Bengal), famous for the delta region called The Kakdwip Research Centre of CIBA is situated about 100 km from Kolkata, in West Bengal is considered an important landmark of Kakdwip, engaged in the development of culture technologies for crustaceans and finfish. Established as early as 1973 as the first-ever experimental brackishwater farm in the country with about 30 acres of land area under ICAR-CIFRI, the later merged with ICAR-CIBA on 1st April 1987. Presently the Research Centre has fully developed farm facility, modern analytical laboratory, wet lab facilities, feed production etc. Now, this center is fully engaged in research and technology development for the benefits of brackishwater aquaculture farmers with particular reference to Eastern India.

ICAR –CIBA established its first aquaculture research center on the west coast of India at Navsari Agricultural University campus, Navsari Gujarat. The Navsari Gujarat research center of CIBA was established on 7th June 2018 in the Navsari district of Gujarat. Having a 7.5 ha farm area for development and demonstration of brackishwater aquaculture, the main objective of the center is to carry out R&D activities related to brackishwater farming along the west coast of India.

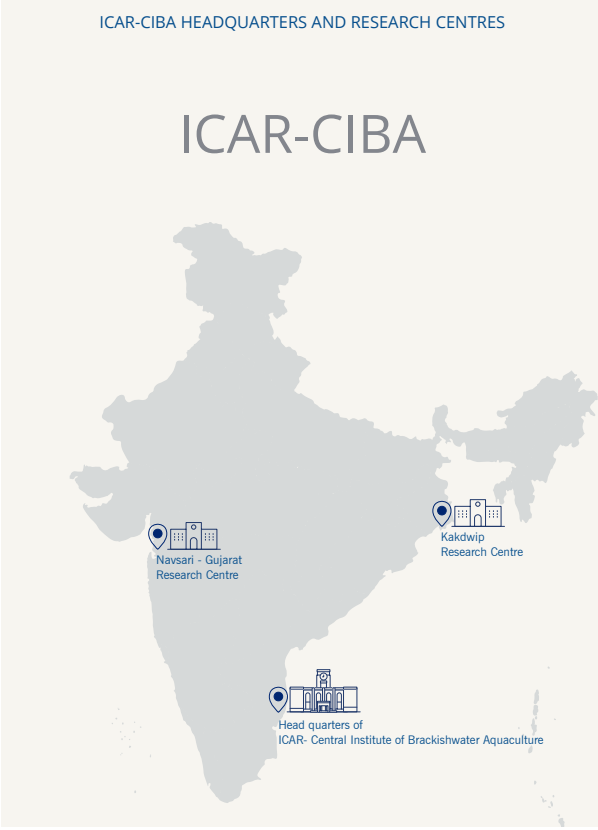
Overall, CIBA has world-class facilities to carry out cutting edge research in the frontier areas of genetics and breeding, nutrition and feed technology, biotechnology, molecular biology, aquatic animal health, therapeutics and prophylactics, environmental and social sciences. Commendable progress has been made in multi-disciplinary areas of shellfish and finfish rearing (hatchery and farming) systems, broodstock development, induced maturation and spawning, live and formulated feed development, disease diagnostics and health management.

Overview of the brackishwater aquaculture sector

Owing to the ever-increasing demand for seafood year after year, aquaculture would be the only choice to meet the demand. Aquaculture currently produces 50 percent of food fish for the world, and it supplies more than 60 percent of food fish to the Asian population. India continues to be the second-largest producer of farmed fish and offers a vast potential for aquaculture development and doubling the farmer's income. Although aquaculture is possible in all types of water resources (freshwater, brackishwater and seawater), the pressure on freshwater resources due to multi-user demands and climate change-related impacts constraint its expansion in the freshwater sector, hence the future aquaculture development is expected to occur mostly in brackishwater.

Of the 3.9 million ha of the brackishwater area estimated, 1.2 million hectares have been identified

to be potentially suitable for brackish water farming. Additionally, about 9 million hectares of salt-affected inland soils in the hot semi-arid and arid eco-region of northern plains and central highlands in Haryana, Rajasthan, Punjab, Uttar Pradesh, Maharashtra, and Gujarat are found to be suitable for brackishwater farming. Estimates show that only 11% of the potential coastal area available is utilized for farming.



It is inspiring to witness the spectacular growth of this industry in India, spearheaded by shrimp farming, a relatively nascent industry, with an export of about 7 billion US$ plus in 2017-18. The aquaculture sector is also confronting severe challenges, such as the impact of climate change and variability, disease outbreaks, environmental degradation, increasing input costs, anthropogenic activities, and related social and economic changes, increasing intra-regional trade and public health concern over food safety. Therefore, addressing these issues through research and development, and policy formulation is of utmost necessity.

At CIBA, we support leading-edge science and research to develop customized technologies suitable for different agro-climatic conditions to grow sustainable aquaculture in India and reap its social, economic, and environmental benefits. The institute has been advocating diversification of brackishwater aquaculture with alternative shellfish and finfish species and optimally utilizing 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 resources, ecosystems, and vibrant coastal communities.

This annual report is a comprehensive combined report on ICAR-CIBA's research progress and administrative activities throughout the year 2019. Expectantly this report will provide adequate information about events, performance, and contribution to the brackishwater farming sector.

VISION

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

MISSION

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

Mandates

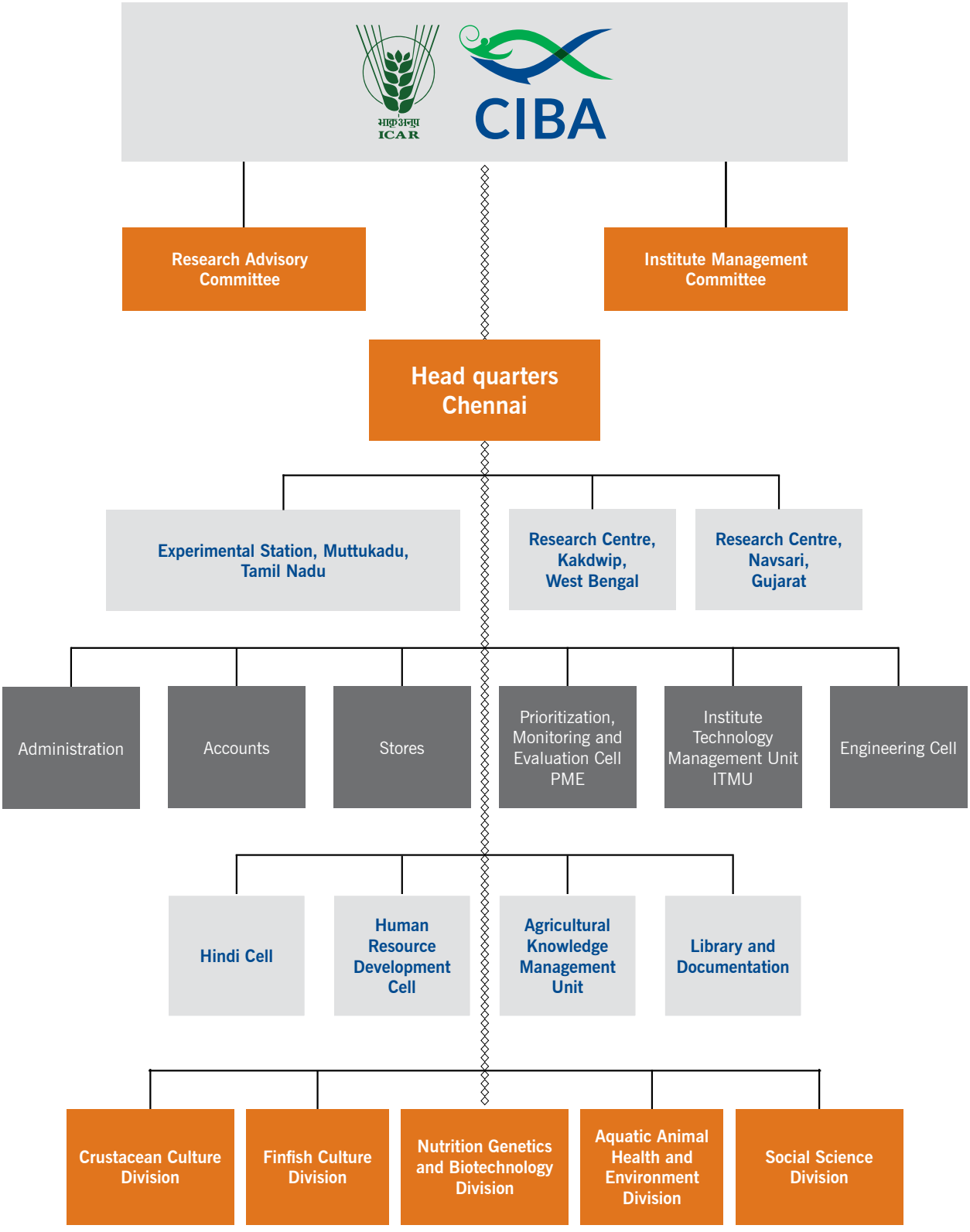
Basic, strategic and applied research for techno-economically viable and sustainable culture systems for finfish and shellfish in brackishwater.

Species and systems diversification in Brackishwater aquaculture.

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

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

Organogram


CIBA
Research Advisory Committee
Institute Management Committee
Head quarters Chennai
Experimental Station, Muttukadu, Tamil Nadu
Research Centre, Kakdwip, West Bengal
Research Centre, Navsari, Gujarat
Administration
Accounts
Stores
Prioritization, Monitoring and Evaluation Cell PME
Institute Technology Management Unit ITMU
Engineering Cell
Hindi Cell
Human Resource Development Cell
Agricultural Knowledge Management Unit
Library and Documentation
Crustacean Culture Division
Finfish Culture Division
Nutrition Genetics and Biotechnology Division
Aquatic Animal Health and Environment Division
Social Science Division

Unified budget of CIBA, Chennai for the year 2020

(Rs. In lakhs)

S. No.	Name of the Head of Account	Unified Budget		
		RE 2020-21	Expenditure from 01.04.2020 to 31.03.2021	Closing Balance
1	2	3	4	6
Grants for creation of Capital Assets (CAPITAL)				
1	Works			
	(A) Land			
	(B) Building			
	i. Office building	120.91	120.91	0.00
	ii. Residential building			
	iii. Minor Works			
2	Equipments	10.30	10.30	0.00
3	Information Technology	7.17	7.17	0.00
4	Library Books and Journals	5.24	5.24	0.00
5	Vehicles & Vessels	0.00	0.00	
6	Livestock			
7	Furniture & Fixtures	14.38	14.38	0.00
8	Others (TSP)	12.00	12.00	0.00
9	Others (SCSP)	32.00	32.00	0.00
	Total Capital (Grants for creation of Capital Assets)	202.00	202.00	0.00
Grants in Aid - Salaries (REVENUE)				
1	Establishment Expenses			
	(A) Salaries			
	i. Establishment charges	2280.00	2280.00	0.00
	ii. Wages			
	iii. Overtime Allowance			
	(B) Loans & Advances			
	Total -Establishment Expenses (Grants in Aid-Salaries)	2280.00	2280.00	0.00
Grants in Aid - General (REVENUE)				
1	Pension & Other Retirement Benefits	1981.32	1981.32	0.00
2	Travelling Allowance			
	(A) Domestic TA/Transfer TA	2.86	2.86	0.00
	(B) Foreign TA			
	Total - Travelling Allowances	2.86	2.86	0.00
3	Research & Operational Expenses			
	(A) Research Expenses	157.65	157.65	0.00
	(B) Operational Expenses	33.32	33.32	0.00
	Total - Res. & Operational Exp.	190.97	190.97	0.00

S. No.	Name of the Head of Account	Unified Budget		
		RE 2020-21	Expenditure from 01.04.2020 to 31.03.2021	Closing Balance
4	Administrative Expenses			
	(A) Infrastructure	241.90	241.90	0.00
	(B) Communication	3.56	3.56	0.00
	(C) Repairs & Maintenance			
	i. Equipments, Vehicles & others	44.06	44.06	0.00
	ii. Office building	187.41	187.41	0.00
	iii. Residential building			
	iv. Minor Works	70.04	70.04	0.00
	(D) Others (excluding TA)	304.42	304.42	0.00
	Total - Administrative Expenses	851.39	851.39	0.00
5	Miscellaneous Expenses			
	A. HRD	0.78	0.78	0.00
	B. Other Item (Fellowships, Scholarships etc.)			
	C. Publicity & exhibitions			
	D. Guest House - Maintenance	6.00	6.00	0.00
	E. Other Miscellaneous (TSP)	40.00	40.00	0.00
	F. Others (SCSP)	98.00	98.00	0.00
	Total - Miscellaneous Expenses	144.78	144.78	0.00
	Total Revenue (Grants in Aid-salaries + Grants in Aid - General)	5451.32	5451.32	0.00
	Grand Total (CAPITAL + REVENUE)	5653.32	5653.32	0.00

Staff position

Position	Sanctioned	Filled	Vacant
Director (R.M.P)	1	0	1
Head of Divisions/Principal Scientist	7	0	7
Senior scientists	14	6	8
Scientists	52	56	(+)4
Technical Officers / Technical Assistants	24	19	5
Administrative Officer	1	1	0
Finance & Accounts Officer	1	1	0
Deputy Director (OL)	1	0	1
Assistant & Administrative Officer	3	2	1
Junior Accounts Officer	1	1	0
Private Secretary	1	1	0
Personal Assistants	2	2	0
Stenographers Gr.III	1	1	0
Assistants	7	2	5
Upper Division Clerks (UDC)	3	3	0
Lower Division Clerks (LDC)	5	2	3
Skilled Support Staff	28	17	11
Grand total	152	114	38

On Going Research Project

CRUSTACEAN CULTURE DIVISION

INSTITUTE FUNDED PROJECTS

Sl. No.	Project Title	Funding	Project Team
1.	Breeding biology, reproductive challenges and larviculture of candidate crustacean species of brackishwater aquaculture	ICAR	PI: Dr. C.P. Balasubramanian Co-PIs: Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. S. Kannappan, Dr. P. Nila Rekha, Dr. K.P. Kumaraguru Vasagam Dr. P. Shyne Anand, Ms. L. Christina, Dr. T.N. Vinay, Dr. N.S. Sudheer, Shri Jose Antony, Shri R. Aravind, Shri I.F. Biju
2.	Novel approaches for technology refinement and upscaling of diversified systems and species of shrimp for sustainable development	ICAR	PI: Dr. A. Panigrahi Co-PIs: Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. P. Nila Rekha, Dr. S. Kannappan, Dr. K.P. Kumaraguru Vasagam Dr. P. Shyne Anand, Ms. L. Christina, Shri R. Aravind, Shri Jose Antony, Dr. N.S. Sudheer, Shri I.F. Biju, Dr. T.N. Vinay, Dr. K. Ambasankar, Dr. R. Geetha, Dr. T.K. Ghoshal, Dr. M. Kumaran, Dr. P. Ezhil Praveena, Dr. Sanjoy Das, Dr. Suvana Sukumaran, Shri Pankaj Amrut Patil Dr. S. Sivagnanam, Shri S. Rajamanickam,
3.	Technological backstopping and promotion of sustainable aquaculture in west coast with particular reference to the state Gujarat	ICAR	PI: Shri Jose Antony Co-PIs: Shri Pankaj Amrut Patil Dr. M. Kailasam, Dr. C.P. Balasubramanian, Shri Tanveer Hussain, Dr. P. Mahalakshmi, Dr. R. Saraswathy, Dr. K. Ambasankar
Externally Funded Projects			
4.	Mapping of coastal resources and identifying suitable areas for expanding Integrated Multi-Trophic Aquaculture (IMTA) in Maharashtra	IMTA Maharashtra	PI: Dr. M. Jayanthi Co-PIs: Dr. C.P. Balasubramanian Dr. M. Muralidhar, Dr. K.P. Kumaraguru Vasagam, Dr. P. Kumararaja, Shri Pankaj Amrut Patil

Sl. No.	Project Title	Funding	Project Team
5.	Coastal watershed based surface and subsurface salinity mapping and modelling of Thiruvallur and Kanchipuram districts, Tamil Nadu for sustainable aquaculture	NABARD	PI: Dr. P. Nila Rekha Co-PIs: Dr. C.P. Balasubramanian
6.	Identifying suitable brackishwater lands for increasing aquaculture area in the coastal states of India with reference to environmental conditions and regulation using multi criteria decision support system	ICAR	PI: Dr. M. Jayanthi Co-PIs: Dr. M. Muralidhar, Shri J. Ashok Kumar, Dr. R. Saraswathy
7.	Resource mapping of brackishwater aquaculture in Tamil Nadu	Dept. of Fisheries, Tamil Nadu	PI: Dr. M. Jayanthi Co-PIs: Dr. M. Muralidhar, Shri J. Ashok Kumar, Dr. M. Kailasam, Dr. K. Sandeep
Finfish Culture Division **Institute Funded Projects**			
8.	Application of improved techniques for captive maturation, assessment of reproductive biology, system development of induced breeding, larval rearing and seed production of brackishwater candidate finfish species	ICAR	PI: Dr. M. Kailasam Co-PIs: Dr. M. Makesh, Dr. K.P. Kumaraguru Vasagam, Dr. T. Senthil Murugan, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Pankaj Amrut Patil, Shri Tanveer Hussain, Shri Dani Thomas, Shri T. Sivaramakrishnan, Dr. P. Kumararaja, Dr. Neethu, K.C., Shri R. Subburaj
9.	Development and evaluation of novel culture technologies for candidate brackishwater finfishes for sustainable aquaculture.	ICAR	PI: Dr. M. Makesh Co-PIs: Dr. M. Kailasam, Dr. T. Senthil Murugan, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Tanveer Hussain, Shri Dani Thomas, Shri Pankaj Amrut Patil, Dr. P. Kumararaja, Dr. Neethu, K.C., Shri R. Subburaj

Sl. No.	Project Title	Funding	Project Team
Externally Funded Projects			
10.	Development of brackishwater aquaculture through optimisation of captive breeding protocols of potential and emerging ornamental fish species, technology transfer and livelihood generation	ICAR	PI: Dr. M. Kailasam Co-PIs: Dr.M.Makesh Dr. K.P. Kumaraguru Vasagam Dr. T. Senthil Murugan, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Dani Thomas, Shri Tanveer Hussain
Aquatic Animal Health and Environmental Division **Institute Funded Projects**			
11.	Prevention and management strategies for viral, microbial and parasitic diseases of candidate species in brackishwater ecosystem	ICAR	PI: Dr. S. V. Alavandi Co-PIs: Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. P.K. Patil, Dr. S. K. Otta, Dr. Sanjoy Das, Dr. P. Ezhil Praveena, Dr. R. Ananda Raja, Dr. Sujeet Kumar, Dr. T. Bhuvaneswari, Dr. Vidya Rajendran, Shri T. Sathish Kumar, Shri Mary Lini, Shri Joseph Sahaya Rajan Associates from other division Dr. M. Makesh, Dr. P. Shyne Anand, Smt. Leesa Priyadarsani, Dr. Satheesha Avunje, Dr. B. Sivamani, Dr. T.N. Vinay, Ms.Misha Soman
12.	Abiotic stress management for enhanced productivity and environmentally sustainable shrimp farming	ICAR	PI: Dr. M. Muralidhar Co-PIs: Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. Satheesha Avunje, Dr. Suvana Sukumaran, Dr. A. Nagavel, Scientists from other division Dr. M. Jayanthi, Dr. J. Syama Dayal
Externally Funded Projects			
13.	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. S.K. Otta, Dr. Sanjoy Das, Dr. Sujeet Kumar, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja, Shri T. Sathish Kumar, Dr. Vidya Rajendran Dr. Joseph Sahayarajan

Sl. No.	Project Title	Funding	Project Team
14.	All India network on fish health	ICAR	National Coordinator: Dr. K.K. Vijayan Project Coordinator & PI: Dr. P.K. Patil Co-PIs: Dr. S.V. Alavandi, Dr. S.K. Otta, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. Satheesha Avunje, Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. E. Praveena, Dr. T. Ravisankar, Shri J. Ashok Kumar Dr. R. Geetha
15.	Consortium research platform on vaccines and diagnostics	ICAR	Project Coordinator: Dr. M. Makesh
	a. Development of RNAi – mediated prophylaxis and therapy of white spot syndrome virus (WSSV)		PI: Dr. S.K. Otta Co-PIs: Dr. S.V. Alavandi, Dr. M. Makesh
	b. Development of vaccine for betanoda virus infecting seabass, *Lates calcarifer*		PI: Dr. M. Makesh Co-PIs: Dr. M. Poornima, Dr. K.P. Jithendran, Dr. P.K. Patil, Dr. Sujeet Kumar
	c. 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
	d. Development of improved diagnostics to existing and emerging pathogens of shrimp and fish		PI: Dr. M. Makesh Co-PIs: Dr. S.V. Alavandi, Dr. P. Ezhil Praveena, Dr. M. Poornima, Dr. S.K. Otta, Shri T. Sathish Kumar, Dr. Vidya Rajendran Dr. Joseph Sahaya Rajan
	e. Development of prophylactic strategies for the control of Enterocytozoon hepatopenaei (EHP)		PI: Mr. T. Sathish Kumar Co-PI: Dr. Joseph Sahaya Rajan
	f. Development of diagnostics for differentiation and quantification of pathogenic Vibrio harveyi clade species		PI: Dr. Sujeet Kumar Co-PI: Mr. T. Sathish Kumar Dr. Joseph Sahaya Rajan

Sl. No.	Project Title	Funding	Project Team
16.	Network project on antimicrobial resistance	ICAR	PI: Dr. S.K. Otta Co-PIs: Dr. Satheesha Avunje, Dr. Vidya Rajendran
17.	National Innovations in Climate Resilient Agriculture (NICRA)-Developing sustainable adaptive and mitigation strategies for climate smart aquaculture	ICAR	PI: Dr. M. Muralidhar Co-PIs: Dr. M. Jayanthi, Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Dr. S.K. Otta, Shri J. Ashok Kumar, Dr. P. Kumararaja, Dr. Aritra Bera, Dr. Satheesha Avunje, Dr T Sathish Kumar, Dr. Suvana Sukumaran, Dr Jose Antony, Dr. A. Nagavel
18.	Impact assessment of aquaculture on agriculture, coconut gardens and drinking water in East Godavari District, Andhra Pradesh with specific reference to salinization	Dept. of Fisheries, Andhra Pradesh	PI: Dr. M. Muralidhar Co-PIs: Dr. P. Nila Rekha Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. A. Nagavel
Nutrition, Genetics & Biotechnology Division **Institute Funded Projects**			
19.	Application of advanced molecular and bioinformatic tools for improvement of brackishwater fish and shell fish	ICAR	PI: Dr. M. Shashi Shekhar Co-PIs: Dr.K.K. Vijayan, Dr. Sherly Tomy, Shri J. Ashok Kumar Dr. K. Vinaya Kumar, Dr. B. Sivamani, Dr. J. Raymond Jani Angel, Ms. Misha Soman
20.	Novel approaches for development and improvement of sustainable shrimp and fish feeds	ICAR	PI: Dr. K. Ambasankar Co-PIs: Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru vasagam, Shri K.P. Sandeep, Shri T. Sivaramakrishnan Dr. Sherly Tomy Dr. B. Sivamani

Sl. No.	Project Title	Funding	Project Team
Externally Funded Projects			
21.	Outreach activity on fish feeds and nutrient profiling of brackishwater fish and shrimp	ICAR	PI: Dr. K. Ambasankar Co-PIs: Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Shri K.P. Sandeep, Shri T. Sivaramakrishnan
22.	Genomic resources for augmentation of economic traits in Indian white shrimp and whole genome sequencing of brackishwater aquaculture candidate species	ICAR	PI: Dr. M. Shashi Shekhar Co-PIs: Shri J. Ashok Kumar, Dr. K. Vinaya Kumar, Dr. J. Raymond Jani Angel Dr. M. Kailasam Dr. Krishna Sukumaran
23.	Investigations on dietary alterations in shrimp for abiotic stress using nutrigenomics approach	ICAR	PI: Shri J. Ashok Kumar Co-PIs: Dr. J. Syama Dayal, Dr. M. Shashi Shekhar Dr. K. Vinaya Kumar Dr. K.P. Sandeep Dr. M. Grover
Social Sciences Division **Institute Funded Projects**			
24.	Research on socio-economics, frontline extension and information technology for sustainable brackishwater aquaculture sector	ICAR	PI: Dr. C.V. Sairam Co-PIs: Dr. T. Ravisankar Dr. B. Shanthi Dr. D. Deboral Vimala Dr. M. Kumaran Dr. P. Mahalakshmi Dr. R. Geetha
Externally Funded Projects			
25.	Brackishwater cage culture with multi-trophic candidate species diverse rearing systems for alternate livelihood and societal development in Maharashtra	Mangrove cell Maharashtra	PI: Dr. C.V. Sairam Co-PIs: Dr. M. Kailasam Dr. C.P. Balasubramanian Dr. Pankaj Amrut Patil Shri Tanveer Hussain Shri K.P. Sandeep

Sl. No.	Project Title	Funding	Project Team
26.	Cage culture in brackishwaters of Puducherry and Karaikal regions of Puducherry Union Territory A - feasibility study	FIMSUL	PI: Dr. M. Kumaran Co-PIs: Dr.M. Jayanthi Dr. D. Deboral Vimala Dr. C.V. Sairam Dr. M. Muralidhar Dr. K.P. Kumaraguru Vasagam Smt. Babita Mandel Shri R. Subburaj
27.	Knowledge and Economic Empowerment of women, tribal and their families in coastal villages of Tamil Nadu through adoption of brackishwater aquaculture and allied technologies integrated with societal development programmes	CPCL	PI : Dr. B. Shanthi Co-PI : Dr. C.V. Sairam
28.	Sustainable livelihood models for resource poor fish farmers/fisher folks in Nagapattinam district of Tamilnadu for doubling their income	CPCL	PI : Dr. D. Deboral Vimala Co-PI : Dr.C.V.Sairam Dr. M.Kumaran Dr. K.P. Kumaraguru Vasagam Dr. P. Nila Rekha, Dr. P. Mahalakshmi
29.	Development and Validation of Smart Aquaculture Model (SAM): Application of ICT and Data analytics for sustainable shrimp aquaculture	NASF	PI : Dr. M. Kumaran Co-PI : Dr. M. Muralidhar, Dr. D. Deboral Vimala Dr. K. Ambasankar, Dr. P. Mahalakshmi, Shri J. Ashok Kumar, Dr.T. Sathish Kumar, Shri Jose Antony Shri S. Nagarajan
Kakdwip Research Centre **Institute Funded Projects**			
30.	Development and dissemination of economically viable and sustainable brackishwater aquaculture technologies for livelihood improvement of small and marginal farmers of Indian Sundarban	ICAR	PI: Dr. Debasis De Co-PIs: Dr. T. K. Ghoshal Dr. Sanjoy Das, Dr. G. Biswas, Dr. Prem Kumar, Ms. L. Christina, Smt. Babita Mandal

Sl. No.	Project Title	Funding	Project Team
Externally Funded Projects			
31.	Elucidation of molecular mechanism of dopamine action on final oocyte maturation of Goldspot mullet (Lisa parzia, Hamilton, 1822)	DBT	PI: Dr. Prem Kumar Co-PIs: Dr. G. Biswas, Dr.T.K. Ghoshal
Other Projects			
32.	Agri-Business Incubation centre (ABI) at CIBA, Chennai	NAIF - ICAR	PI: Dr. P.K.Patil Co-PI : Dr. K.P. Kumaraguru vasagam, FCD Dr. T. Ravisankar, SSD Divisional Members Dr. R. Geetha, SSD Dr. T.N.Vinay, CCD Dr. J. Raymond Jani Angel, NGBD (Genetics) Dr. K.P. Sandeep, NGBD (Nutrition) Shri Dani Thomas, FCD
33.	Intellectual property Management and Transfer/ Commercialization of Agricultural Technology Scheme (Up-scaling of existing components i.e. Intellectual property Right (IPR)	NAIF - ICAR	Dr. P.K. Patil, OIC Divisional Members Dr.K.P.Kumaraguru vasagam, FCD Dr. T. Ravisankar, SSD Divisional Members Dr. R. Geetha, SSD Dr. T.N.Vinay, CCD Dr. J. Raymond Jani Angel, NGBD (Genetics) Dr. K.P. Sandeep, NGBD (Nutrition) Shri Dani Thomas, FCD

Research Highlights

Brackishwater Production System Research

The growth of brackishwater aquaculture during the last three decades has been spectacular. However, this industry in India solely depends on one commodity, shrimp, and more particularly one species, *Penaeus vannamei.* During the last one decade the farmed shrimp production escalated several times, largely due to the introduced exotic white shrimp, *P. vannamei.* Although aquaculture of the non-native *P. vannamei* revived the Indian farming sector, the industry has been in downward trend during recent years due to multiple issues. At this context, the development of native shrimp is found to be a viable option for the long-term sustainability of the industry. Additionally, the production system research of the institute focuses on the development of viable technology of other brackishwater species such as milkfish, sea bass, grey mullet, pearl spot and mud crabs. Diversification, as such, for the stable and sustainable industrial development is not a radical idea; it has been a component of successful aquaculture development in many countries.

Brackishwater Production System Research

CRUSTACEAN PRODUCTION SYSTEM

Comparison of nursery rearing of *P. vannamei* and *P. indicus* at different stocking densities during different season

Nursery rearing of *P. vannamei* and *P. indicus* using aquamimicry during different seasons (summer, pre-monsoon, monsoon and winter season) and at different stocking densities (2500, 5000, 7500 and 10000 PL/ton) were studied. Further, compensatory growth during grow-out culture except winter season were compared with conventional grow-out culture. There is a significant difference in growth of *P. vannamei* in nursery reared grow-out culture compared to conventional method during summer, pre-monsoon and monsoon season. During the nursery rearing period, highest growth and survival was observed during summer and pre-monsoon period and lowest was observed during winter season when the water temperature and salinity were low. Highest growth was observed during pre-monsoon in nursery reared grow-out farming system (13.8g in 90 DOC) compare to other seasons. The overall study reveals that nursery rearing of *P. vannamei* can be done with a maximum stocking density of 7500 PL/ton of water in all the seasons and corresponding compensatory growth and production can be achieved in the nursery reared grow-out system compare to conventional system.

Nursery rearing experiments of *P. indicus* was conducted in all the season and grow-out culture was done during summer and pre-monsoon period. The study observed that nursery rearing of *P. indicus* can be done with a maximum stocking density of 5000 PL/ton of water and highest growth and survival was observed during summer followed by pre-monsoon and monsoon season respectively. There is a significant difference in survival rate at stocking density of 2500 and 5000 PL/ton compare to 7500 and 10000 PL/ton during nursery rearing. There is a significant difference of compensatory growth in nursery reared grow-out farming during summer and pre-monsoon period. The overall

***P. vannamei* grow-out farming during different season**

Season	Species	Salinity at stocking (ppt)	DOC	Average Size (g)	Biomass (Kg)	Survival (%)	FCR	Productivity (ton/ha)	Estimated Net Profit/ ha (Rs Lakhs)
Summer crop	Nursery reared *P. vannamei*	43	92 (Including 30 DOC Nursery)	12.5±1.1	135	72	1.62	2.7	3.02
	P. vannamei (Conventional system)	42	118	10.14±1.3	103.4	68	1.68	2.07	2.12
Pre-monsoon crop	Nursery reared *P. vannamei*	34	94 (Including 30 DOC Nursery	13.8±1.9	145.3	70.2	1.48	2.91	3.59
	P. vannamei (Conventional system)	32	123	10.42±1.1	100	64	1.78	2.00	1.88
Monsoon crop	Nursery reared *P. vannamei*	28	90 (Including 30 DOC Nursery	11.12±1.01	110	66	1.65	2.2	2.32
	P. vannamei (Conventional system)	26	119	9.51±0.7	78.5	55	1.75	1.57	1.41

***P. indicus* grow-out farming during different season**

Season	Species	Salinity at stocking	DOC	Average Size (g)	Biomass (Kg)	Survival (%)	FCR	Productivity (ton/ha)	Estimated Net Profit/ ha (Rs)
Summer crop	Nursery reared *P. indicus*	41	90 (Including 30 DOC Nursery)	12.5±1.1	127.5	68	1.68	2.55	2.71
	P. indicus (Conventional system)	42	122	11.6±1.3	106.1	61	1.72	2.12	2.12
Pre-monsoon crop	Nursery reared *P. indicus*	34	96 (Including 30 DOC Nursery	11.8±1.5	113.3	64	1.55	2.27	2.58
	P. indicus (Conventional system)	32	132	10.05±0.9	92	61	1.64		

study reveals that nursery reared *P. vannamei* and *P. indicus* showed compensatory growth and better survival compare to conventional method to increase the income for the farmers and also reduce the time lag between each crops for the better production.

Effects of dietary minerals and vitamin C supplementation on production characteristics of *P. vannamei* post larvae reared in earthen ponds

Supplementation of commercial diets with mineral salts and vitamin C is a common practice in shrimp aquaculture as farmers believe such amendments in the diets would improve survival and growth of the shrimp especially when rearing shrimp at low and intermediate salinities. In order to introspect possible effects of such supplementations to the

commercial diets on the shrimp post larvae, a 66 days field study was carried out at the CIBA-NGRC farm in Matwad, Navsari. The study comprised of four experimental treatments: commercial shrimp diets supplemented using potassium chloride (KCl, AR grade-5g/Kg feed-P), magnesium chloride anhydrous ($MgCl_2$, AR grade – 5g/Kg feed-M), combination of KCl and $MgCl_2$ (2.5g/Kg feed for both salts, P+M), vitamin C (ascorbic acid, AR grade – 5g/Kg-VC). Additionally two groups (controls) commercial feed (no supplementation, C) and non-fed group (no feed offered-NF). The non-fed group (NF), wherein no feed was provided to the shrimp, was incorporated in to the trial, to evaluate the growth and survival of post larvae (during the first 15 days) that is exclusively dependent on live feed available in the pond and to study whether early feeding of post larvae with respect to ration size and feeding frequency is important in shrimp farming. To evaluate the effects of such dietary supplementations in actual pond conditions, the study was carried out in nylon 20 mesh hapas (cages: 2m x 1m x 1m) installed in a common 2000 m^2 earthen pond. *P. vannamei* post larvae (PL), 7 days old (PL7) was obtained from a commercial shrimp hatchery and were nursery reared in indoor FRP tanks for 15 days prior to release of the PL to the hapas and initiation of experiments. *P. vannamei* PL (PL22, avg BW-0.048 g, TL-18.3 mm) were stocked at 150 PL./hapa. Eighteen hapas were installed in the earthen pond and the treatment (4) and control groups (2) were randomly distributed to the different hapas in triplicate. The trial was carried out during the winter season wherein water temperatures ranged from 19.6°C during the night to 26.5°C during the day. The salinity during initiation of the trial was 7 ppt and subsequently the salinity was maintained at 8 ppt for first 30 days following which salinity was gradually adjusted to 16 ppt through addition of high saline water for 6 days and later on maintained at 16 ppt for the last 30 days of the trial. A commercial shrimp feed [crumble, crude protein (%): 35%], was top coated with the mineral salts and vitamin C using a binder and the control diet was also top coated exclusively with the binder to nullify the effects of the binder. Feeding was carried out thrice a day wherein the total ration was distributed equally among three feeding sessions. The non-fed group was discontinued after the third sampling due to completion of the necessary objectives. At the end of 66 days, the experiment generated several mixed results. The average final body weight at the end of the trial was highest in the control group (commercial feed without any supplementation), whereas no significant differences existed between shrimp fed using Vitamin C, and potassium supplemented diets and the control groups. The final body weight of shrimp was significantly lower ($p<0.05$) in magnesium and the combination (P+M) treatments compared to the control group, although no significant differences ($p>0.05$) existed between the mineral salt supplemented groups (P, M, & P+M). However, the total biomass yield at the end of the trial was significantly higher ($p<0.05$) in the potassium fed groups compared to the control group (C) and the mineral salt combination fed groups (P+M). No significant differences was found among potassium, magnesium and vitamin C fed groups in terms of yield, although potassium and Vitamin C fed groups resulted in numerically higher yields. Survival rate was significantly higher ($p<0.05$) for shrimp fed using diet supplemented with potassium over shrimp fed on the control diet. Average daily growth rate (ADG) was significantly higher ($p<0.05$) in the control group over the magnesium and combination salt groups. Overall, superior FCR, final yield and growth rates were observed in the case of shrimp fed using diets supplemented with potassium and vitamin C. Interestingly, shrimp fed using diets supplemented with vitamin C did not show any improvement in survival, as survival rates were similar to the control diet fed groups and numerically lower than the mineral salt supplemented groups. However, shrimp fed using vitamin C supplemented diets and control diets demonstrated the superior final weight and growth rates

Supplementation of Vitamin C to the diets during the trial did not improve the survival rates, although increased the growth rates. Potassium supplementation in diets may have a positive effect on both growth and survival of the shrimp. Potassium may have a stress mitigating and immunogenic role in shrimp that needs to be validated with further studies. Overall, the study indicates that supplementation of diets using potassium can improve the survival rates and yield levels in shrimp farming. Farmers shall adopt a combination of potassium and vitamin C supplementation in field conditions to obtain the desired survival, growth rates and yields. Although, magnesium supplementation also resulted in improved survival and similar

Experimental ponds, NGRC, Gujarat

production characteristics, potassium supplementation resulted in numerically higher values and further investigations are required for studying other effects of magnesium on shrimp production systems.

Growth characteristics of *P. vannamei* juveniles exclusively fed using fermented soya bean meal in comparison to formulated shrimp diet

A study carried out to evaluate the effects of fermented soya bean meal as the soul diet for *P. vannamei* juveniles, and the growth characteristics were compared with a commercial formulated shrimp diet. The present trial consisted of three treatments viz. soya bean meal fermented using yeast (Y-*Saccharomyces cerevisiae*, 10^6 CFU/g), novozymes Pond Plus (P- Bacillus sp. 10^9 CFU/g) and combination of yeast and pond plus (Y+P) at 1:1 ratio and the control consisted of a commercial shrimp crumbled diet. *P. vannamei* PL obtained from a commercial hatchery (9 days old, PL 9) was nursery reared in an indoor system for 20 days prior to initiation of the trial. At the end of 69 days, final mean weight of shrimp was significantly ($p<0.05$) higher for shrimp fed using a formulated shrimp feed over the FSBM treatments. The final weight of shrimp fed using SBM fermented using yeast, Pond Plus and combination of both, did not vary significantly ($p>0.05$). The study indicates that fermented soya bean meal can be used as the soul supplementary diet for *P. vannamei* PL for the first 30 to 45 days of culture as it did not affect survival and final yield remained similar. Although, growth was significantly lower compared to formulated diet, the application of such feeds need to be further studied with additional modifications. The study also indicates that fermentation of FSBM can be adequately achieved by yeast and Bacillus sp. bacteria. The success of such dietary advancements would be helpful for organic shrimp farming and preparation of farm made feeds to reduce production costs.

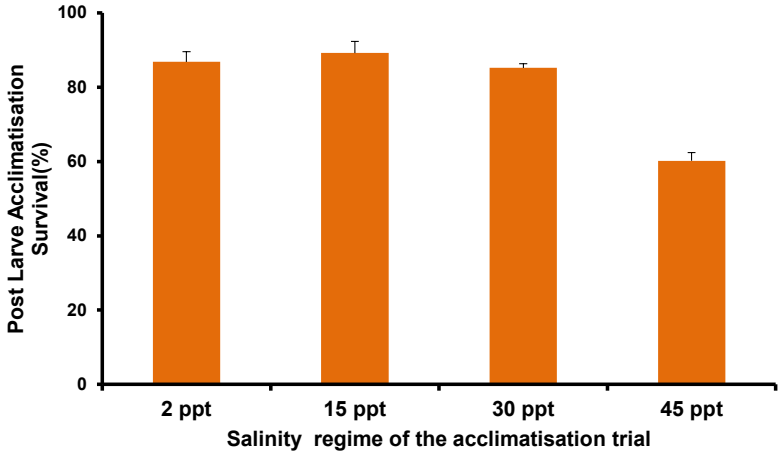
Acclimatization of *Penaeus vannamei* at different salinity and nursery production

Effect of acclimatization and nursery rearing of *P. vannamei* under different salinity regime was studied. Post larvae of *P. vannamei* were divided into five treatments (2, 15, 30, 45 and 65 ppt) and PL 4 was gradually acclimatized at 3 ppt per day from an ambient salinity

Growth and production characteristics of *P. vannamei* post larvae reared in hapas at the end of 66 days' trial, fed using commercial diets supplemented with mineral salts and vitamin C

Treatments diets	Initial weight (g)	Final weight (g)	Survival rate (%)	Biomass (g)	WG(%)	ADG	FCR
Potassium	0.04 ± 0.0052^{a}	$5.86\pm0.32^{a,c}$	60.89 ± 0.59^{a}	537.1 ± 3.06^{a}	17099.0 ± 2341.65^{a}	$0.089\pm0.005^{a,c}$	1.17 ± 0.006^{b}
Magnesium	0.05 ± 0.0048^{a}	$5.81\pm0.22^{b,c,d}$	$54.22\pm5.78^{a,b}$	$478.7\pm28.09^{a,c}$	$16,467.5\pm1828.59^{a}$	$0.088\pm0.003^{b,c,d}$	$1.33\pm0.084^{b,c}$
P + M	0.04 ± 0.0038^{a}	$5.41\pm0.15^{b,c}$	$56.22\pm0.44^{a,b}$	$457.7\pm2.17^{b,c}$	$15,836.9\pm1789.43^{a}$	$0.0827\pm0.002^{b,c}$	$1.37\pm0.006^{a,c}$
Vitamin C	0.04 ± 0.0038^{a}	$6.69\pm0.27^{a,d}$	$52.44\pm3.87^{a,b}$	$519.5\pm21.89^{a,c}$	$19,225.7\pm2128.46^{a}$	$0.1022\pm0.004^{a,d}$	$1.22\pm0.051^{b,c}$
Control	0.04 ± 0.0038^{a}	6.84 ± 0.28^{a}	45.11 ± 0.97^{b}	$458.1\pm6.17^{b,c}$	$19,620.8861\pm2282.05^{a}$	0.1046 ± 0.004^{a}	$1.37\pm0.018^{a,c}$
F statistic	0.2592	5.4713	3.3490	4.9956	0.6436	5.4538	4.3012
P value	0.9346	0.0003	0.0551	0.0059	0.6320	0.0003	0.0113

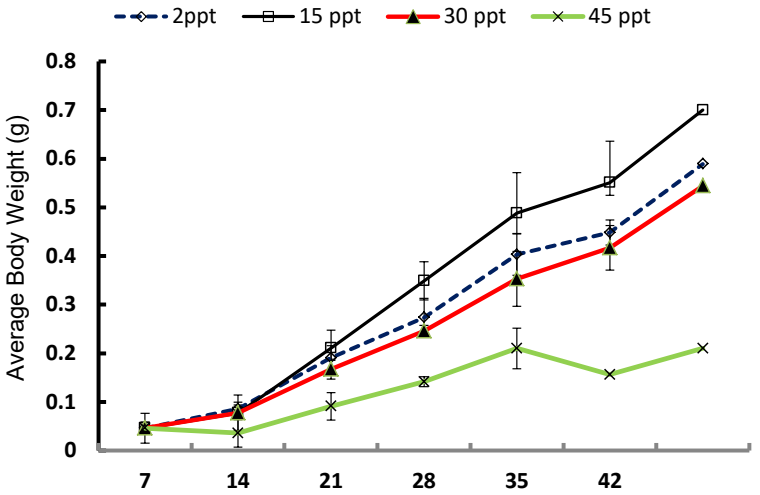
at 26 ppt, to achieve the desired salinities. The highest survival, (89.2 ± 3.14%) was recorded in 15 ppt followed by 2 ppt, and 30 ppt, and the lowest survival (60.17 ± 2.2%) was recorded in 45 ppt. In the second experiment, nursery rearing of *P. vannamei* was conducted in 2, 15, 30, 45 and 65 ppt indicate the highest survival (89.3±2.96%) in 2 ppt followed by 30 ppt and 15 ppt salinities while final average body weight, 0.7±0.09 and SGR, 6.48±0.1 was noted the highest in 15 ppt followed by 2 ppt. The shrimp reared in low salinity was hyper-osmoregulator and higher salinity was hypo-osmoregulator.



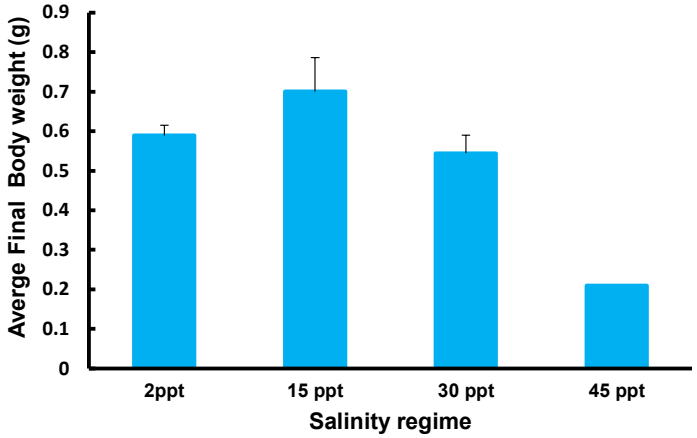
Survival of *Penaeus vannamei* at different salinity regime

Nursery rearing of Indian white shrimp, *Penaeus indicus*: Optimization of stocking densities under different management regimes

Nursery rearing experimental trials (45 days) were carried out to optimize stocking densities of Indian white shrimp, *Penaeus indicus* post-larvae in nursery rearing. The experiment had 3 × 3 factorial design with three levels of stocking density (1650, 3350, 8350 PL m^{-3}) and three management systems; zero water exchange (ZWE), ZWE with soil base (ZWE+SN), and ZWE with soil base and substrate integration (ZWE+SN+SUB) resulting in nine treatments. The experiment was followed by a 21-day growth trial in low volume floating cages to estimate the compensatory growth performance. At the end of the experiment, both the stocking densities and management system had a significant effect ($p<0.05$) on growth performance parameters. The final body weight and survival in low (1650 PL m^{-3}) and medium-density (3350 PL m^{-3}) groups were



Average weekly body weight (Mean ± SD) of *Penaeus vannamei* reared under different salinity regime during 42 days nursery rearing

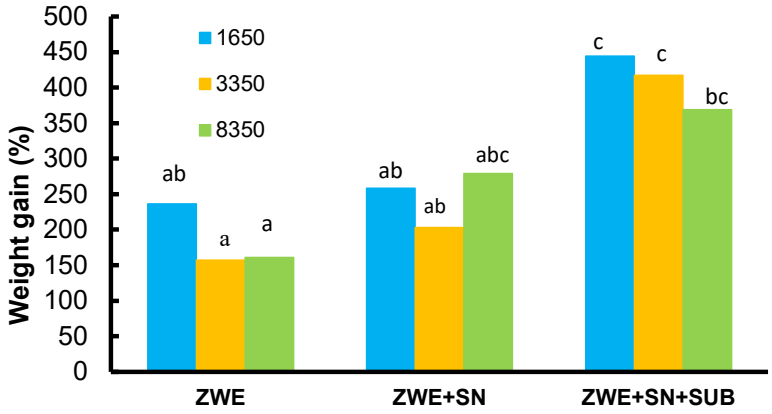


Final average body weight (Mean ± SD) of *Penaeus vannamei* reared under different salinity regime during 42 days nursery rearing

not significantly different (p>0.05). However, a density-dependent growth reduction (p<0.05) was observed in high-density (ZWE and ZWE+SN) groups. Integration of substrate (ZWE+SN+SUB) in nursery rearing has resulted in better growth characteristics even at high-density groups (8350 PL m^{-3}) through alleviating the adverse effects of crowding stress. Water quality parameters such as total ammonia nitrogen (TAN), nitrite-N, dissolved oxygen level, and total suspended solids (TSS) varied significantly (p<0.05) among the treatments. Significantly lower TSS (p<0.01) and TAN (p<0.05) were recorded in zero water exchange (ZWE) and zero water with substrate integrated nurseries (ZWE+SN+SUB), respectively. The compensatory growth of the nursery reared shrimp in cages exhibited stocking size-dependent (p<0.05) growth gain.

Co-culture of shrimp with penaeid shrimp

To understand the compatibility of co culture of Pearlspot (*Etroplus suratensis*) with penaeid shrimp polyculture of shrimp with various size groups was studied with pearl spot of different size groups. Three size groups of pearl spot (0.3 g; 2 -5g and 20-25g and 100 g) were used with different size groups. Four set of experiments were carried out: Exp 1, shrimp PL density 350 / m^3 and *E. suratnesis* (0.2 g) at 70/ m^3 were reared in 100L FRP tanks for a period of 15 days. The pearl spot below 0.3g were not fed the post larvae. In experiment 2, when shrimp was reared (350 / m^3) with pearl spot (2-3 g) at 70/ m^3 all shrimp post larvae were consumed by pearl spot within three days. In Experiment 3, 1.5g shrimp were stocked at 180 /m^3 and 2-3g etroplus 70/m^3, 100% mortality was recorded .In exp 4, 1.5g shrimp stocked 180 /m^3 (10/ tank) and 50g etroplus at 10/m^3 100% eaten within a day. In Exp 5, 5-7g shrimp (25/m^3) and etroplus (100g) at 10/m^3 .On (5th day 100% eaten by etroplus. 90% survival was recorded in all positive control tanks without etroplus.



The compensatory weight gain (%) of the nursery reared *P. indicus* in low volume floating cages. The data was analysed by one-way ANOVA (n=30 number for each replicate) followed by Tukey's test. Mean with different superscripts differ significantly.

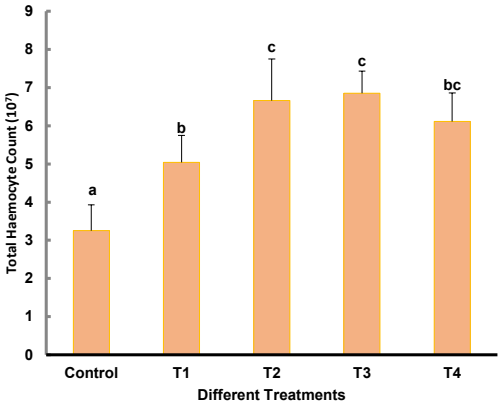
Nursery rearing of Indian white shrimp, *Penaeus indicus* in a Recirculating Aquaculture System (RAS) blended with Biofloc enriched rotifers as feed supplement

A 60 day nursery rearing experiment of Indian white shrimp, *Penaeus indicus*, was carried out in a Recirculating Aquaculture system (RAS; 6000 L capacity; FRP tank) using biofloc enriched rotifer (*Brachionus plicatilis*). A comparison of growth and production of *P. indicus* at high density (PL10 @ 2000 m^{-3}) was conducted between RAS, Hybrid RAS and RAS with biofloc enriched rotifer using aquamimicry system. The treatments conducted in triplicates comprised of C: Control (without RAS), T1: only RAS (RA), T2: RAS with Biofloc (RA-BFT), T3: RAS with biofloc enriched rotifer using aquamimicry (RA-BFTR) and T4: RAS with only Rotifer (RA-R). *Brachionus. plicatilis* were mass cultivated using biofloc in large quantities and supplied to cultured tank at the rate of 10-20 animal/ml. The survival, growth and immunity were monitored at every 15 days interval in each treatment. At the end of experiment, the biofloc enriched rotifer (RA-BFTR) showed better growth (3.89±0.25 g) and survival (91%) which is significantly different from control animals (3.24±0.29 g, 85%). The immune parameters also varied from control to biofloc and rotifer added tanks. The PO activity in treatment animals from ranged 0.068±0.009 to 0.11±0.014 and highest observed in RA-BFTR. The lysozyme activity also ranged from 0.061 ± 0.009 to 0.12 ± 0.021 (OD /min). Total plasma protein ranged between 60.51±13.07 to 92.57±7.03 mg/ ml. Total haemocyte count ranged from 4.11×10^6 to 7.52×10^6 and SOD inhibition percentage also varied from 28.33±.77 to 71±9.4.

The highest SOD inhibition rate found in control and lowest found in RA-BFTR. Study revealed that nursery rearing of shrimp in RAS with biofloc enriched rotifer improved the growth, immunity and survival ability.

Growth potential and immunity of the Indian White shrimp, *Penaeus indicus* (H. Milne-Edwards, 1837), cultured in grow-out ponds at varying densities and salinities

The growth performance and immunity status were assessed under two different stocking densities (low and high) at each salinity regime (S1:3-7, S2: 8-15, S3:15-25, S4:25-35, and S5:40-60 ppt) for a period of 80-120 days. Healthy post larvae (PL) 10 (0.01 g) were stocked after proper acclimatization under different salinities. Significantly higher growth was observed in the salinity range of 15 to 35 ppt with average daily growth (ADG) up to 0.195±0.032 compared to low ADG of 0.125 ±0.021 in very low and very high salinity range (<7 ppt and >40 ppt). Similarly,



Total Haemocyte count (THC) in different treatments C: Control (Static) T1: RA, T2: RA-BFT T3: RA-BFTAR, T4: RA-R.Values are represented mean ± SD. Mean values with different superscripts are significantly different between treatments (P < 0.05)

the final mean harvest weight of *P. indicus* reared at 15 - 25 ppt salinity was significantly (P<0.05) higher compared to other salinity ranges. The lower stocking density treatment demonstrated higher mean harvest weight (18-30 g) compared to higher density ponds (12 -20 g). There was a significant (P<0.05) difference in the feed conversion ratio (FCR) and protein efficiency ratio (PER) across different salinities whereas stocking density does not influence the FCR much. The specific growth rate varied among different salinity regimes and stocking densities. Similarly, the weight gain was maximum at salinity 8-15 ppt observed in Odisha, followed by West Bengal, Kerala and Tamil Nadu. FCR was significantly ($p<0.05$) higher for shrimp reared at higher salinities (S4, S5). However, differences in FCR were not observed between shrimp reared at high and low stocking densities at any salinity except for the trial in Kerala (S1) wherein FCR was significantly ($p<0.05$) lower in lower stocking density. The total productivity (Kg/ha) significantly

Growth Parameters observed during culture periods; C: Control (Static) T1: RA, T2: RA-BFT T3: RA-BFTAR, T4: RA-R. Values are mean ± standard deviation. Mean values with different superscripts in the same column are significantly different (P < 0.05).

Growth parameters	Control	T1	T2	T3	T4
IW (g)	0.012±0.001	0.012±0.001	0.012±0.001	0.012±0.001	0.012±0.001
FW (g)	$2.32±0.25^{a}$	$2.83±0.31^{a}$	$3.55±0.35^{b}$	$3.82±0.31^{b}$	$3.36±0.23^{b}$
WG (g)	$2.31±0.25^{a}$	$2.81±0.31^{a}$	$3.54±0.35^{b}$	$3.81±0.25^{b}$	$3.35±0.24^{b}$
ADG (g d^{-1})	$0.038±0.004^{a}$	$0.046±0.005^{ab}$	$0.059±0.005^{b}$	$0.063±0.004^{b}$	$0.055±0.005^{b}$
SGR (%d^{-1})	$8.11±0.25^{a}$	$8.44±0.24^{ab}$	$8.49±0.29^{b}$	$8.56±0.26^{b}$	$8.48±0.26^{b}$
FCR	$1.7±0.51^{b}$	$1.6±0.33^{b}$	$1.2±0.39^{a}$	$1.5±0.45^{ab}$	$1.3±0.65^{a}$
IL (cm)	10.94±0.79	10.94±0.79	10.94±0.79	10.94±0.79	10.94±0.79
FL (cm)	$59.65±4.39^{a}$	$67.75±4.52^{ab}$	$64.5±5.54^{ab}$	$64.45±10.05^{ab}$	$71.21±4.22^{b}$
Survival rate (%)	$68.69±1.9^{a}$	$85.00±1.5^{b}$	$87.51±1.78^{b}$	$91.15±2.15^{b}$	$90.25±0.55^{b}$
Production (kg m^{-3})	$5.25±1.8^{a}$	$8.01±1.5^{b}$	$10.35±2.5^{c}$	$11.8±1.8^{c}$	$10.08±1.6^{c}$

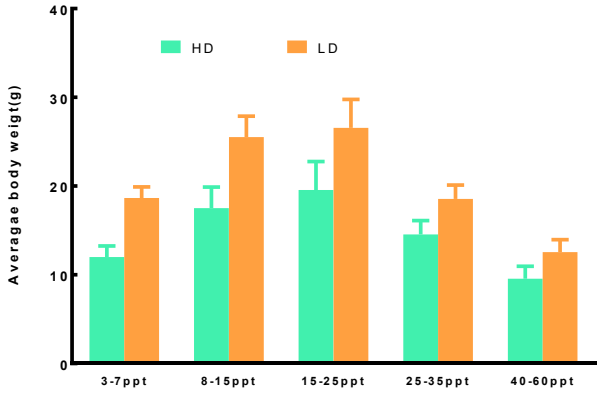
*IW-Initial weight, FW-Final weight, IL-Initial length, FL-Final length

(P< 0.05) increased with increase in stocking density by 20-30% while it was comparable between salinity ranges. The prophenoloxidase (PPO) activity gradually increased or decreased correspondingly to the salinity level with significantly lower PPO activity being observed at very low (5ppt) and very high (60 ppt) than other salinity ranges. The serum protein and lysozyme also varied with the salinity range. Different densities did not affect immune parameters although lower stocking density was showing marginal increase. This study is based on large data from multi-location trials undertaken across different salinity ranges and stocking densities and provides a field-level assessment of growth potential of this native shrimp species in different geographic locations.

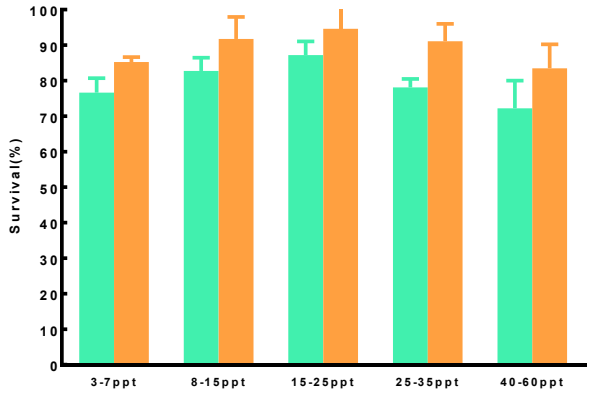
Production performance and immune response of Indian white shrimp *Penaeus indicus* (H. Milne-Edwards, 1837), reared in a biofloc-based system with different protein levels of feed

This study focuses on the immunity and growth of *Penaeus indicus* cultured in a biofloc based rearing system by providing diets in varying protein levels (25%, 30%, and 35%). A combination of different carbon sources (molasses, wheat flour, and rice bran) and a probiotic consortium (*Bacillus* sp. and *Saccharomyces* sp.) were used in a specific ratio and protocol for the development of biofloc. The growth parameters of shrimps such as final weight, Feed conversion ratio (FCR), and daily growth coefficient (DGC) were computed at regular intervals. The results indicated that medium (30%) protein fed group (MP) followed by high (35%) protein fed group (HP) significantly (P<0.05) improved the growth performances compared to low protein level (25%) group (LP) in a biofloc system and control group (35%).

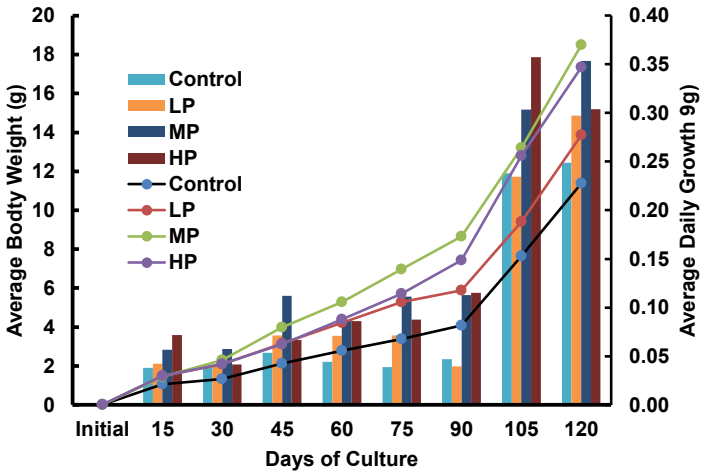
PO activity in plasma was found to be higher in high protein fed animals, whereas, medium protein resulted in enhanced PO activity in serum. Similarly, lysozyme and SOD were inhibited well in high protein fed animals. The mRNA profiles of vital immune genes in the shrimps showed a potential rise in the expressional pattern in MP and HP treatments. BGBP and Hemocyanin mRNA transcript levels were highly upregulated in the HP (5 fold) and moderately expressed in MP (2 fold) and LP (1-2 fold). The transcripts of peroxinectin, antimicrobial peptides like crustin showed significant upregulation in HP followed by in MP and LP. Likewise, other immune genes, such as SOD, prophenoloxidase (proPO) showed a similar trend in a marginal way, indicating immunomodulation in the biofloc groups. This study suggested that biofloc with high protein (35%) supplementation can substantially enhance the immune response of shrimps though medium protein level (30%) is optimum for improving the survival, growth, and economic return in Indian white shrimp *Penaeus indicus*.



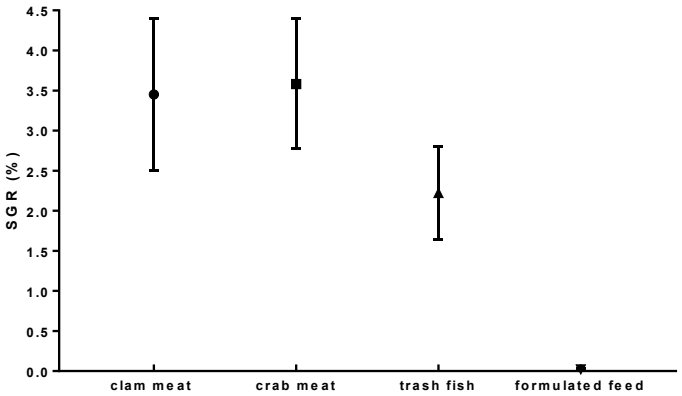
Average body weight (ABW) of *Penaeus indicus* at 90 days under different salinities and densities. Data is shown as Mean ± SD. Significant difference (p< 0.05) between the groups is indicated by superscript (a,b) marks on top of the bar.



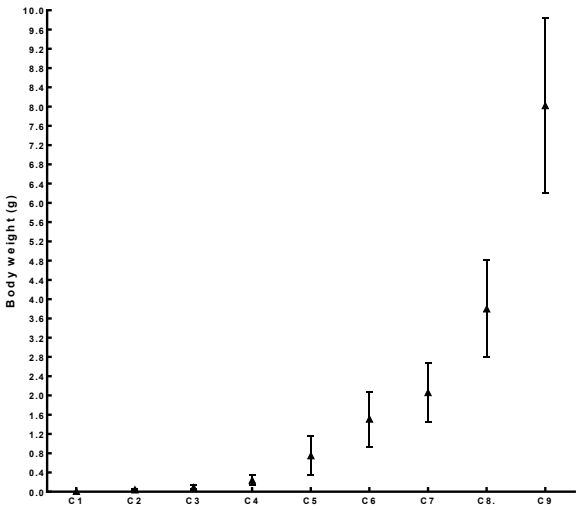
Survival (%) in different stocking densities (SD) in respective saline region. Data shown as mean with standard deviation as error bars. Significant difference (p < 0.05) between the groups is indicated by superscript (a,b) marks on top of the bar.



The Growth performance of Indian white shrimp as shown in Average body weight (ABW) and Average daily growth (ADG)



Specific growth rate of mud crab *Scylla serrate* received different fresh and formulated diet



Growth of *Scylla serrata* juveniles (crab stages 1–8): Body weight during different instars

MUD CRABS

Evaluation of the efficacy of the formulated feed on survival and growth of mud crab, *Scylla serrata* juveniles.

As a part of the development of formulated diet for mud crab *Scylla serrata*, experiments were carried out to evaluate the efficacy of formulated diet in comparison with three natural diets: Trash fish meat, crab meat and clam meat. All the four treatments were replicated thrice and each replicate was composed of 15 animals of average size, CW: 18.1 to 19.1 mm and initial body weight, BW: 0.87 to 1.13 g. In order to exclude the possibility of cannibalism, each animals in the treatment were housed in separate PVC containers. Animals were reared for 57 days. Significantly higher survival rate was recorded in the treatment group received clam meat followed by formulated feed, however weight gain and specific growth rate (SGR) in the formulated feed treatment was lowest among all the treatment. The study indicates that there is a potential for the improvement of the quality of formulated feed, and wet feed could be replaced in grow out production system.

Individual growth pattern of juvenile stages of the mud crab (*Scylla serrata*) reared individually

Cultivation of individual crab in separate compartment has become popular, for example: soft shell crab industry and vertical rearing system. Although growth data during communal rearing in pond has been reported, it does not provide accurate estimation of growth. In order to obtain growth and molt pattern of individual crabs, a study has been carried out:

Final body weight, survival and weight gain of mud crab *Scylla serrata* received formulated feed and wet feed

	Initial Carapace width (mm)	Final Carapace Width (mm)	Initial Body weight (g)	Final Body Weight (g)	Weight gain (g)	Survival (%)	Days for moulting (ays)
Fish meat	19.12±4.10	28.02 ± 0.70 [a]	1.13±0.88	3.29 ± 0.30 [a]	1.89 ± 0.17 [a]	53.33 ± 3.84 [a]	23.1 ± 1.71
Crab meat	18.12±3.15	30.19 ± 0.56 [a]	0.87±0.52	4.15 ± 0.20 [a]	3.02 ± 0.12 [b]	46.66 ± 10.18 [a]	17.87 ± 1.5
Formulated pellet	18.18±3.80	24.75 ± 0.62 [b]	0.87±0.63	2.38 ± 0.18 [b]	0.51±0.12	95.55 ± 2.22 [b]	21 ± 1.63
Clam meat	18.70±3.40	33.24 ± 0.54 [c]	1.02±0.62	5.39 ± 0.21 [c]	3.97 ± 0.17 [d]	97.77 ± 2.22 [b]	17.75 ± 0.96

Growth, intermoult period, and survival of juveniles of *Scylla serrata* over 129 days (mean±S.D.)

Instar	Survival (%)	CW (mm)	BW(g)	CW(%)	BW(%)	Inter molt days (days)	SGR (%)
C1-C2	100	6.005 ±0.367	0.035 ±0.007	74.74 ±18.84	199.88 ±124.56	5.67 ±4.03	30.40 ±19.01
C2-C3	100	8.58 ±1.22	0.09 ±0.04	43.37 ±22.86	179.40 ±145.19	21.50 ±8.70	4.80 ±2.61
C3-C4	93	12.25 ±1.89	0.25 ±0.12	43.32 ±19.94	186.44 ±216.64	14 ±10.2	9.44 ±6.48
C4-C5	93	18.06 ±3.54	0.76 ±0.41	46.18 ±35.49	226.48 ±223.89	15.00 ±13.88	10.06 ±7.319
C5-C6	93	22.68 ±3.35	1.51 ±0.57	30.32 ±10.71	130.4 ±35.61	16.69 ±8.21	6.32 ±3.45
C6-C7	93	25.57 2.628	2.06 0.62	27.2 5.536	98.05 16.4	16.29 8.056	5.11 2.61
C7-C8	93	31.36 2.881	3.804 1.006	28.43 4.007	113.1 16.27	12.6 7.057	7.44 3.418

growth and molting data of fifteen crabs from instar 1 onwards were traced individually for a period of 129 days (up to instar 9).

Survival rate form C1 to C8 was very high as expected (93%). Juveniles had a high percentage of wet weight gain, between 98.05% and 226.48% but the%WG values were highly variable between stages. SGR was almost similar in all phases except in C1 to C2 phase. The relationship between carapace width and body weight is shown in the figure, and body weight shows negative allometric growth. Up to sixth molt or 6 th instar all crabs molted whereas from 6 th to 7, 50% crab only molted, and subsequently molting frequency diminished. The present study provides a guideline for farmers to manage their stock in the individual cages.

FINFISH PRODUCTION SYSTEMS

GREY MULLET

Growth performance and feed utilization of grey mullet fry fed with different levels of protein formulated feed in pond based nursery culture

Brackishwater grey mullet, *Mugil cephalus* is a high valued food fish and an important component of polyculture in traditional and contemporary farming systems in India. Hence to optimize the protein requirement and as well as to study the acceptance of formulated feed, an experiment on growth and survival of grey mullet fry fed with different levels of protein concentration in formulated feed was conducted at NGRC Farm, Matwad. The experiment was conducted in nursery hapa (2 x 1 x 1 m) installed in brackishwater pond (2000 sq.m) for 90 days. The wild collected grey mullet seed in the size range of 2.0-2.5 cm were stocked at density of 200 numbers hapa^{-1}. The experiment had a 4 x 3 factorial design and four floating diets were formulated containing four graded levels of proteins i.e. 30%, 35%, 40% and 45%. The formulated feed (0.6-1.2 mm) with different levels of protein were fed to grey mullet fry twice a day at 8-10% of body weight. The water quality parameters such as pH, temperature (^{0}C), salinity, dissolved oxygen (mg/L) were monitored daily whereas ammonia (mg/l), nitrite (mg/l), nitrate (mg/l) were estimated weekly and were found to be in the optimal range required for grey mullet nursery culture. After 90 days, growth parameters such as weight (g), feed conversion ratio (FCR), protein efficiency ratio (PER), specific growth rate (SGR) were found better in grey mullet fingerlings fed with formulated feed containing 35% protein. However, decrease in growth parameters were observed in grey mullet fingerlings fed with the higher levels of the protein (40 and 45%) feed. The results of the study indicated that formulated floating feed containing 35% protein is ideal and economical for the nursery rearing of grey mullet in hapa in pond.

Nursery rearing of grey mullet

Growth performance of grey mullet *Mugil cephalus* fed with different dietary crude protein levels in grow out culture pond

Grey mullet, *Mugil cephalus* is a high valued food fish and an important component of polyculture in traditional and contemporary farming systems in India. Many fish farmers of Gujarat, Kerala are practising grow out culture of grey mullet fed with commercial feed in ponds. An experiment was undertaken to optimize the dietary crude protein requirement as well as the acceptance level of formulated feed on growth performance of grey mullet juveniles grow out culture in pond (2400 m2) at NGRC Farm, Matwad Navsari, Gujarat. Two diets were formulated to contain dietary crude protein levels as 35 (T1) and 40% (T2). The pond was divided into six units (each 400 sq.m) by creating internal partition in the pond with the help of HDPE garden fencing net (10 mm mesh). Grey mullet juveniles in the size range of 80-100g were stocked in each unit @ density of 400 numbers per unit and fed with two different dietary crude protein formulated floating feed @ 2-5% of body weight twice a day. The water quality parameters such as pH, temperature (^{0}C), salinity, dissolved oxygen (mg L^{-1}) were monitored daily whereas ammonia (mg/l), nitrite (mg/l), nitrate (mg/l) were estimated weekly and were found to be in the optimal range required for pond based grey mullet grow out culture. The culture is in progress and after culture of 120 days the grey mullet juveniles have grown to size of 380-420g and the highest growth parameters such as weight (g), feed conversion ratio (FCR), protein efficiency ratio (PER), specific growth rate (SGR) were found better in grey mullet fingerlings fed with formulated feed

Growth study of grey mullet fed with 35% crude protein feed in pond based system

containing 35% protein. Similarly, good growth was also observed in grey mullet juveniles during winter season (16-24 ^{0}C). The culture will be continued for another 60 days and finding of study will be helpful for suggesting dietary crude protein requirement of grey mullet juveniles for commercial grow out culture in ponds.

MILK FISH

Demonstration cum experiment on periphyton based nursery rearing of milkfish in hapas with reduced feed inputs under schedule caste sub plan (SCSP)

A total of 4800 hatchery produced milkfish fry (2.46 ±0.04 cm & 0.25±0.02 g) was obtained from headquarters, CIBA, Chennai for demonstration cum experiment on periphyton based nursery rearing of milkfish in hapas with reduced feed inputs under SCSP. A self-help group comprises of six women and two men were formed for demonstration of periphyton based nursery rearing of milkfish in hapas with reduced feed inputs at NGRC – CIBA Matwad farm. Demonstration cum experiment was carried out in 1800 m^2 pond in which hapas, 2×1×1 m were installed and provided substrates (sugar cane + split bamboo+coir) for periphyton growth using PVC frame. The experimental set up consist of 6 treatments with triplicates, T1 (periphyton + 100% feed), T2 (periphyton + 25% feed reduction), T3 (Periphyton + 50% feed reduction), T4 (periphyton + 75% feed reduction), S1 Periphyton (no feed) and C (100% feed). In each hapa, 266 milkfish fry were stocked and fed with nursery feed. Milkfish were fed @ 8% body weight twice a day in control and feed adjusted with respect to treatments. At the end of 60 days of experiment. The results revealed that growth parameters of milkfish showed a significant differences ($p<0.05$) among the treatments. The highest mean total length, 10.51±0.10 cm and bodyweight, 9.66±0.12g of milkfish was observed in treatment with periphyton+100% feeding. However, milkfish fingerlings reared in T3 (Periphyton + 50% feed reduction) attained fingerling size with mean total length and body weight, 9.20±0.14 cm and 8.24±0.19g with 95% survival rate. Based on economics of the culture experiment, milkfish reared in T3 (periphyton + 50% feed reduction) is ideal for nursery rearing in hapas provided with 40% substrate area (0.80 m^2) for periphyton growth to reduce feed cost upto 50%. A total of 4100 milkfish fingerlings were produced and sold @ Rs 15/fingerlings and this generated a revenue of Rs 61500/- to SCSP beneficiaries.

Evaluation of growth performance of *Penaeus vannamei* with a varied stocking density of milkfish in a low input based polyculture system

Polyculture of *Penaeus vannamei* with milkfish is considered as a sustainable and economically viable model of farming system. Milkfish can be used as secondary crop along with shrimp to reduce cost of production. Milkfish consumes

Preparation of periphyton growth substrate using PVC frame

Growth performance of *P. vannamei* and milkfish in low input based polyculture system at 1000 m² pond

Stocking ratio	Milkfish 0.5 no/m²+ *P. vannamei* 25 no/m²	Milkfish 0.25 no/m² + *P. vannamei* 25 no/m²
Growth performance of P. vannamei		
Initial length (cm)	0.78±0.08	0.78±0.08
Initial weight (g)	0.001	0.001
Final length (cm)	14.60±0.11	15.26±0.40
Final weight(g)	18.59±0.52	21.91±0.78
SGR (% day^{-1})	3.38±0.072	3.29±0.08
Average daily growth	0.17±0.007 g	0.19±0.07 g
FCR	1.65	1.61
Survival rate (%)	37.65	35.6
Days of culture	110	110
Production (kg)	178	192
Productivity (kg/ha)	1780	1920
Growth performance of milkfish		
Initial length (cm)	12.61±0.24	12.61±0.24
Initial weight (g)	15.49±0.54	15.49±0.54
Final length (cm)	28.16±0.23	29.54±0.29
Final weight (g)	184.02±4.10	231.1±6.91
SGR (% day^{-1})	1.58±0.042	1.80±0.06
Days of culture	80	80
Production (kg)	83	45
Productivity (kg/ha)	830	450

excessive organic matter, reduces dissolved nutrients, improving water quality and increasing disease resistance against pathogens. Field experiments were carried out to evaluate growth performance of *P. vannamei* and milkfish in a low input based polyculture system in two different 1000 m² pond. The milkfish were stocked in 2 different ratio along with *P. vannamei* i.e T1 (0.50 no/m² milkfish : 25 nos/ m² *P. vannamei*) and T2 (0.25 no/m² milkfish : 25 nos/m² *P. vannamei*). Milkfish fingerlings (12.61±0.24 cm, 15.49 ±0.54 g) were stocked after 30 days of stocking *P. vannamei*. Independent t-test was performed to assess significant difference among the treatments. At the end of 110 days of culture *P. vannamei* attained 18.59±0.52g and 21.91±0.78g with 37.65% and 35.6% survival rate in both T1 and T2, whereas, milkfish attained 184.02±4.10g and 231±6.91g in 80 days of rearing along with *P. vannamei* in T1 and T2. From the study, it was found that both stocking densities of milkfish 0.50 nos/m² and 0.25 no/m² was found to be beneficial for culture of *P. vannamei*. However, from an economical point of view, stocking milkfish 0.50 no/m² with *P. vannamei* at 25 no/m² considered ideal for low input-based polyculture system. A sum of Rs 1,32,000 was generated from sale of farm produced shrimp and milkfish at NGRC-CIBA.

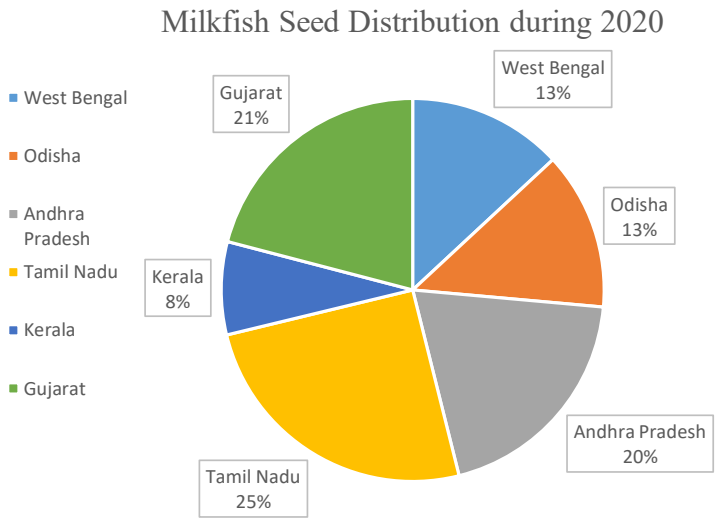
Hatchery produced milkfish seed demand during COIVD -19 period and successful polyculture of milkfish in farmers' pond at Chellanam, Ernakulam district, Kerala

Species diversification is key for sustainable aquaculture. In recent years there is an increased demand of hatchery produced milkfish seed for monoculture and polyculture among farmers from east and west coast of India. In the year 2020, in spite of COVID 19 scenario and nationwide lockdown, demand for hatchery produced milkfish seed was high. During this time maximum seed demand was recorded from Tamil Nadu (25.11%) and Andhra Pradesh (19.67%) and from the west coast

Gujarat. These seed requirements were catered to by strictly adhering to all necessary protocols.

To promote milkfish, *Chanos chanos* farming in west coast of India, a polyculture demonstration was conducted in farmers' pond at Chellanam, Ernakulum District, Kerala. Initially 3000 milkfish seed (tl.2.5 cm, 32 dph) were stocked in pen based enclosed nursery for 30 DOC and around 2700 number, 8- 12g size fingerlings were stocked along with monosex tilapia (10,000 number) and tiger shrimp (50,000) for grow out farming in 0.72 ha area having salinity 05-25 ppt. During culture milkfish were fed with indigenous feed (32% protein; 6% fat) @ 3% body weight twice a day. After a culture period of 3 months, milkfish were grown to 250 – 400g and monosex tilapia grown to 150 – 200g with 85% survival. Pond soil was treated with probiotic every 15 days and applied through feed. Partial harvest of fish was done at a farm gate price of Rs. 300/- kg. After six months of farming it is expected to get around 1 ton harvest of milkfish alone with ABW 500 g.

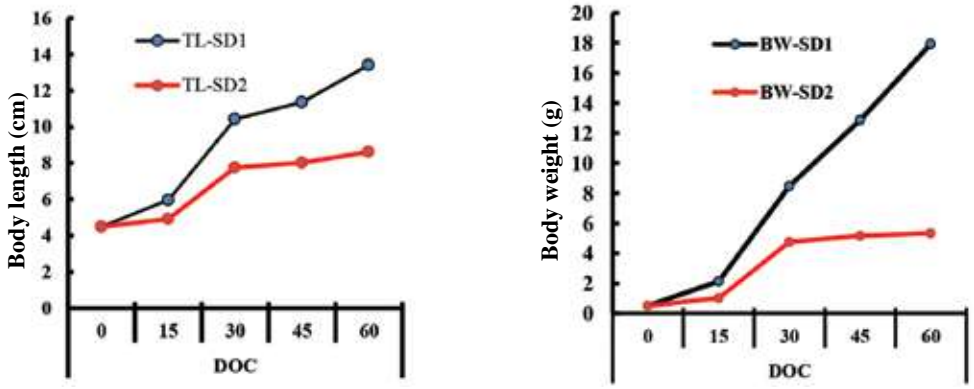
Handing over of hatchery produced milkfish seed to enterprising farmers from Andhra Pradesh



Hatchery produced milkfish seed distribution during COVID - 19 scenario

Stocking density- a factor influencing pond and tank-based production of milkfish as stunted fingerlings

Hatchery produced milkfish juveniles are used to stock monoculture and polyculture systems and also has potential as ornamental fish and also as tuna live bait. An experiment was designed to understand effect of stocking density on growth and survival of milkfish juveniles reared in pond and tank-based systems. Under pond-based experiment, milkfish fry (ABW, 0.5 g; average tl, 4.5 cm) were stocked at two different densities i.e. 4 number/m^2 and 8 number/m^2 in two nursery ponds (size 190 sq-m). Fish were fed with 8-10% of body weight and after 60 days of culture milkfish juveniles showed higher ABW, 7.92g and total length, 13.40 cm when reared at lower stocking density of 4 number/m^2 whereas at under higher stoking density of 8 number/m^2 a reduced ABW, 5.35g and tl, 8.63 cm was observed. Milkfish juveniles under lower stocking density showed positive allometric growth, which resulted in higher SGR, 5.96. In second experiment milkfish fry of similar size were stocked in two 5 t capacity outdoor tanks at two different stocking densities i.e. 200 numbers/m^3 and 400 numbers/m^3 and fed with 8-10% of body weight for 60 days. At end of rearing higher average body weight, 2g and total length, 5.66 cm were observed at lower



Length and weight of milkfish fingerlings during pond based nursery

Local farmer with nursery reared milkfish fingerlings for participatory farming trial at MES-CIBA

Growth assessment and partial harvest of milkfish with farmers' participation in MES-CIBA pond.

densities. Milkfish juveniles under lower stocking density in tank-based system showed positive allometric growth. In both the rearing system positive allometric growth was higher (b = 3.59) when fishes stocked in higher densities suggesting capacity of milkfish to get stunted by growing only body weight but keeping body length constant over time compared to rearing in lower densities (b= 3.15). Around 1100 number pond reared juveniles were given to local farmers for community-based farming in polyculture pond. After 60 days of rearing fish attained body weight, 22- 45 g, tl 17.24 – 25.8 cm in polyculture with other brackishwater finfishes. Milkfishes after reaching 100-150g size will be used for tuna live bait by local fisherman community. It is expected that use of smaller sized milkfish as tuna live bait will popularize the milkfish farming further as smaller size groups will also fetch a good market potential.

PEARLSPOT

Effect of feeding different dietary crude protein levels on growth performance of nursery cultured pearlspot fry provided with and without substrates in hapa within pond system

Pearlspot is a commercially important edible fish food and have a good demand in west coast of India. It is a omnivorous fish and with aquaculture prospects for pond as well as cage culture. Commercial nursery culture of pearlspot is gaining attraction in Kerala, Goa, Maharashtra, Gujarat as an income generation activity. Hence, a 90 days study was undertaken to evaluate the effect of feeding different dietary crude protein levels feed provided with and without periphyton substrate on nursery culture of pearlspot in hapa was conducted at NGRC Farm, Navsari. Pearlspot seed of 2.0-2.5 cm were randomly stocked @ density of 200 no's in each hapa (2 x 1 x 1 m) installed in 2000 m^2 pond. Three isocaloric diets were formulated to contain dietary crude protein (CP) levels as 30, 35 and 40%. PVC pipe frames of 4 x 2 feet (8 sq.ft) long were fabricated; sugarcane bagasses (16 numbers of 1 feet long) were attached to each frame through thread and 10 such PVC frames were floated in 10 hapas for development of periphyton. The experimental setup consisted of 7 treatments with triplicates, T1 (30% CP feed), T2 (35% CP feed), T3 (40% CP feed), T4 (30% CP feed + sugarcane bagasse substrate), T5 (35% CP feed + sugarcane bagasse substrate), T6 (40% CP feed + sugarcane bagasse substrate), T7 (Control-only sugarcane bagasse substrate). Throughout study, fishes were fed with 8-10% body weight twice a day. Regularly cleaning of hapa and feding with crude protein feed were done to avoid growth of periphyton in hapa. Hapa with sugarcane bagasse substrate were not cleaned to promote periphyton growth in hapa. Water parameters such as pH, temperature, salinity, dissolved oxygen, ammonia, nitrite, nitrate, alkalinity, and hardness were found to be in optimal range required for pearlspot nursery culture. At the end of 90 days of experiment the growth parameters of pearlspot such as length (cm), weight (g), feed conversion ratio (FCR), protein efficiency ratio (PER), specific growth rate (SGR) were found higher in fish fed with treatments provided with sugarcane bagasse substrate in hapa as compared to control. The significant difference ($p< 0.05$) was observed in growth parameters among fish fed with only CP feed treatments and no significant difference was observed in fishes fed with only CP feed provided with sugarcane bagasses substrate. No fish mortality observed in all treatment over the culture period. Hence, from the results it can be concluded that provision of periphyton substrates in hapa along with feed to pearlspot seed not only reduces the cost of feed but also promotes faster and higher growth of the seed. The findings of the study suggest that floating feed containing 30% crude protein with provision of periphyton substrate i.e sugarcane bagasse is economically suitable for commercial nursery culture of pearlspot in hapa (2 x 1 x 1 m) for obtaining higher returns to fish farmers.

Demonstration cum experiment on effect of different stocking densities on growth and survival of nursery cultured pearlspot fry within hapa in pond system

The size and density of fish plays an important role in growth, survival as well as economic return in nursery culture in ponds of brackishwater candidate finfishes. Hence a demonstration cum experiment was undertaken to study and standardize the optimum density for better growth and survival of nursery culture of Pearlspot fry in hapa in pond at Redi Village, Sindhudurg, and Maharashtra under CIBA-Mangrove Foundation Project work. A twenty four members Self-help group comprising of 18 women and 6 men were formed. Demonstration cum experiment was conducted in hapa (2 x 1 x 1m) installed in pond (4000 m^{-2}) for 90 days. The pearlspot fry (14000 no's) in the size range of 2.0-2.5 cm were stocked at densities of 200, 300, 400, 500, 600, 700 and 800 fry $hapa^{-1}$ respectively. The experiment had 7 x 3 factorial designs and throughout the experimental period fishes were fed with 30%. crude protein floating feed

Pearlspot nursery unit and fish sampling by Mangrove women SHGs at Redi, Sindhudurg in COVID-19 Pandemic

@8-10% of body weight twice a day. The water level in the pond was maintained up to 1.5 m and all water parameters such as pH, temperature (^{0}C), salinity, dissolved oxygen (mg/l), ammonia (mg/l), nitrite (mg/l), nitrate (mg/l) were found to be in the optimal range required for pearlspot nursery culture within ponds. At the end of the experiment, the fishes stocked in the range of 200-600 numbers per hapa exhibited better growth, survival, feed conversion ratio with no significant difference among the fishes stocked at densities between 200-600 fishes per hapa. However, significant difference in growth parameter and survival of fish was observed at highest stocking densities viz: between 600 and 700-800 fishes per hapa, respectively. After harvest the Self-help groups members were able to sell 3-4 inch pearlspot fingerlings @ Rs. 18-20/fingerling and earned around Rs.2.64 Lakhs. From the demonstration cum experiment study, it was found that the stocking density of 600/hapa to be ideal for commercial nursery culture of pearlspot fry in hapa in ponds.

Demonstration of pearlspot nursery culture as a livelihood generation activity by mangrove women self-help groups in different coastal districts of Maharashtra

ICAR-CIBA, Chennai in collaboration with Mangrove cell, Government of Maharashtra formed eight different Self Help Groups comprising of 16 men and 48 women at different locations for demonstration of Asian seabass nursery in pond and mangrove coastal waters in Sindhudurg and Thane district of Maharashtra. Demonstration was carried out in hapa (2 x 1 x 1m) installed in pond and carried for 90 days. Pearlspot fry in size range of 2.0-2.5 cm were procured from Kerala farmers and stocked in hapa. The SHGs were provided with feed, nursery material and trained on nursery rearing, feeding, hapa and pond management. The fishes were feed with 30% crude protein floating feed @8-10% of body weight twice a day. After rearing for 90 days, seed reached to stockable fingerlings size of 3-4 inch and 20-25g with 100% survival. The SHGs generated total revenue of Rs. 4.57 lakhs through pearlspot nursery culture under the scientific guidance of ICAR-CIBA.

ASIAN SEABASS

Farming of the high value food fish, the Asian seabass *Lates calcarifer* in recirculatory aquaculture system

Objective of the study was to farm the high value food fish, Asian seabass *Lates calcarifer* in recirculatory aquaculture system (RAS) and to develop the cost effective indigenous-RAS. Hatchery produced seabass fry (0.21 g, 18 mm) were nursery reared for 90 days in tank system fitted with flow through. During nursery rearing, seabass fry were fed with artificial pelleted feed @ 10-12% of bodyweight. At the end of nursery fish attained the average size of 2.5 g, 56 mm with average survival of 40%. Nursery reared fingerlings were stocked in brackishwater pond and reared for 30 days. After 120 days of total nursery period, fishes attained the average size of 18.2 g, 41.5 mm and stocked in RAS system @ 10 numbers /m^3 and 20 numbers/m^3. RAS was fitted with, 1 HP electric water pump, pressure sand cum biological filter (10,000L/h). Electric pump was operated for 16-18 h in a day. Fish were fed twice daily artificial pelleted feed @ 3-5% of bodyweight to the satiation. Physicochemical parameters such as temperature, pH, alkalinity, dissolved oxygen, total hardness, ammonia –N, nitrite-N were 28.5^{0}C, 8.31, 3.78 ppt, 100 ppm,

Lates calcarifer juvenile reared in RAS system

800 ppm, 0.04 ppm, 0.27 ppm, respectively. After three months of rearing at 10 numbers /m^3 and 20 numbers /m^3 stocking densities fishes attained the average size of 60.1g and 28 g, respectively.

Nursery rearing of Asian seabass in lined pond system- a comparison with tank based system following similar rearing techniques

Asian seabass nursery rearing trial were undertaken in HDPE lined pond 300 m^2 at MES in February 2020. Ponds were prepared following standard protocols; fertilized with urea and superphosphate @50kg/10kg/ton respectively. After 3 days, after algal bloom development *Artemia* nauplii @20nos/ml were stocked. Seabass seed 10,000nos in the size of 12 mm were stocked, and the seabass larvae were fed on *Artemia* nauplii and subsequently supplemented with frozen Artemia biomass @500g/day, after a week formulated feed @15% of body weight. The nursery rearing was carried out for 20 days. After 20 days seed were harvested, 70% survival was achieved, the larvae attained an average size of 3.3 cm and 1.3 g. A comparison with nursery rearing in FRP tank system which followed similar feeding protocol resulted in a survival of 75%, however a lower size of 2.2 cm and 0.8g seed were obtained in 20 days rearing period. The trial was repeated on second time in the month of June also following same protocols but the survival was only 45% and average size was 2.75cm. The above trial indicated that lined pond nursery rearing of seabass seed with feeding combination of Artemia nauplii, frozen Artemia biomass and formulated feed will yield stockable size seed of 2 to 3 inch size in 20 days rearing period will be profitable and maybe recommended for nursery rearing. The reared seed were sent to Navsari, KRC and we have to further rear to fingerlings size in our seed bank facility.

Nursery rearing of Asian seabass in lined pond

Demonstration of low volume cage culture of Asian seabass and pearlspot in floating cages installed in mangrove creeks as an alternate livelihood for coastal fisher folks of sindhudurg

ICAR-CIBA, Chennai in collaboration of Mangrove cell, Government of Maharashtra formed Self-Help Groups at different locations for Asian seabass and Pearlspot low volume low cost cage culture in creek and mangrove coastal waters in all Sindhudurg district of Maharashtra. As a part of demonstration trial, a total number of 113 cages of 4 x 4 x 2 m ($32m^2$) were allotted to 28 SHGs units comprising of 277 mens and 62 womens of Sindhudurg. The Asian seabass seed (3-4") procured from Andhra Pradesh were stocked in cages @ density of 1000no.s/cage and fed with CIBA seabass plus feed @ 3-10% of body weight two times a day.

The fishes attained growth of 300-850g with survival ranging from 30-70%. Pearlspot seed (1-2 inch) stocked in cages at density of 3000 no.s/ cages and fed with CIBA Seabass^{Plus} feed @ 3-10% of body weight two time a day. The fishes attained growth 50-100g with survival ranging from 50-70%. The culture of all cages harvested in June 2020 and the fish, pearlspot and seabass were sold to local vendor @ Rs. 100-450/- kg. The demonstration work resulted in revenue generation of Rs. 24.08 lakhs to SHGs beneficiaries of Sindhudurg, Maharashtra during COVID-19 pandemic. The present on-going nursery, pre-growout culture, cage culture training and demonstration in different coastal districts of Maharashtra is emerging as successful livelihood model since it provide the income generation for the unemployed coastal fisher communities through participatory approach of Self Help Group with the technological support by ICAR-CIBA and funding supporting from the Mangrove Foundation, Government of Maharashtra.

Harvest of cage cultured Asian seabass

On site grading of Asian seabass in grow out cage culture units by mangrove SHGs in Sindhudurg, Maharashtra

RED SNAPPER

Pond based cage culture of red snapper *Lutjanus argentimaculatus* to study feed acceptance and growth performance

A study was undertaken on formulated feed acceptance and growth of wild collected red snapper in pond-based cage culture in Ratnagiri, Maharashtra. Red snapper (3-6" & 20-40g) were collected and purchased from local dragnet fishermen. In 2019-20, around 1130 juveniles of red snapper are collected from different local creeks of Ratnagiri. For cage culture in pond, the cages of 4 x 4 x 1 m were fabricated by using 18 mm and 30 mm HDPE knotless nets and floated in pond (1.5 m water depth) with the help of PVC pipe frame. The fishes were fed with 6-8% body with the CIBA formulated artificial feed twice a day. During sampling of the fishes, no cannibalism is found in red snapper culture. The stocked fishes (1130 no.s) attained 600-1200g within period of 6-8 months with survival ranging from 64.75%. The findings revealed that wild collected red snapper easily accept the artificial feed and is a good candidate species for cage culture in pond as well in creeks as an alternative livelihood for coastal fishfolks.

Collection of Wild Red Snappers from different creeks of Ratnagiri. Culture of wild Red snapper in Cages installed in Ponds, Ratnagiri, Maharashtra

BRACKISHWATER CATFISH

An innovative nursery rearing method of brackishwater catfish, *Mystus gulio* in simplified floc system

Brackishwater catfish, *Mystus gulio* has good market demand as a high value species in Eastern India and Bangladesh. The hatchery produced fry are further reared in nursery to produce fingerlings suitable for stocking in grow-out system. Nursery rearing methods of this fish in net cages and ponds have been standardized for fingerling production. To develop an innovative and cost-effective method of nursery rearing, 25 days old fry (mean body weight: 0.30±0.04 g) were reared for 60 days in a simplified floc system consisting of 2 ton tanks kept under shade with transparent roofing. Before 10 days of stocking, tank water was added with molasses, Plankton^{Plus} (a plankton booster developed by CIBA) and *Bacillus subtilis* DDKRC5 (JN641293) (4.6×10^9 CFU/ml) at 0.05% (v/v) keeping carbon:nitrogen (C:N) ratio as 15:1 for development of flocs. Varied stocking density at three levels (50, 75 and 100 no./m^3) was the test variable in triplicate tanks. A CIBA formulated feed (crude protein 30%, lipid 6%) was provided at 20% of biomass per day for the first 10 days, followed by 18, 15, 12, 10 and 8% adjusted at 10-day intervals, actually 50% of feed quantity was reduced. After 60 days, fry attained significantly higher growth (79.65±1.35 mm/ 5.48±0.25 g) at 50 no./m^3 stocking density compared to other groups (P<0.05). However, a significantly higher survival (95.14±1.11%) with lowest apparent feed conversion ratio (1.27±0.10) was obtained at 100 no./m^3 stocking density (P<0.05). Microbial

Simplified floc system with 2 ton tanks.Harvested *M. gulio* fingerlings from simplified floc system at 50, 75 and 100 no./m3 stocking densities

dynamics in water examined at 20-day intervals revealed that total heterotrophic bacterial (THB) population was significantly lower at 50 no./m^3 stocking density as compared to other two stocking densities at the final day of experiment (P<0.05). However, total *Vibrio* count did not vary among treatments at any sampling time. Similarly, no significant differences were recorded among treatments for water quality parameters. This study suggested that in brackishwater simplified floc system, *M. gulio* fry can be reared at higher density of 100 no./m^3 to achieve maximum survival and better feed conversion for economic benefit. This is the first report on nursery rearing of *M. gulio* in simplified floc system and the information has practical significance as a major step for establishing seed rearing package of practice, and would benefit the nursery operators.

MONO ANGEL

Nursery rearing of silver moony (*Monodactylus argenteus*) with farmers participation as an additional income generation activity

As an initiative to promote brackishwater ornamental fish rearing, ICAR- CIBA supplied hatchery produced silver moony seed to the fishermen youth in Karikattukupam village, Muttukadu, Chennai for nursery rearing and income generation. Seeds were stocked in cages and hapas in the pond system and fed with formulated diet. In 60 days culture period the fishes attained weight ranged from 25 to 30 g. Fishermen youth was able to produce 9 to 10 cm with in a 60 days period of nursery rearing in small net cages and hapas and he sold the seeds @ Rs. 50/- per seed. The initiative showed that nursery rearing of this brackishwater ornamental species to can be developed as an income generation activity.

Nursery rearing of silver moony

IMTA cage unit established at Hadi, Sindhudurg stocked with tiger shrimp postlarvae in IMTA cages

Demonstration of integrated multi trophic cage aquaculture in creek of sindhudurg

Integrated Multi-trophic aquaculture is one of the most promising and sustainable aquaculture models in brackishwater aquaculture and a potential strategic choice for aquafarmers. To develop and propagate family farming models of candidate finfish and shellfish species in west coast of India, IMTA cage culture was initiated in Gad creek of Malvan, Sindhudurg. Three families comprising of two men and one women with experience in brackishwater fishing in creeks were selected from villages of Tondavali, Talashil and Pan-Khol Juva, Taluka-Malvan, District-Maharahstra for IMTA culture of seabass and green mussels in cages installed in creeks. For culture, 700 seabass fingerlings (8-10 cm and 06-12 g), 300 pearlspot (1-2 inch and 01-02 g) and 10,000 tiger shrimp (PL 20) were stocked in each pre-fabricated GI pipe frame cages (8 x 4x 1.2 m). The shrimp were cultured in 40 micron mesh cage net (4x4x2 m) till grown to size of 3-5g and later in 3 mm mesh cage net (4 x 4 x 2m) till harvest. The seabass were fed with CIBA seabass slow sinking grow-out feed of size 2-6 mm @ 10% body weight two times a day whereas pearlspot were fed with CIBA Polyplus feed @ 8-10% body weight and tiger shrimp were fed with shrimp feed @5-10% body weight two times a day. To achieve good growth, survival and to avoid cannibalism, regular grading of seabass fish at

Crab box culture in pond. Livestock shed on pond dyke

an interval of 15 days was carried out at each IMTA cage site. After culture for 4-6 months, seabass attained 200-300g with a survival ranging from 60-95%; pearlspot attained a body weight of 40-70g with 70-90% survival and tiger shrimp attained 13-20g with survival ranging from 20-50%. Due to heavy monsoon, harvesting was done in mid-June 2020, a total revenue of Rs. 1.0 lakhs was generated. Integrated cage culture of shrimp and finfish in open creek is the first kind of activity and needs some more scientific research for better utilization of untapped and unutilized brackishwater bodies and creeks for sustainable development of brackishwater aquaculture in India. However, the revenue and income from this system depends mainly on availability of culture area, availability of seeds of various compatible species to be cultured and management of the system and can be successfully adopted across the all coastal states of country through the year.

Development and demonstration of integrated fish farming system in brackishwater pond along with livestock and horticulture on pond dyke as a livelihood model for tribal communities of Palghar, Maharashtra

Under TSP, an integrated fish farming system (IFF) in brackishwater pond with livestock and horticulture on dykes has been developed for tribals of Chinchani Palghar. The model comprises nursery rearing of Asian seabass, *Lates calcarifer*, pearlspot, *Etroplus suratensis* in hapas, polyculture of pearlspot and crab box culture, *Chanos chanos* and pearlspot in pond with surati goat, poultry farming on dykes and low salt tolerant tomato and brinjal vegetable crops on dyke. The pond of around 2000 sq. m with a depth of around 1.5 m has been developed for IFF system with a goat (16 x12 ft) and poultry shed (20 x20 ft) on one side of pond dyke whereas 50 sq.m area of other dyke developed for horticulture crop. The selected tribal group (8 No.s) comprising of men and womens of Chinchani village were trained on each aspect of fish culture, livestock culture and all required material was provided to them. After a period of 75-90 days culture, SHGs sold about 5000 pearlspot (3-5") to the local fishermen for cage culture in creek and generated a revenue of Rs. 1.50 lakhs . The culture is in progress and soon the tribals will be provided vegetables, goats and poultry for livelihood development.

Development and demonstration of integrated fish farming system in brackishwater pond along with livestock and horticulture on pond dyke as a livelihood model for tribal communities of Navsari, Gujarat

An integrated fish farming system (IFF) in brackishwater pond with

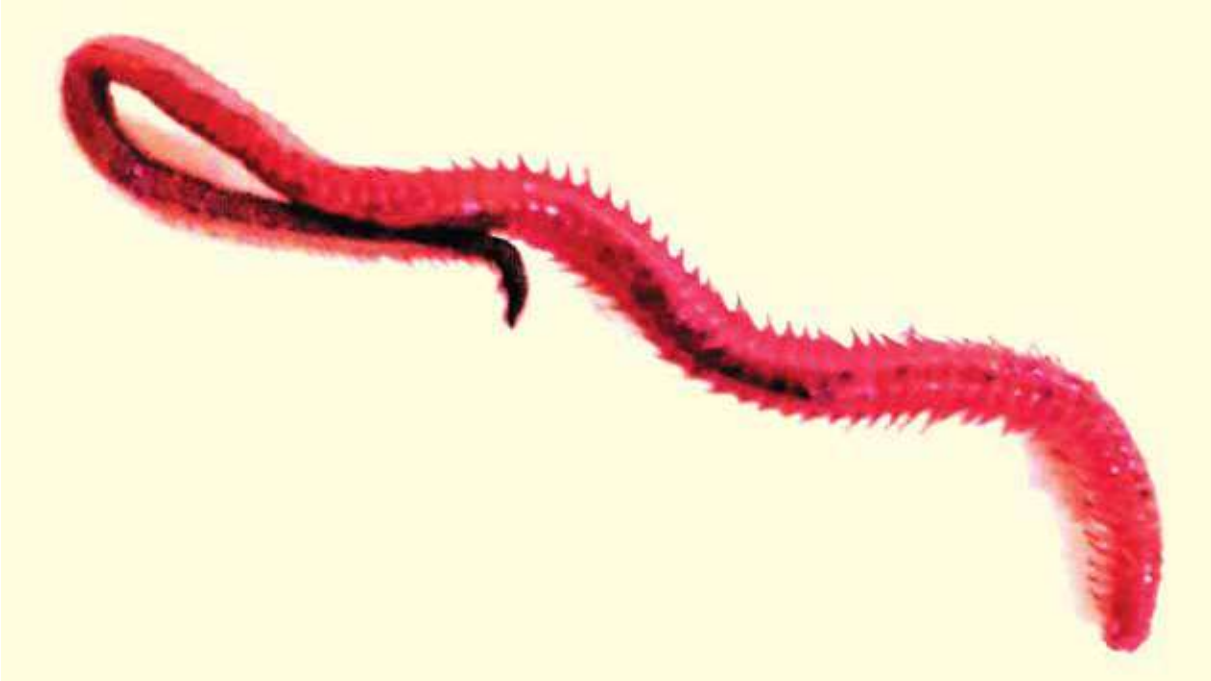
Milk fish seed stocking. Cattle shed etc

livestock and horticulture on dykes is being developed at NGRC Matwad farm for tribals of Matwad Village, Navsari, Gujarat. The model comprises nursery rearing of Asian seabass, *Lates calcarifer*, Milkfish, *Chanos chanos*, Pearlspot, *Etroplus suratensis*, and White leg shrimp *P. vannamei* in happas, polyculture of Milkfish, *Chanos chanos* and Pearlspot in pond with surati goat, poultry farming on dykes and low salt tolerant tomato and brinjal vegetable crops on dyke. The pond of around 2000 sq. m with a depth of around 1.5 m has been developed for IFF system with a goat (16 x12 ft) and poultry shed (20 x20 ft) on one side of pond dyke whereas 50 sq.m area of other dyke developed for horticulture crop. The selected tribal group (8 no's) comprising of men and women of Matwad village were trained on each aspect of fish culture, livestock culture and the required input material were provided to them. The selected tribal group of Matwad village successfully completed nursery rearing of milkfish pearlspot and shrimp in hapas installed in the IFF pond. Along with nursery, polyculture of milkfish, *Chanos chanos* and pearl spot, *Etroplus suratensis* was carried out in pond. The fishes were fed with CIBA Polyplus feed twice a day @ 3-8% bodyweight twice a day. The three surati goats are being reared and the droppings from goat shed were allowed to fall into the pond water which in turn acted as a fertilizer for the pond system. The goats were fed with grass grown on pond dyke and artificial feed in morning and evening respectively. Integration of livestock with fishes resulted in good growth and survival of fish. After a period of 75-90 days culture, SHGs sold about 3500 milkfish (3-5") and 3500 pearlspot (3-5") to the local fishermen and generated a revenue of Rs. 1 lakh. The culture is in progress, stocked fishes as well as vegetables growth is good and soon the tribals will be provided goats and poultry for livelihood development

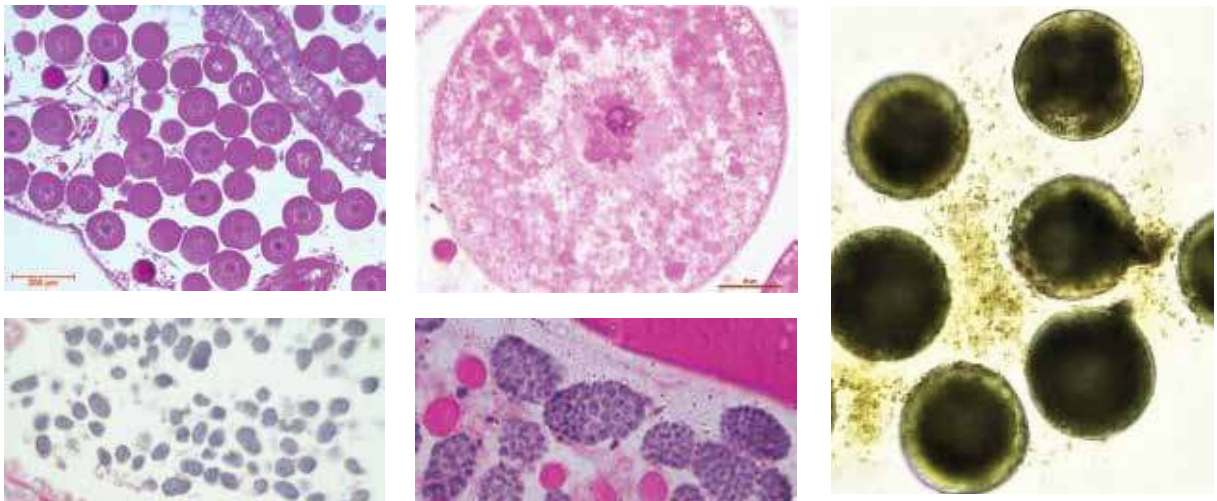
POLYCHAETES

Culture of estuarine polychaete worm *Nemalycastis abiuma.* influence of salinity, type of feed and substrate

Marine worms, Polychaetes, have been widely used as maturation diet for penaeid shrimp across the world, it has becom an integral fresh feed in shrimp and fish maturation diet. Inclusion of polychaete as part of shrimp diet provide essential nutrients, hormones and polyunsaturated fatty acids required for shrimp growth and maturation. *Nemalycastis abiuma* is a brackishwater polychaete of the family *Nereididae* under subfamily *Namanereidinae.* The species is found associated with organic rich sediments with

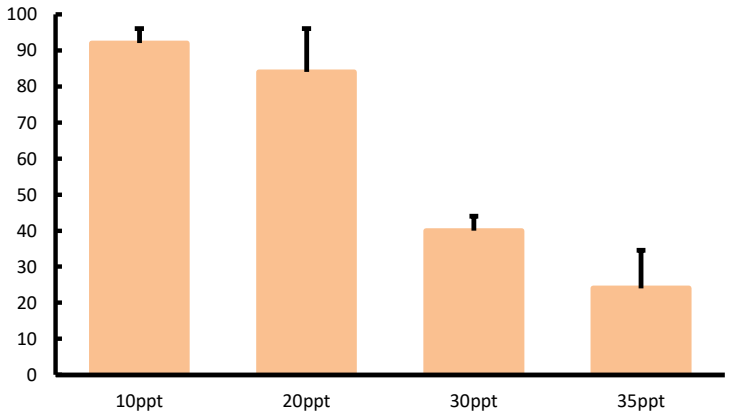


Nemalycastis sp. A) Whole worm



Various vitellogeneic and spermatogenic stages of polychate, fertilized eggs are shown in last panel

decaying plant materials. To rear the worms under captivity, juvenile worms were collected; length and weight were measured, and reared in a sediment bed of 15 cm thickness prepared from estuarine soil topped with filtered sea water in 30 litre plastic tanks provided with gentle aeration. To study the salinity tolerance, the tanks were filled with seawater of different salinity (10 ppt, 20 ppt, 30 ppt and 35 ppt). Worms with an average body weight of 0.16 ± 0.09g and length 6.6 ± 1.1cm were stocked in tanks at a stocking density of 25 worms/tank. Four types of feeds tested were: powdered leaves of 1) *Spinacia oleracea* 2) *Avicennia marina* 3) *Salicornia sp.* and 4) powdered shrimp feed. The experiment was conducted for 25 days. To find a suitable substrate for culture, another batch of 50 worms each were cultured in, a) Pond soil, b) coir pith and c) sludge from Biofloc tank. The average percentage survival was 92 ± 4%, 84% ± 12, 40% ± 4 and 24 ± 10.5% respectively for 10 ppt, 20 ppt, 30 ppt and 35 ppt salinity. The percentage survival

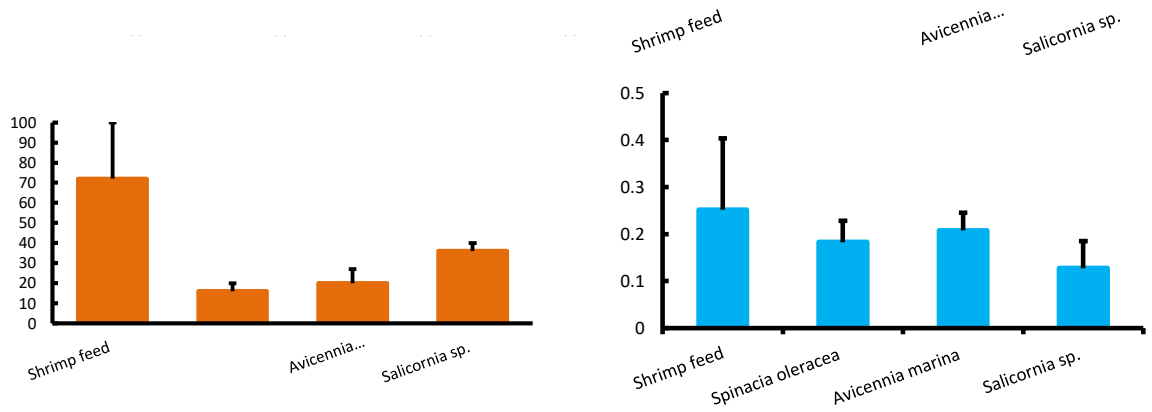


Salinity tolerance of (Nema Nereis) *Nemalycastis sp.*

for various feed types were 72 ± 22%, 36 ± 4%, 20 ± 6.9% and 16 ± 4% respectively for shrimp feed, *Salicornia sp., Avicennia marina* and *Spinacia oleracea*. The highest average weight (0.25 ± 0.15 g) was achieved for shrimp feed. Among various substrates studied the highest survival (89 ± 4.2%) and total biomass production (7.1± 0.9 g) was observed in coir pith. During the experiment, the worms attained maturity and laid down eggs. The average size of the mature egg was 128. 8 ± 2.8 µm.

The results suggest that the type of feed, substrate and salinity are the factors determining the survival and growth of *Nemalycastis sp*. under captive condition.

Microscopic observation of histological sections of *N. abiuma* was carried out. Histological observations successfully demonstrate the sexual features of *N. abiuma.* A total of 10 specimens were observed, of which seven were females and three ware male. The length-weight relationship of the species showed that the males



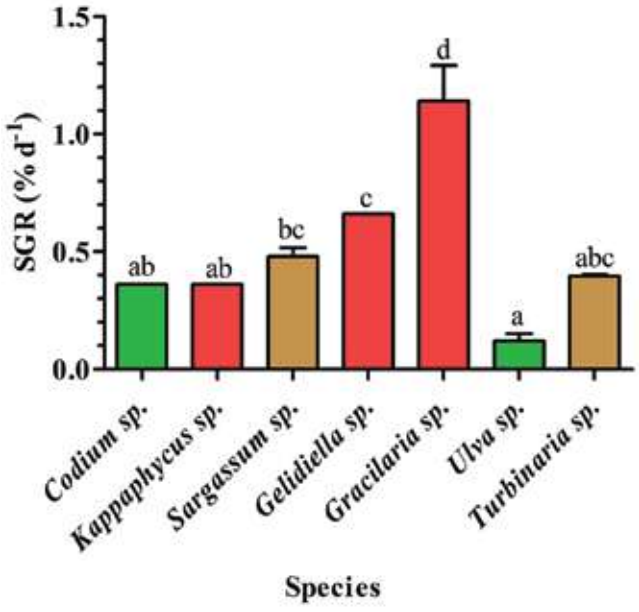
Experiment to investigate on suitable feed for (Nema Nereis) *Nemalycastis sp.*
A) Percentage of survival B) Weight gain in g in response to various feed

are smaller than the female (male: 8 ± 1cm long and 0.22 ± 08 g; female: 13.5 cm ± 3.4 cm and 0.55 ± 0.2 g). It was found that ovaries of *N. abiuma* are located in the coelomic cavity. In each segment of the worms' posterior side, the ovary appears as a coelomic germ cell cluster surrounded by follicle cells. Each cluster of the ovary is found attached to the genital blood vessels. The smallest oocytes found in the specimens were 19.5 ± 5.9 µm in diameter. The Average diameter of the egg at the initial stage of vitellogenesis was 78.4 ± 4.1 µm. The largest observed egg measured 127.5 ± 5.6 µm in diameter. The entire coelomic cavity is filled with uniform size mature oocytes) in matured animals. At 100X magnification, following the structures of the egg could be visible. A central nucleus followed by clear cytoplasm was observed. A cortical zone with many cortical granules was located under the vitelline membraneMicroscopic observations of the male revealed spermatogenesis taking place in the coelomic cavity. The sperm plates appeared throughout the coelomic cavity of each posterior segment noticed. The germinal elements developed in the coelomic cavity appeared as a mulberry-like cluster of spermatogonia. Sperm plates had an average Length of 25.09 ± 5.3 µm and a width of 16.7 ± 2.7 µm. The average numbers of spermatocytes present in the sperm plate were 30 ± 12 Numbers per plate. The average size of spermatozoa was 1.9 ± 0.6 µm

SEA WEEDS

Culture trial of different commercially important seaweed species in brackishwater system

Six different seaweed species of commercially importance were collected from Mandapam coastal region of Ramanathapuram district, Tamil Nadu. To estimate



Specific growth rate (SGR) of different species after 96 h. Data represents mean ± SE (n = 3). Different small and capital letters indicate statistical significance ($p < 0.05$) among different seaweed biomass intensity and species, respectively.

the growth performance in brackish water salinity regime, an experimental trial with eight treatment (seven seaweed species from Mandpam coast, *Gracilaria* Sp. locally available in Chennai coast and a control) was conducted in 24 plastic tanks each having a capacity of 0.03 m^3 (triplicate) were filled with filtered sea water of 25 ppt salinity. The experiment was continued up to 96 h from the time of addition of seaweed in the tanks and final biomass was recorded.

Specific growth rate was observed significantly higher in *Gracilaria* (1.141 ± 0.15) among the three Rhodophytes. Similar growth was observed between two Pheophytes and in case of Chlorophytes, the *Codium* sp. showed better growth performance in brackishwater salinity. Overall growth performance in brackishwater salinity regime was found maximum in *Gracilaria* sp. This species has been identified as one of the most abundant species in the local brackishwater system. Among the Rhodophytes, *Kappaphycus* is more abundant than *Gelidiella* in Mandapam coast but this study led us to a challenge for its culture in brackishwater system due to its slower growth rate (0.36 ± 0.001). Therefore, further trials were conducted to study the growth performance of *Kappaphycus* in brackishwater salinity regime.

Experimental trials of *Kappaphycus alvarezii* farming carried out at MES

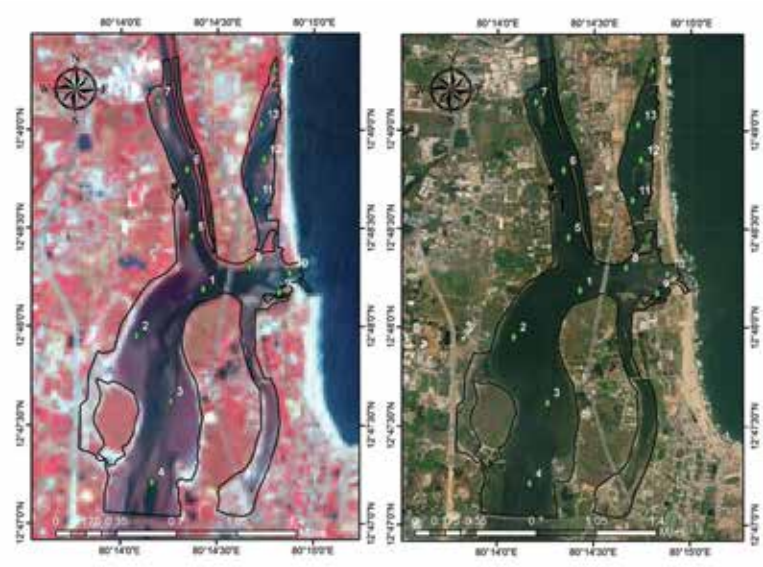
Kappaphycus alvarezii (Doty) is the most important carrageenophyte cultivated in the world for the production of κ-carrageenan. The rapid growth rates, easy dispersal and ways to cultivate *K. alvarezii* make the species adaptable and flourish in new habitats. Understanding the environmental factors influencing survival and growth of *K. alvarezii* in brackishwater is of prime importance. Therefore, an experimental trial of *Kappaphycus* farming was conducted at Muttukadu Experimental Station (MES) to evaluate the influence of environmental parameters for the growth of *Kappaphycus* in confined brackishwater discharge system (14 m^2). The *Kappaphycus alvarezii* seedlings were procured from Mandapam coastal region of Ramanathapuram, Tamil Nadu.

Equally weighed (750g as initial weight) *Kappaphycus alvarezii* seedlings were kept in floating cages and installed in two effluent cement tanks (depth 1.8 m) of shrimp hatchery for observing the growth. ADG increased to 3.71g per day in the next 7 days of culture. SGR increased to 0.47% per day. The nutrient concentrations of NO_2-N, NO_3-N, NH_4-N, and PO_4-P were found higher in the discharge tanks. Therefore, the SGR of *Kappaphycus* was ranged between 0.3 – 0.47% per day during 14 days of culture in the brackishwater salinity regime.

Brackishwater resource management

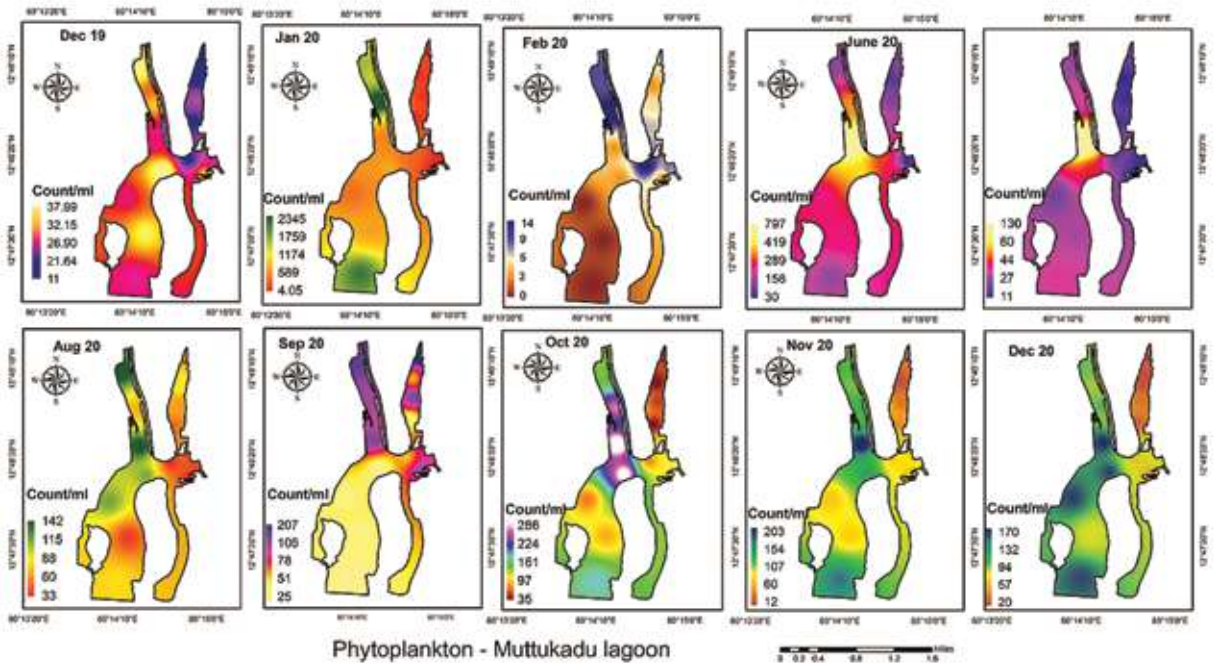
1. Muttukadu lagoon mapping

Muttukadu backwater is located parallel to east coast road, and it forms a complex system of shallow estuarine network and drains into Bay of Bengal. In

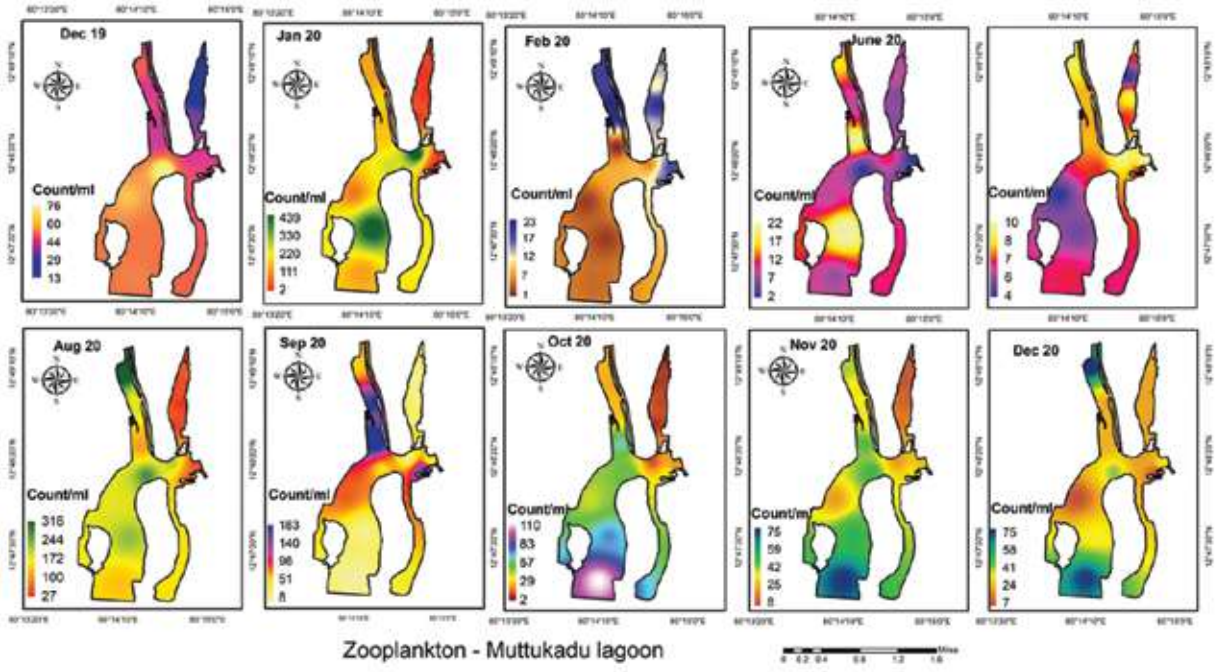


Location number	Name
Location 1	Boat house opposite
Location 2	Hindustan college opposite
Location 3	Thiruvidanthai
Location 4	Kelambakkam
Location 5	Padur
Location 6	NIEPMD-NBER opposite
Location 7	Panjabur opposite
Location 8	Near CIBA island
Location 9	Opposite to CIBA island
Location 10	Bar mouth
Location 11	Near crab hatchery CIBA
Location 12	Near olive island
Location 13	Nilgiris opposite
Location 14	Near MGM

Muttukadu backwater sampling location map



Monthly distribution of phytoplankton



Monthly distribution of zooplankton

order to map the productivity of the lagoon 14 representative sampling locations has been identified Monthly samples were collected and analysed for primary productivity (Phytoplankton & Zooplankton), and the physico chemical parameters of water from January 2020 – December 2020. Phytoplankton has been mapped for its total count and it varies from lowest 4 to the highest 2,345 in the lagoon Monthly variation showed phytoplankton is less in February 2020 December

2020 when compared to January 2020 and June 2020. Highest phytoplankton is found in sampling location 1-7 *Thalassiosira* species is the most prominent phytoplankton species in the lagoon followed by *Chaetoceros* sp. The occurrence of *Thalassiosirahas* has been reported in all months and was highest during July 2020 (85.44 %). Zooplankton has been mapped for its total count as shown in figure. Rotifer species is observed to be most prominent species compared to others zooplankton species. The diversity index is given in figure.

2. Seaweed and Seagrass mapping

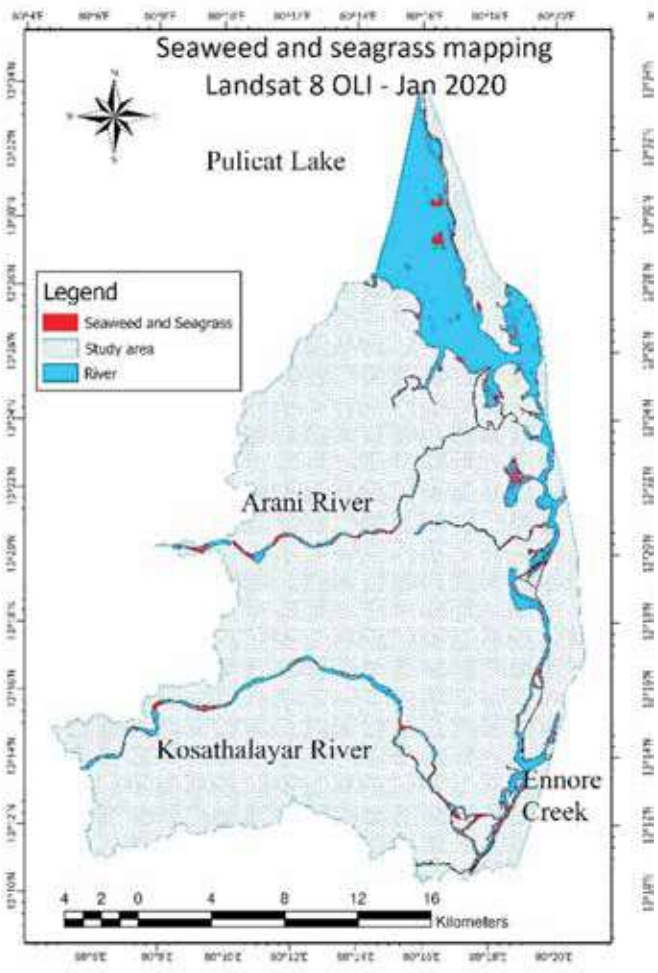
Seaweed and seagrass mapping has been done using Landsat 8 OLI image. To increase accuracy pan sharpening has been applied using ArcGIS pro 2.6. NDVI technique ((NIR-RED) / (NIR+RED)) has been used for estimating seaweed and seagrass. Field survey and ground truthing has been done and the seaweed mapping has been done. From the map, it is observed that seaweed and seagrass are more prominent after February month. The various species available in Pulicat Lake has also been given.

3. Flood mapping and modelling

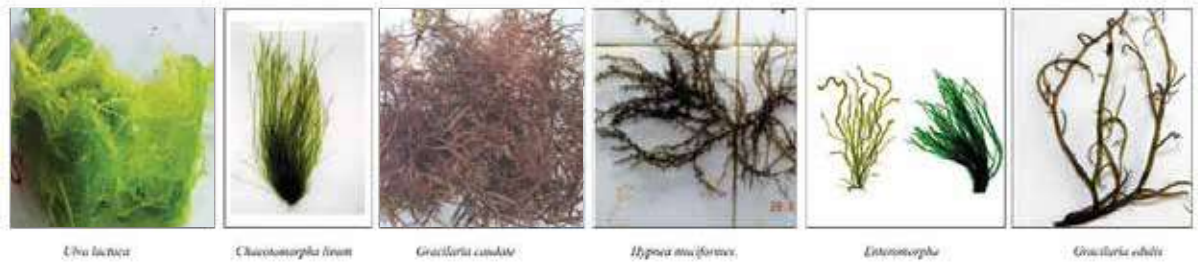
Brackishwater aquaculture farms are located in the coastal regions and they are prone to flooding

Land area details

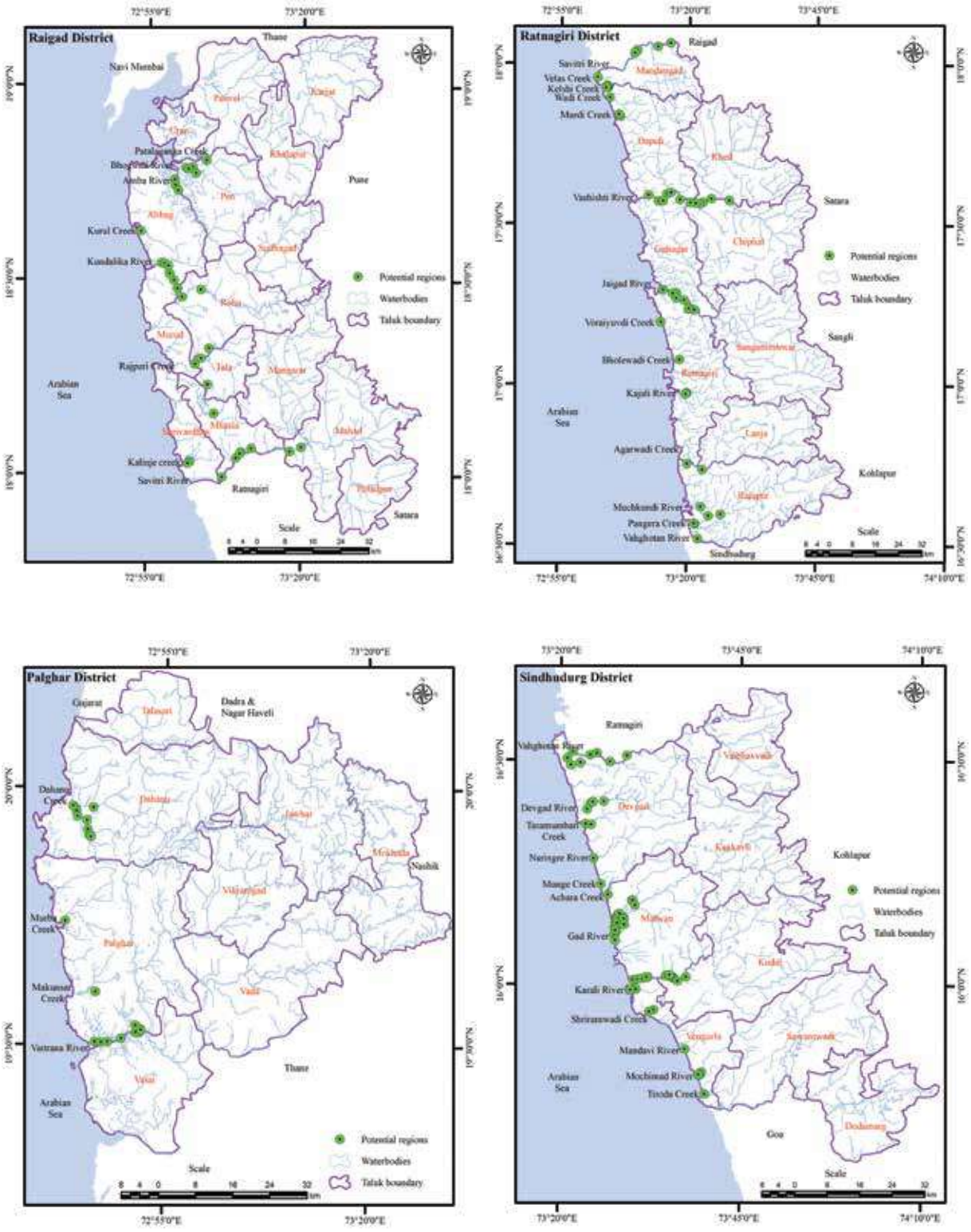
S.no	Place	Survey number	Total area in acres
1	Thiruvidanthai	37, 38, 39pt1	12.75
2	Thiruvidanthai	43pt	11.01
3	Kelambakkam	188pt	27.48
4	Thaiyur	1402pt	13.31
Total area			64.55



Seaweed and Seagrass Species available in Pulicat Lake - Thiruvallur District



Seaweed and Seagrass mapping using Landsat 8 OLI



Suitable sites for cage aquaculture in coastal districts of Maharashtra

due to its lower elevation. During last decade, Chennai faced three flooding viz., Chennai 2015 flood, Vardha 2016 and Nivar 2020 cyclones. Hence, a detailed flood analysis was done for Kovalam Experimental Station (KES) through Aerial surveying, Total station and Differential Global Positioning System.

Kovalam Experimental Station (KES) is about 64.55 acres covering 4 land parcels located viz Thiruvidanthai part 1 and 2, Kelambakkam, and Thaiyur. The details of the 4 land parcels are given in table.

Detailed flood inundation area for KES during Chennai flood 2015 Vardha 2016 and Nivar 2020 were analysed using sentinel 1A. Result shows that maximum height at which flood inundated in KRC during Chennai flood 2015, Vardha 2016, Nivar 2020 is more or less similar, with 2.4-2.55m, 2.3-2.45m and 2-2.2m respectively. Highest flooding occurred during 2015 which is about 2.55m above MSL.

Flood modelling

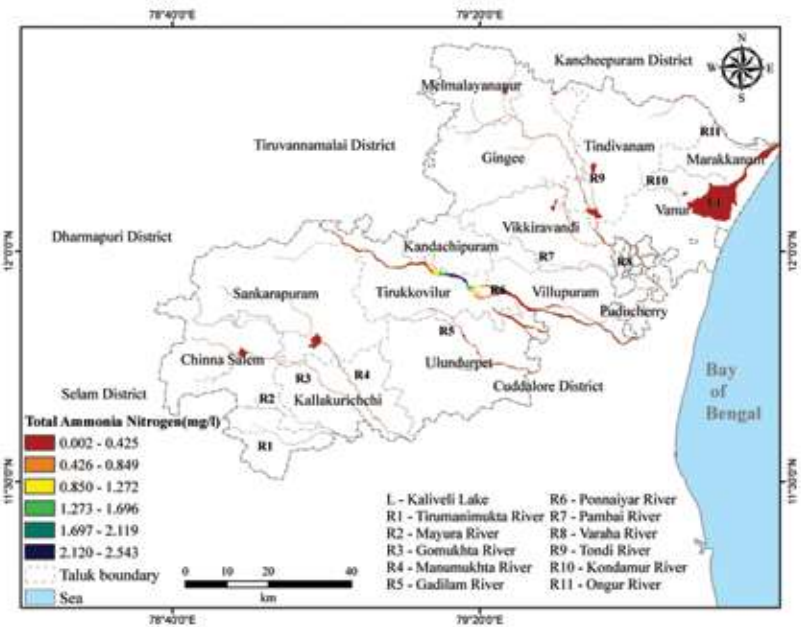
Flood modelling was done using ArcScene and the inundation area was stimulated. Water inundation area at 2.5m height in Thiruvidanthai, Kelambakkam and Thaiyur is about 9.60 acres, 22.80 acres, 11.02 acres respectively. The water height during low tide ranges from 0.8-1.3m and during high tide, it ranges from 1.3-1.5m. The flood model has been stimulated from low tide (0.8m) to highest possible flooding height (2.9m). The flooding scenario at different height is shown in figure. Blue colour indicates water. The results obtained could be used for planning and developing the area.

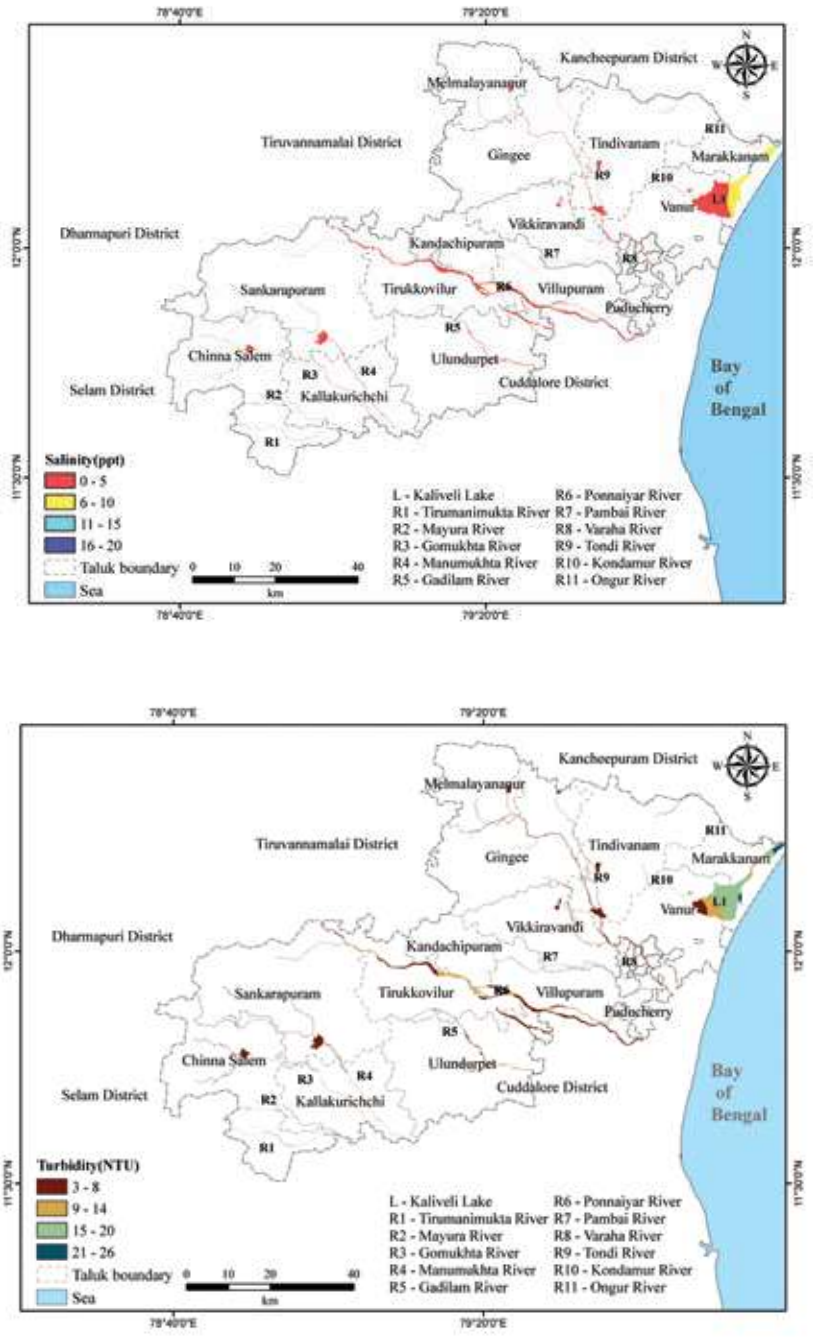
Mapping suitable sites for cage aquaculture in the waterbodies of coastal Maharashtra

The State Maharashtra has vast stretches of estuaries, creeks, and mangrove swamps, which offers great potential for cage aquaculture farming. To develop sustainable aquaculture, the ecological characteristics in the source water bodies of Palghar, Raigad, Ratnagiri, Sindhudurg and Thane Districts were assessed in all seasons. The characteristics namely water depth, temperature, turbidity, pH, salinity, dissolved oxygen, total ammonia nitrogen, nitrate, nitrite, phosphate, and Chlorophyll 'a' have been quantified. Although most water quality parameters were in optimum range to establish cages aquaculture, turbidity and water depth were major limiting factors, which played a crucial role in selecting sites for cages in the districts of Palghar, Raigad, Ratnagiri, and Sindhudurg. Water quality was not suitable in the water bodies of Thane District for cage aquaculture. After considering all the influencing factors, the appropriate sites have been identified for potential cage aquaculture using GIS spatial analysis.

Expanding aquaculture based on environmental characteristics and Coastal Aquaculture Authority regulations

The lessons learned from aquaculture failures have forced us to look into scientific methods that can integrate spatial and other resource characteristics in planning. Land and water resources type and extent, water quality characteristics in source water bodies, soil characteristics, and coastal aquaculture authority regulations have been used in identifying suitable areas for shrimp aquaculture. Eighteen thematic layers were grouped into four fundamental requisites for





Source water characteristics in Villupuram District of Tamil Nadu

vannamei aquaculture, namely land class, water (pH, temperature, salinity, dissolved oxygen, turbidity, total ammonia nitrogen, nitrate, chlorophyll, and phosphate), soil (pH, electrical conductivity, organic carbon, and texture) and resource availability (distance to road, source water, hatchery, and processing facility). The pairwise comparison matrix was used to assign the weights to each criterion based on its relative importance. Spatial restriction rules were framed based on guidelines of the Coastal Aquaculture Authority of India, which excluded the regulated areas, including agriculture, mangroves, forest, settlements, water bodies, regions near the high tide line. The existing shrimp farm area was 715 ha, and the area available for aquaculture expansion in the future was 198 ha in the villages namely Kandadu east, Marakkanam north, Nadukuppam west of Villupuram District. The final area outputs were compared with ground truth survey data and found to be consistent.

Reproduction, Breeding & Larval Rearing

Sustainability of aquaculture depends on continuous control of reproduction. It is the indispensable prerequisite for the domestication and genetic improvement of the farmed stock. ICAR CIBA has been undertaking innovative approaches to develop the technology for controlling captive reproductive maturation, spawning and larval rearing. As the production of stockable juveniles in the aquaculture production system is the major challenge, efforts were made to develop nursery rearing technology of many species. Diversification of species in brackishwater aquaculture is fundamental for the sustainability of aquaculture. Therefore, the major focus of CIBA has been developing farming technologies for diversified brackishwater species.

Reproduction, Breeding & Larval Rearing

Penaeus indicus

Breeding ans Seed production of first-generation *P. indicus*

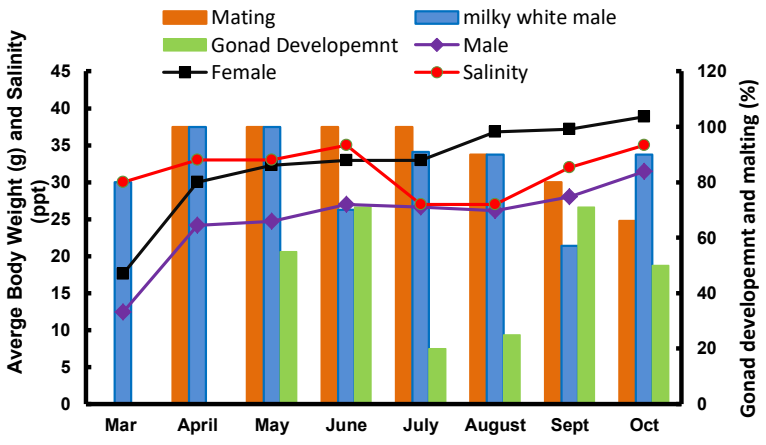
Closing of the life cycle is one of the major thrust areas of research to develop the breeding program. Towards this goal, captive broodstock development of *P. indicus* was initiated. The breeding and seeds production of first-generation produced from the progeny of the wild broodstock were studied. The F1 generation population started mating in 17-18g onwards based on the stocking density (4-7 month grow out duration) in saline water having 32 ppt and above. About 36% of gonad development recorded in 7 months onwards (28g onwards) and reached 70% in 10-11 months . The peak in reproduction was recorded during the July-August period due to a better salinity profile (32-36 ppt). A total of 13 breeding cycles using 40 broodstock of F1 (12 times) were carried out, and 32% of the female having gonad development responded to breeding manipulation. The fecundity ranged from 28,000-90,000. The fecundity per gram body weight ranged 850-2250 gram per body weight whereas wild had 2500-10,000 eggs/g. About 20% of females showed multiple spawning, and 10% had three times breeding per female. Compared to the reproductive performance of the F0 population, the first-generation broodstock had better performance in terms of successful spawning (13 successful aspen cycles compared to 9 cycles in FO population last year).

Further, to enhances reproductive performance, the exogenous steroids (17 β-estradiol) was injected administered. The β-estradiol injection in ablated spawners triggered spawning (200 µL / female) and spontaneous release of the eggs. Nevertheless, the hatchability of the eggs was poor, and none of the E2 injected females responded multiple spawning. Similarly, although hormone injection could initiate 50% gonad development in reproductively passive females, it could not attain the final stage of maturity or spawning. This indicates a deeper understanding of the endocrine mechanism behind the reproductive active and passive females is worth investigating.

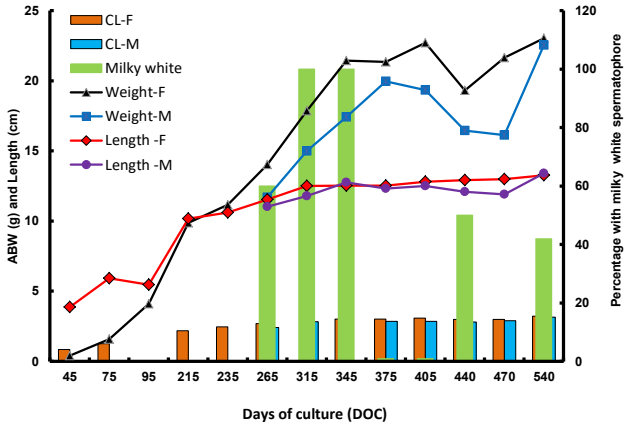
Indoor rearing of domesticated stocks (F1) was carried out at 270 numbers per 10-ton tank for 18 months in a sand-based in situ bio filtration-based circulatory aquaculture system. The females and males attained average body weight, 23.05± 3.70g (CL: 3.23 ±0.17, TL 13.26±0.59) and 22.55 ±5.58g (3.14± 0.21 CL,13.4±0.77) with the highest body weight 26 g. About 10% female population mated, whereas males had milky white spermatophores. Nonetheless, no gonad development was recorded even after 540 days of culture.

Grow out performance of second generation

The second-generation progeny from F1 was nursery reared, and its growth performance was studied in indoor, outdoor sand RAS, cage,



Broodstock growth and gonad development of male and female domesticated first generation of *P. indicus* in broodstock development pond system

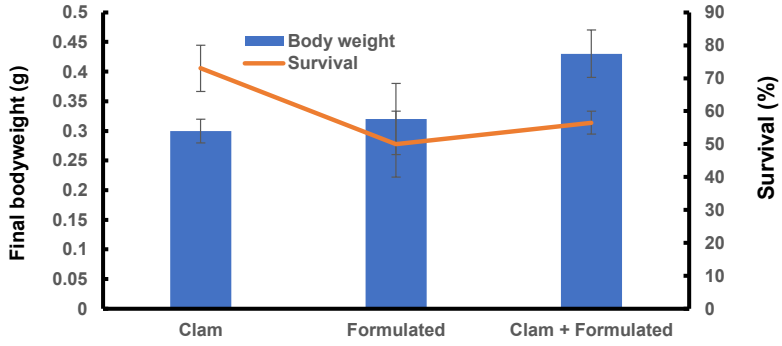


Broodstock growth performance of male and female domesticated first generation of *P. indicus* in indoor maturation system

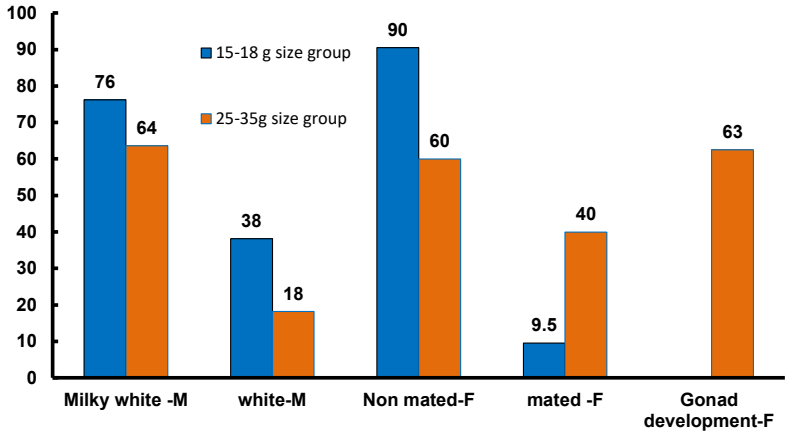
and pond system. In outdoor RAS after 50 doc nursery reared shrimps attained 5.72±0.32g with 62% survival whereas, in sand-based outdoor RAS system, the average growth of shrimp was 10.78±0.8g with 85% survival. In indoor sand-based RAS rearing units, the nursery reared shrimps attained 6.21±2 with 50% survival after 50 days of rearing. However, in cage rearing after 30 days, shrimp recorded 3.73±0.12g . The F2 raised in the tank nursery system (0.37) reached 16-18g in 4 month culture period when stocked in lined grow-out ponds at 14 no /m^2.

Mating experiment: role of light intensity in indoor and outdoor rearing units

Mating in confined systems is one of the major constraints breeding of closed thelycum shrimp. In natural pond systems, *P. indicus* started to mate from 17-20g onwards based on the age of the culture (6-7 months). However, in the confined indoor units, poor mating efficiency was recorded. Although eyestalk ablation techniques are used for induced maturation, repeated moultng after ESA and subsequent loss of sperm pack and poor mating efficiency even after prolonged confinement remain a constraint in the breeding program of closed thelycum shrimp. Although gonad development in indoor rearing units with fully developed cortical oocytes was recorded, eggs were not developed. To address this challenge, a 60 days mating experiment trial was carried out using two size groups of shrimp; size group 1 (15-18g) and size group 2 (25-35 g) . Pond reared *P. indicus* were randomly assigned indoor tanks with and without sand bottom (5 ton) under two photoperiod (12L:12D) and 18L:6D; and outdoor rearing units with and without sand-based RAS under natural photoperiod. The light intensity during the experimental trial was measured at three times a day (6 am, 12-1 pm, and 5.30-6.30 pm). Male and female were stocked at 1:1 ratio, and mating/ mounting was periodically recorded. Moulting is checked by the presence of exuvia in the tank every 3- 6 hour interval. Forty five subadult groups and 30 adult shrimps were stocked in each rearing tank. The light intensity in the tank was 1200-6000 lux at 6-7 am, 25,000-90,000 lux at 12-1 pm, 40-2 lux at 5.30-6.30 pm in outdoor rearing units. However, the indoor rearing system had reached only 200-300 lux during the day period. The study revealed that although molting was 100% in indoor rearing units, mating success was almost nil in indoor rearing in the sub-adult group (15-18g). The male was categorized into three groups, creamy white, milky white, and immature. In the outdoor rearing system, 76.2% of male shrimps in the subadult shrimp groups (Size Group 1) were milky white, 38% and 9% were immature. In indoor rearing units, mating efficiency was only 9%, and the majority



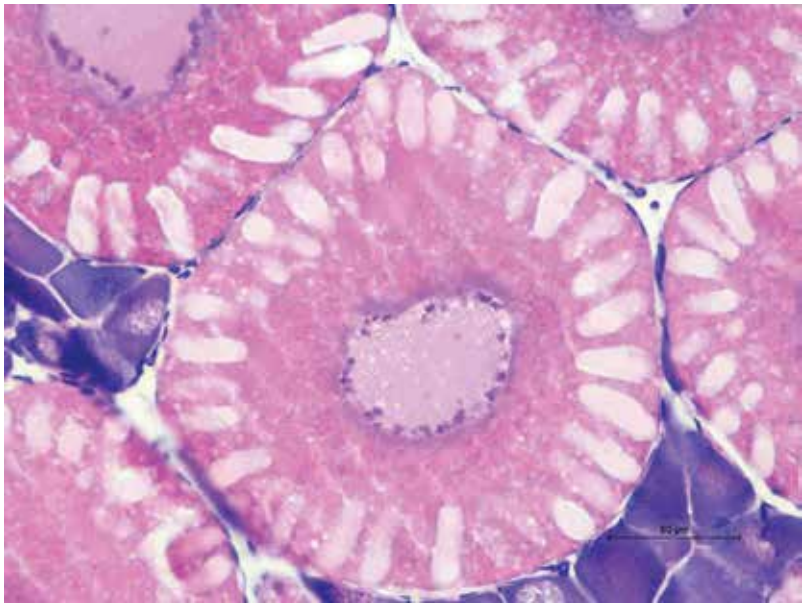
Growth performance and survival of nursery reared F2 generation in indoor and outdoor RAS and cage system



Mating and moulting percentage of male and female of sub adult and adult pond reared *P. indicus* in outdoor rearing units

(90%) were not mated. The male shrimps in the adult size group were 63.6% milky white, 18.2% white, and 18.2% were not good or immature. The molting study revealed that 54.6% of males were in pre-moult, 45.5% were in intermoult stages. In outdoor units, about 90% of females were mated, and 72% were in premoult, and 9% in intermoult stages. The mating and molting of two size groups of male and female populations in outdoor rearing units is given in the figure.

To further reassure that males are reproductively active, a mating study was also conducted indoor rearing units by separately rearing females in the indoor sand-based system for a period of 1 month, followed by the release of the reproductively active male population (from ponds where repeated mating is happening). The breeding population was examined for 21 days, and mating success was below 20% in indoor units. Although

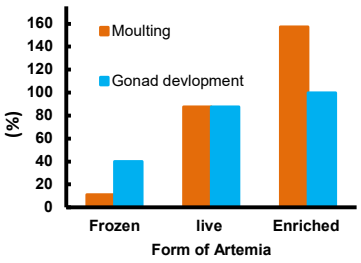


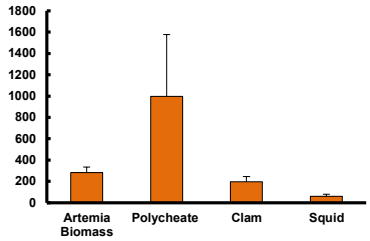
Final oocyte development without impregnation in ESA broodstocks

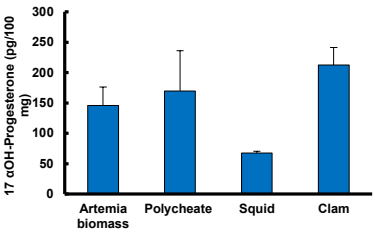
This suggests the environmental cues are paramount in the mating of pond-reared stock of closed thelycum shrimp. The study revealed the positive effect of the natural dawn and dusk effect and the need of a dimer system apart from the natural productivity in the tank system.

Artemia biomass as a bio-vehicle vehicle for E2 enrichment in domesticated broodstock of *P. indicus*

To explore the potential role of Artemia biomass as a quality broodstock diet for penaeid shrimps, a 21 days broodstock feeding trial was carried out. Similarly, the presence of vertebrate like steroids such17 α- hydroxyl progesterone and 17 β-estradiol in Artemia was compared with fresh broodstock, diet evaluated. Thirty pond reared impregnated *P. indicus* (36.44±3.25; TL: 3.63±0.17; 15.36±0.56) were ablated and randomly assigned in three experimental broodstock tanks (5 ton). The broodstocks were fed with frozen, live, and live subadult Artemia biomass enrich with estradiol (17-beta estradiol; pg/100 mg). A 25% of the broodstock diet was replaced with the Artemia biomass. Moulting and gonad development was examined periodically. On the 12 th day, the broodstock fed with enriched Artemia recorded 100% gonad development, followed by 87% gonad development in live and 44.4% in frozen form, and 20% of the shrimp fed with enriched biomass spawned after 14 days of feed trial. The daily molting was recorded based on the exuvia of the molted shrimp. At the end of the 21-day trial, shrimp fed with enriched E2 recorded 157% moulting followed by 87.5% in live form and 11% in frozen form. The





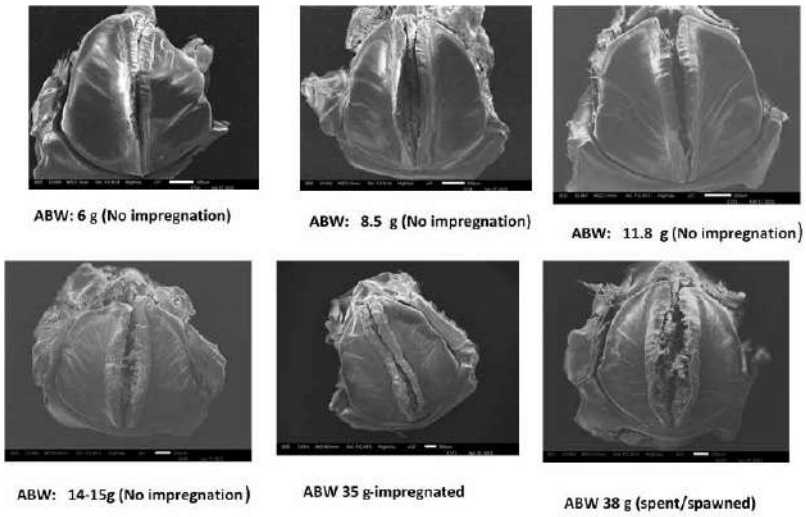


survival of the broodstock after 21 days broodstock trial was 70-90% with lowest survival recorded in shrimp fed with enriched Artemia biomass. The steroid level in Artemia (519±49 pg/100 mg) was higher compared to squids/clams (<200 pg/100 mg) and lower to polychaete (900-1000 pg/100 mg). The study reveals that Artemia biomass is a suitable live feed and due to its bio encapsulation ability and 100% acceptability as a live form with zero wastage of live feed.

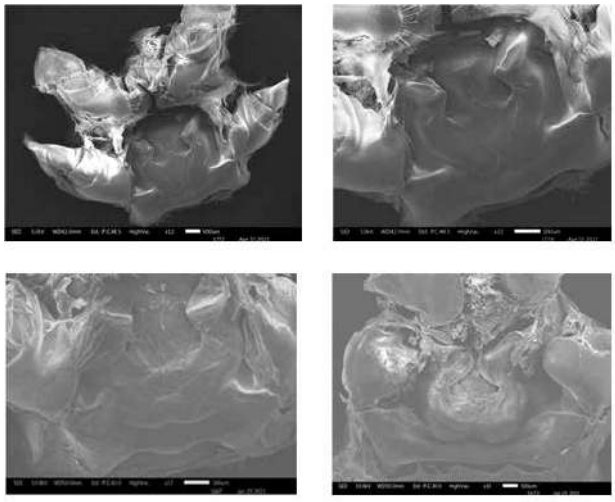
Vertical transmission of WSSV

Indian white shrimp, *Penaeus indicus* being identified as the species of national priority for domestication and genetic improvement program in India, broodstock sourcing and creating disease-free base population is the need of the hour to develop breeding programs Indian white shrimp. Two hundred second step WSSV positive brooder shrimp (pleopod samples) were studied for vertical WSSV transmission studies. Spermatophore (13), ovary (55), fertilized eggs (26), and larval stages such as zoea, post-larvae (40) and gills (37) were studied. Almost 61% reproductive tissues such as spermatophore and 54% and 48% ovarian tissues, were infected with WSSV. Vertical mode of transmission study of the collected brooders revealed gravid ovaries, nauplius, Postlarvae, and juveniles have a low infection (10–200 WSSV particles), with hepatopancreas, muscle has the moderate infection, i.e., 10^5 - 10^6 viral particles, whereas spent ovaries, spermatophores, gills, and pleopod had highest bacterial load above 10^8 viral particles.

Out of the total infected ovarian tissue, the WSSV quantification in the infected eggs and gravid ovary (4+ stages) revealed 46% low infection level with 20-40 WSSV DNA copies, and 50-70 copies /µL in the fertilized eggs. However, *in situ* hybridization study and nested PCR of the fertilized infected egg and ovarian tissue did not give WSSV positive localization or detection. However, 60% of the wild broodstock with the first step and second step positive WSSV gonad tissue were neither in the advance gonad development stages or spawners with a viral copy number $10^{5\text{-}6}$ and found to be regressed ovary indicating the possibility of WSSV infection above a threshold level does not allow the gonad for its final oocyte maturation whereas low-level copy numbers seem to be passive carriers with the developed ovary.TEM analysis of these issues is a matter of further research to localize this viron in the oocytes. Similarly, out of 100% of second step positive pleopod shrimp samples, only 65% were shown positive WSSV gills indicating the chance of surface contamination among the broodstock during transportation. Fertilized eggs and gonad tissue of the infected brooder were analyzed further to quantify and tissue localization through real-time PCR, *in situ* hybridization, and H&E stain. The WSSV quantification revealed low-level infection with WSSV DNA copies below 50-70 copies /µL. Only 46% of gravid ovaries found

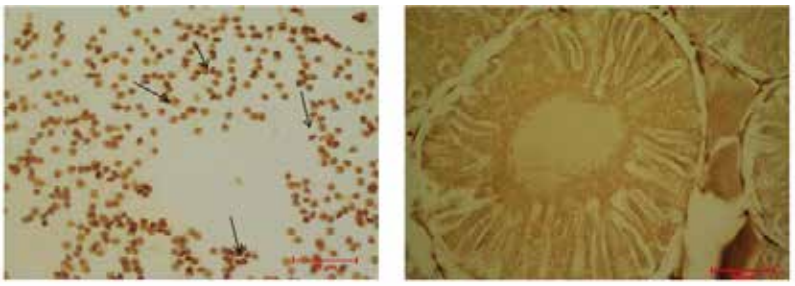


SEM ultrastructure of closed thelycum of *P. indicus* at different developmental stages



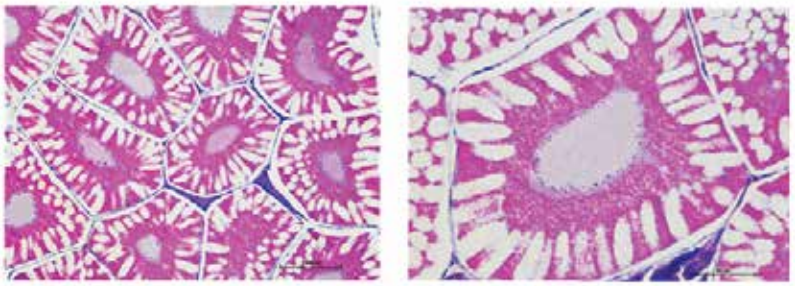
SEM ultrastructure of open thelycum of *P.vannamei* at different developmental stages

to be infected, whereas fertilized eggs recorded 60% WSSV positive, where as *in situ* hybridization study of the fertilized infected egg and ovarian tissue did not give WSSV positive localization. Conversely infected spermatophores could WSSV locates infected cells through ISH. The histological architecture of gravid ovarian tissues revealed oocytes in the cortical stage of development with no sign of WSSV infection with fully developed oocytes. Even oogonia were fully developed with no sign of characteristic cowdry bodies in the nucleus of the cells, or WSSV induced cytopathic effects. Cortical oocyte with no histopathological WSSV infection (H&E) at the cellular level

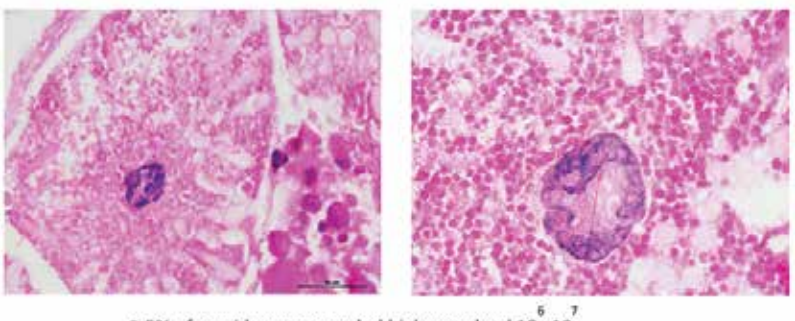


WSSV infected sperm cells (ISH)

Cortical oocyte with no sign wssv infection (ISH)



Cortical oocyte with no histopathological WSSV infection (H&E) at the cellular level



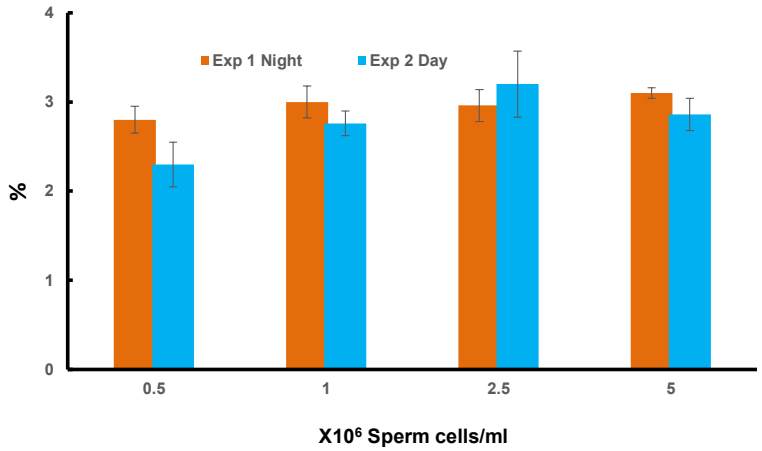
3.5% of gravid ovary recorded high wssv load 10^{6} -10^{7}

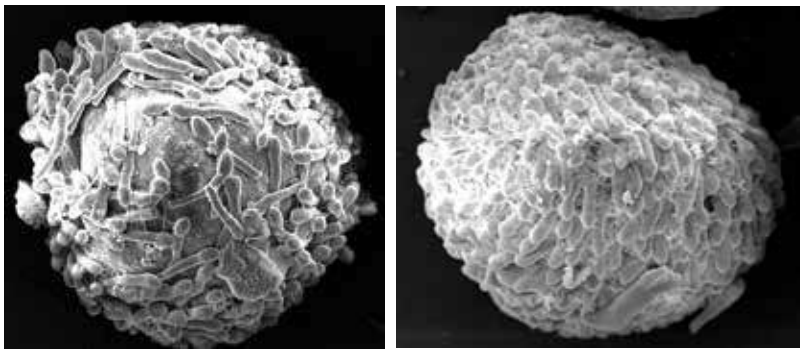
Improving Egg activation during in vitro fertilization

In vitro fertilization technique for shrimps are not popular due to unsuccessful and lower fertilization rates obtained. Our previous studies shows that successful fertilization and hatching can be obtained through in vitro fertilization modes. To further studying this aspect, two experiments were done to study the egg activation capacity and fertilization. One experiment was conducted during the night and the other during the daytime. Ovary was surgically dissected out from wild caught ripe *P. indicus* females. The oocytes were separated out from the ovary by macerating in a mortar and pestle. Similarly fully formed spermatophore from males were collected and sperm homogenate was prepared. The egg aliquots and graded sperm suspension (0.5, 1, 2.5, 5 $X10^{6}$ cells/ml) were mixed in 25 ml six well tissue culture plate. Activated eggs were subjected to electron microscopy studies. The egg activation percentage was lower during both the night and daytime. No successful fertilization was observed in any of the experiments.

Details of the animals used for the study

Experiment	Male/Female	Length (cm)	Weight (g)	Sperm count ($X10^6$ Cells)	Egg recovery
Experiment 1 Night	Male	16.64 ± 0.34	33.96 ± 1.77	21.60 ± 2.70	-
	Female	17.96 ± 0.67	54.02 ± 5.5	-	24100
Experiment 2 Day	Male	16.32 ± 0.14	35.25 ± 1.75	31.35 ± 7.85	-
	Female	17.47 ± 0.19	48.15 ± 2.60	-	54750



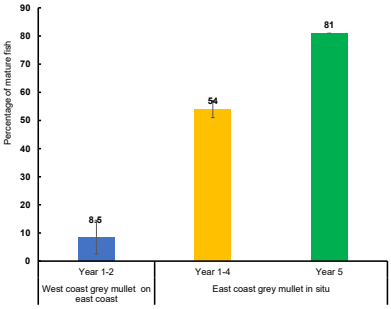


Electron microscopy photographs of activated eggs. Complete emergence of the cortical rods. Cortical rods elongated after protrusion and the ends are bulged

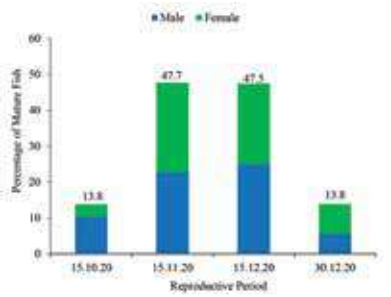
Mugil cephalus

Hatchery production: a holistic approach

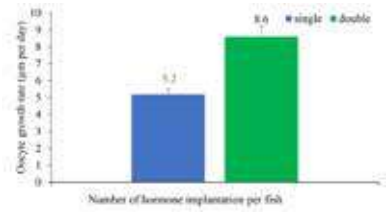
Grey mullet *Mugil cephalus* is the fastest growing species of the family *Mugilidae*. Although a preferred species among brackishwater aquafarmers, grey mullet farming has been on a decline owing to decrease in availability of wild seeds. Considering its significance in brackishwater aquaculture, CIBA has given greater impetus for the breeding of grey mullet since 2015-16, placing special focus on developing a captive broodstock at two geographic locations on east coast at MES-CIBA Chennai and at Ernakulam on the west coast. Three strategies were adopted for development of induced captive reproduction of grey mullet i) reproductive performance of captive east coast stocks- in situ ii) reproductive performance of captive west coast stocks transported and reared on east coast iii) reproductive performance of west coast stocks- in situ. On east coast, broodstock were maintained in flow-through tank systems (capacity, 100 T) at MES-CIBA and used for standardising breeding protocol during November while on the west coast, broodstock were developed in earthen pond system and used for induced breeding using recirculatory low volume breeding system. Chronic hormone therapy of intramuscular hormone pellets (single and double implantation per fish) along with enhanced maturation feed, Cephalus^{Plus} has helped to improve overall fish maturation of captive east coast stocks from 54±3% in 2016-19 to 81% in 2020 and supported in extending the reproductive period of captive grey mullet. On the contrary, west coast grey mullet exhibited reproductive dysfunction at east coast and a maximum maturity percentage of only 8.5±6% was observed. The maximum oocyte size of east coast grey mullet in situ, west coast grey mullet at east coast and west coast grey mullet in situ were 538 µm, 564



Percentage of mature grey mullet during successive annual reproductive periods of west coast grey mullet on east coast and east coast grey mullet in situ when maintained under uniform conditions and treated with similar hormone therapy



Percentage of mature fish during the extended reproductive period of grey mullet in 2020 using staggered hormone therapy and functional feeds



Oocyte growth rate using single and double intramuscular GnRHa implantation during the annual reproductive period

µm and 570 µm respectively. On east coast, fish with oocyte sizes 520-535 µm were used during November and on west coast fish with oocyte size 540- 570 µm were used during June- July for induced breeding trials. For optimising induced breeding protocols using a priming dose, hCG and resolving dose of a combination of GnRHa+metoclopramide was used which resulted in fertlisation percentage of 1-35% at east coast and 45-85% at west coast. First successful larval production of *M. cephalus* was achieved in 2016-17. In the year 2020, through gradual improvisation of larval rearing protocols CIBA has completed producing its third batch of hatchery reared grey mullet fingerlings using enriched rotifers *Brachionus plicatilis*, copepods and green algae *Nanochloropsis oculata* and the estimated survival was over 22%. Fingerlings were distributed to farmers from Kerala, Tamil Nadu and Andhra Pradesh and are also being reared for developing captive F1 stock which is expected to have a relatively elastic reproductive period over the parent stocks. This is to counter the biological challenge of single narrow breeding window of the species which is the main stumbling block in the path towards grey mullet hatchery production. For CIBA, the upscaling and finetuning of the seed production technology of grey mullet is the road ahead to further develop grey mullet hatchery based seed production.

Chanos chanos

Development of brood bank and continuation of extended spawning of milkfish under assisted implantation regime

Strengthening of broodstock is essential requirement in milkfish breeding program as it needs a relatively long duration of 5-6 years for first maturity. Introduction of new population triggers spawning performance in milkfish. Milkfish adult, sub-adults and stunted yearlings are being maintained in 100t RCC tank-based system, lined pond-based system and 50t HDPE tank-based system respectively. For rejuvenating milkfish brood stocks used for induced breeding since last five years, efforts were made to introduce twelve milkfish (body weight 1.8-2.0 kg, tl. < 85 cm) in 100 t RCC tanks as future broodstocks. Fishes reached 3.0 -3.5 kg body weight in 11 months and showed presence of milting male upon gentle pressure on the abdomen region. Around 200 second line sub-adult milkfish (body weight 1.3 kg- 2.3 kg and age 3-5years) are also maintained in newly prepared broodstock pond forseeing the future requirement of broodstock. Stunted yearlings (300 number) of milkfishes aged between 2.5-3 years (body weight: 100-150 g, tl. 25-30 cm) are also maintained in 50 t HDPE tank for long distance transportation to farmers pond where it can attend growth and sexual maturity in shorter time.

Annual reproductive period of grey mullet on the east coast

The effectiveness of assisted (04 implantation/year- Dec, Jan, April, July) implantation of combined hormone pellet (GnRHa and 17 α–MT) over chronic (10 implantations/year- December, January-September) used as breeding option in previous years. Hormone implantation was in synchrony with breeding period and termed as early (January-March), maximum (April-June) and extended (July-September) phase. During the year, 2020, both populations of milkfish were exposed to assisted implantation where total four implantations given during December to July. A total of 22 spawning (13 Chennai population, 09 Kakinada population) was observed in the two domesticated population of milkfish (*Chanos chanos*) during March to September. Assisted hormone implantation helped to achieve desired percentage of unimodal distribution of mature oocytes (650-750 µm) reaching final oocyte maturation (FOM) stage in milkfish along with higher spawning frequency. On the contrary, chronic/ continuous implantation (every month) caused an increased percentage of vitellogenic oocytes with bimodal distribution (250 - 500 µm and 500-600 µm) in ovary with reduced spawning events. It was observed that milkfish breeding was aligned with abiotic factors such as higher water temperature, salinity and also observed to synchronise with lunar phases of full moon or new moon. We conclude that assisted type of implantation pattern significantly improved maturation, male maturity, average fecundity, oocyte diameter, fertilization rate, hatching rate and larval length compared to that of chronic implantation with added benefit of reduced handling stress. A total 46837 hatchery produced milkfish fry were distributed among farmers from Kerala, West Bengal, Gujarat, Orissa, Tamil Nadu and a revenue of Rs. 1,44,090 was generated through these sale.

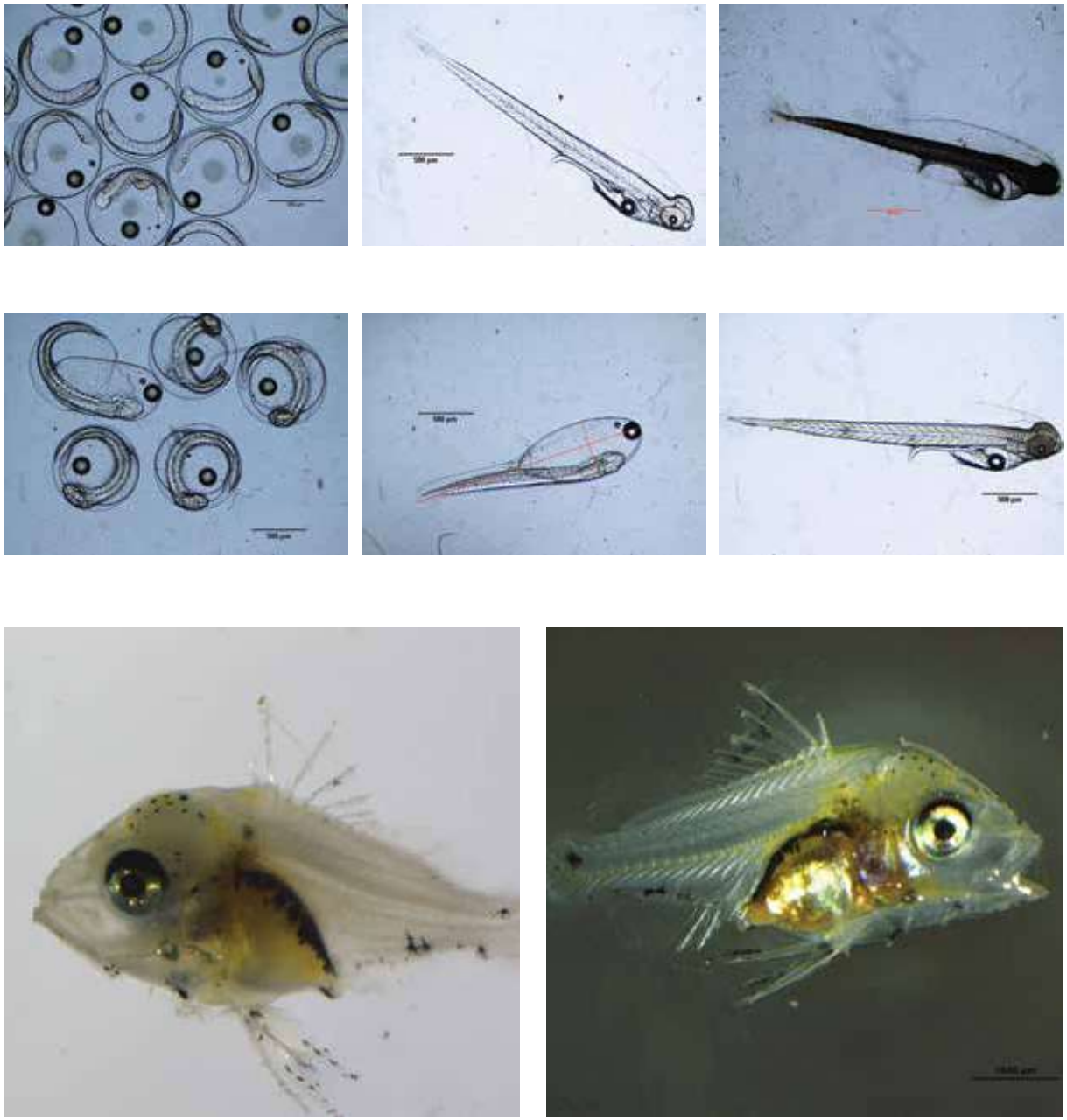
Lutjanus argentimaculatus

Breakthrough on captive breeding and seed production

The mangrove red snapper *Lutjanus argentimaculatus* is high value brackishwater foodfish exhibiting fast growth rates and high market demand. ICAR-CIBA has prioritised this species of snapper due to its high value and fast growth rates which makes a short economical culture package possible for brackishwater finfish farmers . Red snapper broodstocks were maintained in flow-through tank system (100 t) and lined pond system and fed on broodstock maturation feeds and trash fish, tilapia, sardine and mackerel @ 5% body weight in two rations daily. During this four year period, majority of the fish attained captive maturation in response to the standard management protocols at fish hatchery Muttukkadu Experimental Station- CIBA. The peak reproductive period of the fish was observed to be from maturity from March to October during 2020. From a total of 40 fish, size range, 3.2 to 4.3 kg a maximum captive maturity of 67% was noticed during August to September. Males matured dominantly, 45% (18 no) compared to females, 22% (9 no). Mature females having average oocyte diameter of 450 µm and oozing males were selected for induced breeding experiments. A total of 6 induced breeding experiments conducted during July to October 2020 by using hCG hormone treatment @ 1500 IU/kg body weight for females and half of the dose for males. The fish spawned spontaneously after 30-36 h of hormone treatment, the fertilization rate varied from 50-70%. An average of 1.5 lakh larvae could be obtained per spawning. Larval

Mangrove Red snapper *Lutjanus argentimaculatus*

Embryonic and larvel stages of mangrove red snapper *(Lutjanus argentimaculatus)*



Embryonic and larval stages of mangrove red snapper

rearing was carried out by feeding rotifers and copepod nauplii from 1st day post hatch and *Artemia* nauplii from 17 dph. Adult copepods were supplied from 25 dph along with artificial feed. A total of 2000 early fry in the size of 1.0 cm could be produced at 25 days post hatch. After further rearing, the fry reached to the size of 2.5 cm at 60 days rearing and a total 500 numbers could be produced. This is the first record of hatchery production of red snapper juveniles under captive conditions from India.

Lates calcarifer

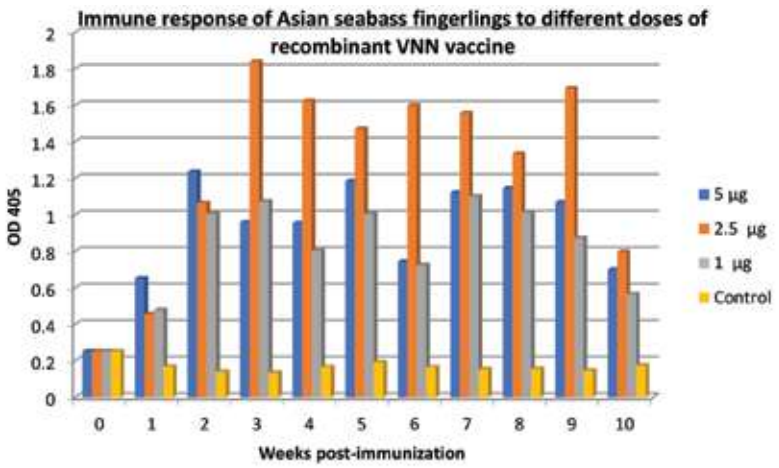
Healthy pathogen free broodstock development

Asian seabass *Lates calcarifer* is the predominant brackishwater finfish species being cultured by aquafarmers throughout the coastal states of our country. CIBA mandates sustainable development this emerging farming practice by insistence on best culture practices starting with quality seed. Every year healthy broodstock are added to the existing stock to mantain genetic heterozygosity of the parent stocks. In 2020. a total of 40 numbers of farm reared broodstock fishes were procured from Sirkazhi and Vedaranyam area. Fishes were quarantined in exclusive quarantine facility established with RAS system at Muttukadu Experimental Station. It is obligatory that each of the fish is screened against VNN-virus, the predominant disease risk for the species and other pathogens before being added as the parent stock at fish hatchery of CIBA. These fish are tagged with passive integrated transponder (PIT) tags and identity maintained to trace the parent fish and the progeny produced at hatchery.

In 2020, despite the challenges imposed by the lockdown due to the global challenge of covid outbreak, fish hatchery of CIBA has continued its production catering to the seed requirements of the aquafarmers. A total of 22 natural spawnings and 8 induced spawning was observed, an overall production of 1.2 million seed were produced. A total of 2,96,000 seeds were sold during the period from June to October 2020. An amount of Rs.7,04,000/- was realised from the sale of seed to 25 farmers belonging to Tamil Nadu, Andhra Pradesh, Kerala and Karnataka. Besides this seed was supplied to NGRC TSP programme and KRC for nursery rearing trials. CIBA also supported the startup initiative of CANARES Aqua start up programme by Fisheries graduates to whom 34,500 seed were supplied. The entire chain of procedures are carried out adhering to protocols to ensure availability of healthy pathogen-free seed to farmers for sustainable diversification of the brackishwater aquaculture sector.

Dose optimization of VNN recombinant vaccine

Viral nervous necrosis is a serious disease of brackishwater finfishes. The infection is caused by a betanodavirus, Nervous necrosis virus. The disease is transmitted both horizontally and vertically making the disease control extremely challenging. Earlier, a recombinant capsid protein and inactivated viral vaccine was developed and administered to Asian seabass broodstock. Recombinant capsid protein vaccine gave better immune response compared to inactivated viral vaccine. The dose of the recombinant vaccine was optimized in the present study. The recombinant protein was purified and emulsified with commercial adjuvants. The vaccine was administered to Asian seabass fingerlings at three different doses *viz.,* 1, 2.5 and 5 µg g^{-1} body weight of fish. The fish were maintained in flow-through system at 27± 1° C. Blood samples were collected from the caudal vein before and every week up to 10 weeks post vaccination. The serum was used to assess the antibody titre by indirect ELISA using anti-seabass IgM monoclonal antibodies. 2.5 µg g^{-1} body weight dose gave better immune response compared to the other two doses. The immune response was above the protective levels in all the three doses up to 10 weeks post-immunization.



Acanthopagrus longispinnis

Broodstock development and captive maturation

Yellow fin bream, *Acanthopagrus longispinnis*, is an important candidate species for aquaculture due to its high market demand, excellent taste and high consumer preference. Non-availability of seed is the major constraint in

development of aquaculture of this species. Therefore development of a hatchery based seed production technology of the species will encourage the farming of *A. longispinnis* in brackishwater systems. Understanding the breeding biology of a species is a necessary prerequisite for captive breeding. Therefore, to know the breeding season and gonad development, fresh specimens were collected (n=10) from October to January (maturation and spawning season) to record the gonadal development, gonadosomatic index (GSI), fecundity and for oocyte diameter studies. Mean GSI (%) value of 0.09, 4.23, 11.37 and 15.73 was observed respectively in the months of October, November, December and January respectively. Maximum GSI (15.73%) values recorded in January indicate that *A. longispinis* may breed in the month of January. Macroscopic observation revealed the six different maturation stages *viz.* immature, early maturing, late maturing, mature, ripe and spent. Relative fecundity ranged from 1400-2000 eggs/g of fish, and oocyte diameter of 410-450 µm was found in ripe female in December and January. To initiate the captive breeding programme of the species, broodstock of *A. longispinis* in size rage of 100 to 300g were collected from Sunderban Bheri during December, 2019, 2020 and transported in open container to Kakdwip research centre of ICAR-CIBA. Fishes were slowly acclimatized to brackishwater pond water salinity (7 ppt) and temperature (24 ^{0}C) and stocked in broodstock pond, 1000 m^{2}. Before stocking fish were treated with potassium permanganate @ 10 ppm. After three to four days of acclimation fish were fed daily with trash fish to satiation. In the brackishwater pond, where salinity varied between 2-18 ppt fish showed signs of sexual maturation in both the sexes. Fully mature oozing male and mature female (oocyte diameter 380-420 µm) were observed during month of December-January in captive reared stock.

Immature

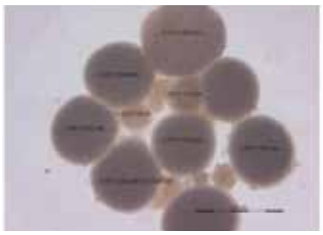
Early maturing

Late maturing

Mature

Ripe

Oozing males



Eggs

Fry

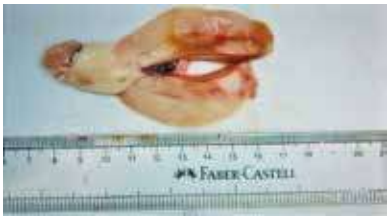
Fingerlinng

Sea bream maturation stages, eggs, fry and fingerling

Rhabdosargus sarba

Broodstock development and captive maturation

The silver or gold lined sea bream *Rhabdosargus sarba* is a widely distributed omnivorous and euryhaline sparid species in the seas surrounding Japan, Korea, Taiwan, East China, Indo-pacific and Red sea in depths less than 50 m. The species has good potential for both culture and restocking. Although the spawnings under captive conditions were reported in countries like Japan, Taiwan, United Arab Emirates and Mauritius it has not been reported in our country. The adult fishes were caught by hook and line near Kovalam seas Latitude: 8.3667 Longitude: 76.9967 and brought to Muttukkadu Experimental Station (MES) of ICAR-CIBA in the month of October 2020. The fishes were immediately given 0.15 ppm formalin bath for one hour, and then placed in 10 t capacity FRP tank connected with RAS facility. The fishes were weighed and measured after the acclimatization period. The fishes readily accepted both formulated and live fish/ prawns/squids from the third day after stocking. The gonadal biopsies were done fortnightly in order to check the reproductive stages and captive maturation recorded.



Male *Rhabdosargus sarba* with matured testis

Female *Rhabdosargus sarba* with ovary

Liza parsia

Effect of different methods of hormone delivery on gonad development

Goldspot mullet, *Liza parsia* is an important brackishwater fish. This species attains partial maturity in captivity, however fails to attain the final oocyte maturation and spawning. Therefore, to accelerate the maturation different mode of hormone delivery is experimented. Different modes of hormone delivery include hormone pellet, injection and osmotic pump. In experiment one, four different types of cholesterol and cellulose based hormone pellet (weight, 0.02 g; length, 6 mm; diameter, 2 mm) length, such as: T1 (without hormone), T2 (LHRHa, 15µg/pellet), T3 (LHRHa, 15µg+metoclopramide, 0.005µg/pellet) and T4 (LHRHa, 15µg+MT 200 µg/pellet) were prepared. First, second and third implantations were made on the first week of October, November and December. Fifteen days after the last implantation fishes from different experimental groups were sampled to assess the expression of D2R in brain, aromatase-a in ovary, gonad development and reproductive hormone level. Relatively highest mean GSI (7.2%), mean oocyte diameter (543 µm) was found in T3 group (LHRH, 15µg+metoclopramide, 0.005µg/pellet).

In experiment two, an osmotic pump (OP) (diameter=0.7 cm, length=3.0 cm, reservoir volume= 200 µl) that releases a constant amount of loaded hormones (12 µl/day) over a 14 days was tested. Carp pituitary extract (CPE) was prepared by homogenizing carp pituitary gland in 0.9% sodium chloride solution, followed by centrifugation at 7000 rpm for 10 min at 4 ^{0}C. hCG was dissolved in 0.9% sterilized sodium chloride solution separately. The pump was loaded with saline, hCG, PGE, and combination of hCG and CPE. A total of 12 fish were randomly divided into 4 groups (n= 3 fishes/group). The first group was the control group, which was implanted with a single osmotic pump containing 0.9% sodium chloride, while the other three groups implanted with a single osmotic pump loaded with CPE (0.24 mg/day/fish), hCG (30 IU/ day/fish), and combination of hCG

Implantation of osmotic pump in *Liza parsia*

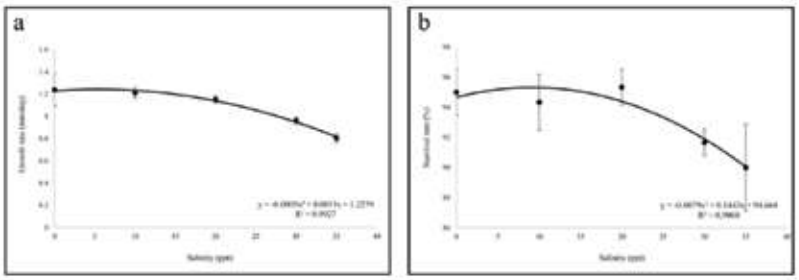
and CPE (15 IU+0.12 mg/day/fish). An osmotic pump was implanted into the peritoneal cavity of each maturing fish (oocyte diameter 320-350 µm) after cutting approximately 8-10 mm opening in the abdomen with a fine scalpel. The wound was sutured and an antiseptic ointment was applied. Wound healed within 11 to 12 days post operation. After 15 days of rearing, samples were collected for hormone assay, histology, expression of D2R and aromatase. Result showed that delivery of hCG and CPE through OP are effective in gonad development of *L. parsia* in captivity.

To evaluate the effect of hormone injection on gonad development of *L. parsia,* different hormones such as T1 (hCG @2 IU/g), T2 (CPE@0.02 mg/g), T3 (hCG+CPE @ 1 IU + 0.01 mg/g) and T4 (physiological saline@25 µl) were injected to maturing fish (oocyte diameter 320-350 µm). Two dose of injection was given at the interval of 7 days and final maturity was assessed after 15th days. Result of the experiment showed administration of hCG induces 100% maturation (oocyte diameter 493 µm). In this group, 16.6% fish spawned after second injection. CPE injected group also induces 100% maturation (oocyte diameter-451 µm). Mixture of both hormones induces maturation only in 66.6% of animals. Control group without any hormone injection around 50% of fish attained maturity. Average oocyte diameter of different experimental groups, T1, T2, T3 and T4 were 493, 451, 396, and 428, respectively. GSI (%) of different experimental groups, T1, T2, T3 and T4 were 8.98, 8.93, 4.3, 8.2, respectively. Therefore, use of hCG as primary and secondary dose will help to improve the maturation and trigger the ovulation in *L. parsia*.

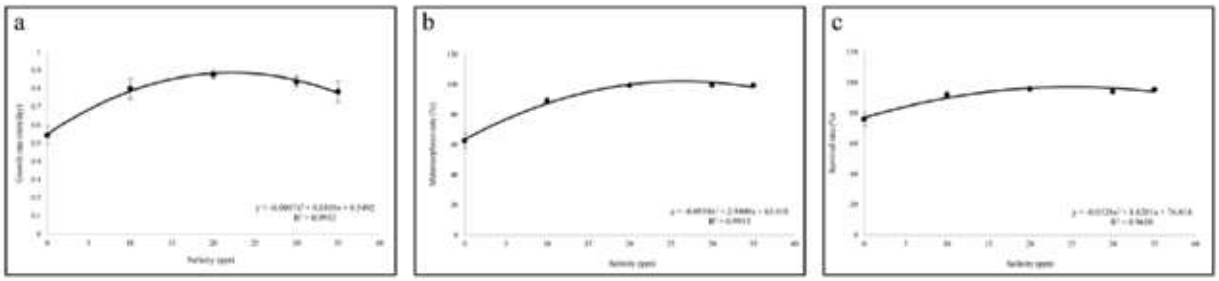
Monodactylus argenteus

Effect of salinity on the development of pre-larvae and post-larvae

The experiment was designed to study the effect of salinity on development of *M. argenteus* pre-larvae and post-larvae. The effect of different salinity ranges: 0, 10, 20, 30, and 35 ppt on growth rate and survival rate of larvae before and after metamorphosis was studied. Each experimental container was stocked with larvae of 22 days post hatch (dph) (n=30, mean total length 12.70±0.33 mm) before metamorphosis, and the experiment continued till the termination of the larval metamorphosis. To study the effect of salinity on the juveniles, larvae which completed metamorphosis (n=30, total length 21.16±0.62 mm, 32 dph) were stocked in the plastic containers, and the experiment continued up to 42 dph at five different salinities (0, 10, 20, 30 and 40‰). Salinity showed significant influences (*P<0.05*) on the growth of *M. argenteus* pre-larvae and post-larvae. The growth rates at 20‰ (0.87±0.04) were significantly (*P<0.05*) higher than the growth at other levels of salinity at pre-larval phase. However, the growth rate at 0‰ (3.13±0.22) was significantly higher than other salinities in the post-larval stage. The regression equations relating to growth rate and salinities yielded an R2 of 0.99 for pre-larvae and post-larvae. There were no significant



a) Growth rate (%), and b) survival rate (%) of post-larvae (32 dph) of *M. argenteus* at different salinities. The regression analysis defined the relationship of growth rate with salinity by $y = -0.0005x^2 + 0.0053x + 1.2279$ ($R^2 = 0.99$); and survival rate with salinity by $y = -0.0079x^2 + 0.1443x + 94.664$ ($R^2 = 0.90$).



a) Growth rate (%), b) metamorphosis rate (%), and c) survival rate (%) of pre-larvae (22dph) of *M. argenteus* at different salinities. The regression analysis defined the relationship between growth rate with salinity by $y = -0.0007x^2 + 0.0305x - 0.5492$ ($R^2 = 0.99$); metamorphosis rate (%) related with salinities by $y = -0.0558x^2 + 2.9408x + 63.418$ ($R^2 = 0.99$); and survival rate related with salinities by $y = -0.0324x^2 + 1.6201x + 76.814$ ($R^2 = 0.96$).

Motility initiation, motility duration and percentage of motile sperms at different salinities

Salinity	Motility initiation	Motility duration (Mean ± SE)	% of sperms motile
0	No motility	0	0
5	No motility	0	0
10	No motility	0	0
15	Slow	1.22 ± 0.19	30%
20	Fast	4.846 ± 0.12	80-90%
25	Fast	4.88 ± 0.19	80-90%
30	Fast	3.76 ± 0.22	80-90%
35	Fast	3.924 ± 0.38	80-90%
40	Fast	3.668 ± 0.23	80-90%

differences ($P<0.05$) in survival rates between larvae reared at 10, 20, 30, and 35‰ salinities. However, the freshwater gradient (0‰) showed a significant lower survival rate (*P<0.05*) from the rest of the treatments in pre-larval rearing. Larvae held at 35 ‰ in the post-larval experiment exhibited the lowest survival (90.0 ± 5.0%) compared to other salinities (0, 10, 20, and 30‰). The regression analysis defined the relationship of survival rate with salinity in pre-larval by y = -0.0324x2 + 1.6201x + 76.814 (R2 = 0.96) and post-larval by y = -0.0079x2 + 0.1443x + 94.664 (R2 = 0.90) phases. The metamorphosis rate at 0 and 10 ‰ was significantly lower than the values at 20, 30, and 35‰, even though the rates were not significantly different between the salinities 20, 30, and 35‰. The relationship between metamorphosis rate and salinity was described by the parabolic equation, y = -0.0558x2 + 2.9408x + 63.418 (R2 = 0.99). Hence, the environmental salinity level should be maintained at 25–35 ppt during embryogenesis and at 20–35 during early larval development for this species.

Present findings demonstrated that pre larvae were stenohaline (before metamorphosis), being able to adjust well to only around 20–35‰ seawater. However, immediately after larval metamorphosis, they survived even in fresh water demonstrating the strong euryhaline nature of this species.

Motility initiation, motility duration and motility pattern of *Monodactylus argenteus* spermatozoa cells at different salinities

Salinity is considered an important parameter which

influences reproduction of many brackishwater and marine fish species. In this experiment the effect of salinity on motility initiation, motility duration and motility pattern of moon fish *Monodactylus argenteus* spermatozoa cells was investigated at different salinities. Milt from five different fishes of size range of 13.5 to 14 cm, weighing 55 to 60g was collected using a cannula and transferred into 5 ml vials where it was diluted with extender solution. The extender solution used was marine finger solution. Out of the four dilutions (milt: marine fish ringer solution; 1:200, 1:800, 1:1400, 1:2000), a range of 1:800 to 1:2000 was found to be effective for performing the sperm count. The diluted milt was shaken well to ensure the thorough mixing of the milt and extender and the counting was done using a haemocytometer and the count was found out to be 3.81 ± 0.38 x 10^{10} per ml of the sample. Milt from a live fish was taken and placed on the clean glass slide with a drop of seawater and observed for the sperm motility pattern. Mainly three types of movement were observed with time; rapid shooting movement, sluggish movement and vibration and sperm motility scores were given according to Jaspers (1972). Milt samples (N=5) having motility score ≥ 4 was diluted with different salinities ranging from 0 to 40 ppt. No motility was exhibited by spermatozoa in fresh water (0 ppt), 5 ppt and 10 ppt. At 15 ppt salinity, only 30% of the sperm exhibited motility in all the milt samples analysed. In 20 and 25 ppt salinity, sperms showed a significantly high motility duration and 80-90% sperms showed motility. Within 2 minutes of time, the percentage of motile sperms came down drastically (30%). At 30, 35 and 40 ppt, there is no significant difference among the motility duration and the percentage of motile sperms was 80-90%. It was found that there exists a significant ($P < 0.05$) difference between motility duration at medium salinities (20 and 25 ppt) and higher salinities (30, 35 and 40 ppt).

Etroplus suratensis

Multiple spawning and lunar periodicity

Pearlspot, *Etroplus suratensis* is commonly called as green chromide and is an economically important food fish as well as emerging ornamental fish. A major bottle neck limiting the expansion of pearlspot farming is inadequate availability of seed for stocking in growout systems. The present experiment aimed to facilitate multiple spawning of pearlspot in cages installed in pond followed by fertilized egg incubation and larval rearing protocols in recirculatory aquaculture system. Pearlspot brooders with male (20.5 ± 0.201 cm; 222 ± 4.33 g) and female (18.57 ± 0.44 cm; 179.15 ± 10.97 g) ratio (1:1) were stocked in 4 different floating cages with varied number of pairs: 1, 3, 12 and 15 (with complete parental care). In each cage, clay bowls were suspended as substrate for laying eggs. Results revealed that a total of 56 spawning were observed in 120 days from 12 pair of brooders stocked in 4 × 4 × 1.5 m with average fecundity 916±23.70 nos. Each pair has spawned at an interval of 26 days with 4.6 times in 120 days. Lunar periodicity of pearlspot spawning showed highest spawning were observed during new moon phase (33.87%) followed by full moon (30.64%), first quarter (29.03%) and last quarter (20.96%). Fertilized eggs of different batches were collected at different time intervals 6 hrs, 12 hrs, 24 hrs, 48 hrs and 54 hrs. It was found that collection of eggs at 12-24 h after spawning resulted in better hatchability, 90%. Collection of eggs at 48 h and 54 h resulted in filial cannibalism. Incubation of fertilized eggs along with substrate were carried out in portable RAS unit with series of 70 l tubs. Mild flow rate of 1 - 1.5 l/min with vigorous aeration resulted in better 90% hatching percentage. Larval rearing of pearlspot was carried out in same system for 20 days by providing combination of *Artemia nauplii* and copepod @ 5 no/ml and weaning with larval diet on 10th day resulted in better growth and survival. Pearlspot larvae attained 9 – 10 mm in 20 days of rearing with 80% survival rate. A total of 18,500 pearlspot early fry were produced from 28 spawning with average of 650 nos early fry produced per spawning. Pearlspot seeds produced from cage based breeding model were supplied to scheduled castes sub plan beneficiaries during August to October 2020 for demonstration of nursery rearing of pearlspot as source of livelihood generation. Early fry of pearlspot (0.9 – 1 cm) were stocked in hapa's (2×1×1 m) @ 500 nos/hapa and reared for 60 days to attain fingerlings (4 - 4.5 cm) with 80% survival rate. A total of 10,500 pearlspot fingerlings were produced at NGRC – CIBA farm with the participation of SCSP beneficiaries. A total of 8000 pearlspot fingerlings (4.5 – 8 cm) were sold @ Rs 15/fingerling and generated revenue of Rs 1,20,000 to SCSP beneficiaries.

Cages for spawning of pearlspot

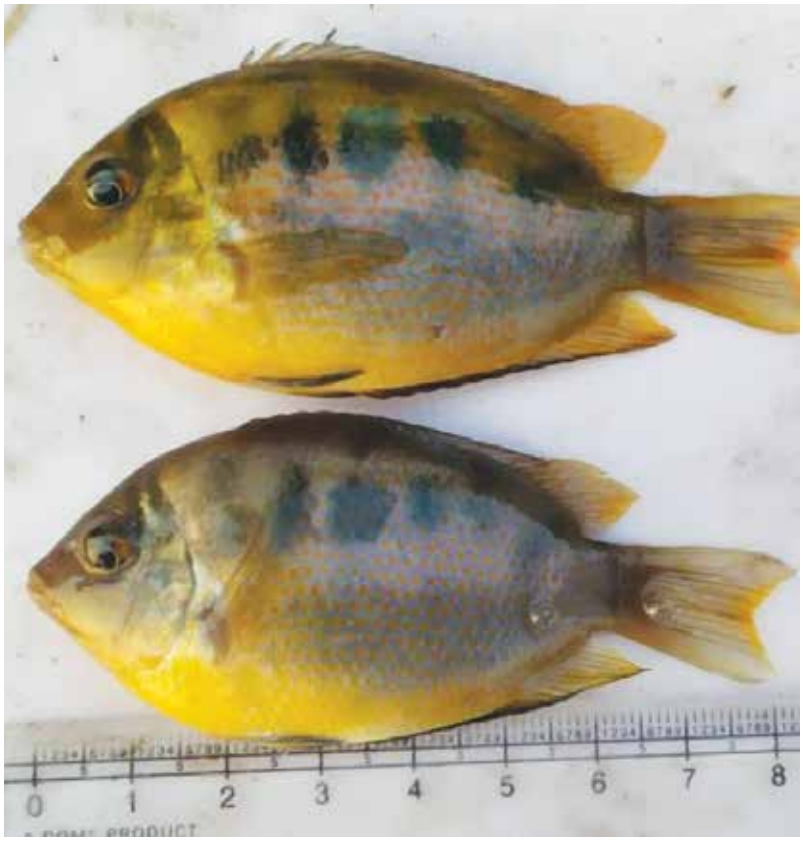
Pearlspot brooders

Pearlspot 21 day old early fry

Etroplus maculatus

Breeding in floating net cages

Orange chromide, *Etroplus maculatus* is considered as one of the potential ornamental fish. The ornamental traits of *E. maculatus* such as the oval shaped body, yellow to orange colouration with black spots make it very attractive. Although many reports are available on breeding and collection of larvae from brooder pairs of *E. maculatus*, there are bottle necks in mass scale seed production of *E. maculatus* due to pair formation, filial cannibalism, and prolonged parental care. Hence, NGRC-CIBA attempted its breeding in floating net cages (2×1×1 m) with 9 pair of brooders stocked in cage, provided with small clay pots as substrate for breeding. The mean average length and bodyweight of male brooders were 7.42 ±0.15 g, 7.87 ± 0.76 cm and of female brooders were 7.35± 0.13, 8.625±0.625 g. After 3 days of providing substrate, a total of 14 spawnings were observed from cages stocked with 9 pairs of brooders in a span of 40 days. The fecundity of *E. maculatus* ranged from 197 – 380 with average of 294.07±13.24. The average interval of spawning was 12 - 13 days after egg collection. The fertilized egg measures 1.86 mm. Substrate with fertilized eggs were transferred to 70 l tubs for incubation, hatching of eggs took place after 48 – 60 h with 90%



Orange chromide juveniles

hatching rate. The newly hatched larvae measures 4.6 mm. Larval rearing was carried out in 70 l tubs by providing *Artemia nauplii* to 3 dph larvae continued upto 30 dph. On 10th day, larvae were weaned to 200 µm larval diet. Larvae attained mean length and weight, 9.0±0.31 mm, 33±3.74 mg in 30 days with 80% survival rate. *E. maculatus* fry stocked in nylon hapa's (2×1×1 m) @ 300 no's fry/hapa and reared for 60 days, juvenile attained mean length 54.2±1.60 mm and 4.46±0.18 g. A total of 1972 no's marketable size *E. maculatus* juveniles were produced from 10 pair of brooders. Cage based breeding model of *E. maculatus* demonstrated scope for mass scale seed production and forms a livelihood option for small scale farmers and SHG groups.

Orange chromide, *Etroplus maculatus* brooders

Nutrition & Feed Technology

While aquaculture is expanding rapidly, understanding the nutrient requirements, optimizing practical feed formulations and dealing with feed inputs are critical to the continued success of the industry. Hence about 50 to 60% of the operational cost spent on feed, it is not only just a biological requirement but also an economic factor which determines the success of aquaculture. CIBA is actively involved in various aspects of nutrition research of the candidate brackishwater species targeting cost-effective feeds and feed management for grow-out farming, functional feeds, speciality feeds for maturation & larval rearing and final product quality.

Nutrition & 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 the coming years. Our dependency on overseas companies for the hatchery feeds continues and it creates 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.

BSF *(Hermetia illucens)* meal as an sustainable alternative to fishmeal for shrimp

Our earlier work revealed that Black soldier fly larva meal has been identifies as an potential alternative to fish meal due to its high protein and fat content. In order to ascertain the nutritional potency of the BSF larvae a feeding experiment was conducted by replacing fish meal with BSF larval meal at 0,5,10 and 15% (W/W). The feeding experiment was conducted for seven weeks in the juvenile *Penaeus vannamei* with an ABW of 4.00±0.06g with three replicates for each treatment. There was no problem in palatability of the test feeds containing varying levels of BSF meal and the test diets and been consumed without any problem. The results at the end of the experiment are given below

Parameters/Feed	BSF0	BSF5	BSF10	BSF 15
Final body weight (g)	11.70	11.87	11.65	11.44
Weight gain (g)	7.65	7.78	7.58	7.41
Weight gain%	188.72	190.45	186.48	183.48
Survival%	92.59	96.30	92.59	88.89

Dried BSF larvae ready for inclusion in shrimp feed

All the groups fed with different diets showed good survival and the group fed with feed containing 5% BSF showed highest weight gain and survival. The group fed with 15% BSF meal showed a slight decrease in weight gain and survival compared to control. We could infer that BSF meal can be included upto 10% in the diet of vannamei without affecting growth and survival. This also revealed that BSF as an sustainable and viable alternative to fishmeal.

Locust meal as a novel ingredient in aquafeed

Adult Desert Locust

India had recently (May 2020) witnessed the attack of the Desert Locust (*Schistocerca gregaria*) and is considered to be the deadliest threat to agriculture. Several strategies have been planned to mitigate the menace. Considering

Oven dried locust insect

this emergency situation and to turn the adverse situation into a potential opportunistic one a study was planned to explore the nutritional potency of Locust as a novel ingredient in aquafeed. Hence a study was attempted to explore its nutritional value. The desert locust sample was collected from Jodhpur, Rajasthan for complete analysis.

Preliminary studies on analysis of the adult locust revealed that it is a very good source of protein and fat. Considering the nutritive richness, it would be an ideal ingredient in fish and shrimp feed as a fish meal replacer. The insect samples were collected after they have been sprayed with insecticide malathion and the analysis revealed that it contained about 13.92ppm. of malathion. In order to explore its utility in shrimp and fish feeds locust samples should be collected physically using proper nets. Hence there is a big scope to turn the adverse situation into opportunity and this would also help in developing cost effective sustainable feed .

Effect of Locust meal as an ingredient in the diet of *P.vannamei*.

The higher crude protein (61.69% and lipid content (16.42) in the desert locust inferred that it can be a potential ingredient for shrimp and fish. In order to ascertain the nutritional potency a feeding experiment for eight weeks duration was conducted using locust meal at 0,5,10 and 15% by replacing fish meal. Though the locust meal contained higher concentration of chlorpyrifos 38.58ppm, this experiment was aimed at the effectiveness of locust as an ingredient. The results revealed that all the treatment groups had accepted the feed containing varying levels of locust. The group fed with diets containing 15% locust meal showed mortality within 24 hours of feeding while the group fed with 10% showed mortality from the 4th day and at the end of 7th day all the shrimp in the group fed with 10 and 15% locust meal showed complete mortality. The shrimps exhibited abnormal and lateral swimming, coming to the surface and some incoordination in the movement. Whereas, the group fed with 5% showed no abnormal symptoms. The growth rate was reduced compared to the control. The ABW in control group was 11.28 ± 0.26g while the group fed with 5% locust meal had attained an ABW of 9.98±0.28g. The survival was 96.2 and 88.3% respectively in control and 5% locust fed group. The results revealed that the locust meal is a potential ingredient for use in shrimp feed. The mortality within 24 hours in the 15% locust meal fed group infers that the pesticide

Locust Body part/ Nutrient	Adult Fledgling	Whole body	Legs	Wings
Crude Protein %	61.63	61.69	79.79	71.28
Crude Fat	16.42	20.31	4.04	5.46
Total Ash	4.94	5.31	4.31	6.71

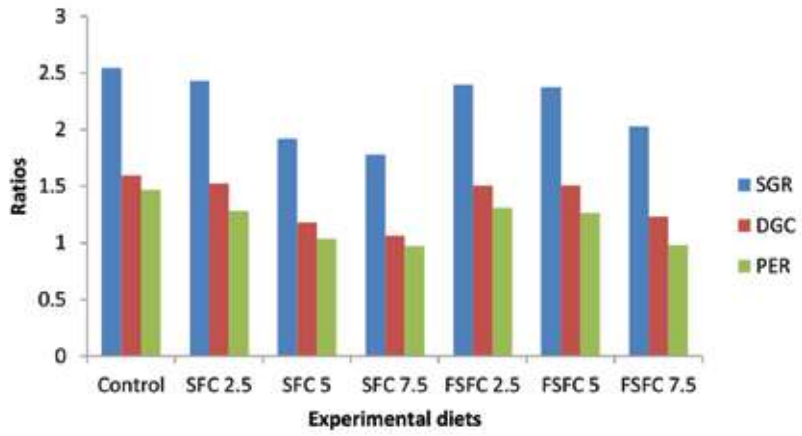
choropyrifos is highly lethal. The near normal performance in 5% locust fed group revealed that though it is toxic shrimps are capable of excreting it and the compound is not stored in the body. This has been confirmed by the residual analysis in post-fed experimental shrimp. The post-fed experimental animals failed to show any residue of choloropyrifos. Thus it is clear that the mortality is due to the pesticide and the locust had got good potential as a protein ingredient. Hence if locust could be harvested physically or without any pesticide, then it can be effectively used in shrimp feed.

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

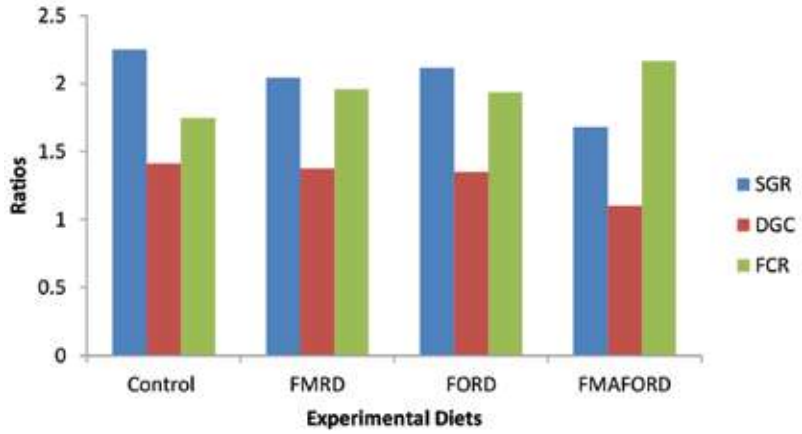
Sunflower oil cake was fermented with yeast, *Saccharomyces cerevisiae* at 60-65% moisture for three days. For optimization of the inclusion level in shrimp feed, nine test feeds having 0, 2.5, 5.0, 7.5 and 10% levels of raw and yeast fermented SFC were prepared by replacing fishmeal. The results indicated that yeast fermented SFC can be included up to 7.5% whereas raw SFC could be included up to 2.5% in *P. vannamei.* The enhanced inclusion level of fermented SFC can be attributed to reduction of saponins (mg/100g DMB) and hemicellulose (% on DMB) from 641.52± 39.57& 16.27±0.44 to 207.01±18.99 & 12.69±0.59, respectively.

Effect of total replacement of fishmeal and/or fish oil in milkfish grow-out feeds on growth in an outdoor microcosm system

Four experimental grow-out milkfish iso-nitrogenous and iso-lipidic diets were prepared by replacing fishmeal/ fish oil or both. A 60 day feeding experiment was conducted in an outdoor microcosm system in the hatchery produced juveniles of milkfish. Though the replacement of either fishmeal or fish oil reduced weight gain in milkfish but values are not significant. But the replacement of both fishmeal and fish oil has significantly ($P<0.05$) reduced the weight gain (%) from 286.10±5.04 to 174.38±5.07. The results have to be further evaluated for the up regulation of genes responsible for fatty acid elongation and desaturases.



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



Effect of replacement fish meal/ fish oil or both in the grow-out diets of Milkfish, *Chanos chanos* on growth

Utilization of Azolla leaf meal in vannamei diet

Azolla is a floating aquatic macrophyte which hosts a symbiotic blue green algae *Anabaena azollae*, which is responsible for the fixation and assimilation of atmospheric nitrogen. Azolla is found to contain 20.04 ± 0.06% crude protein, 2.33 ± 0.10% lipid, 18.61 ± 0.04% ash and 43.74 ± 0.06% NFE and has been reported to be a very good source of protein, essential mineral elements and vitamins for animals. Out of several species

Put label as Azolla leaf meal

of Azolla, *Azolla microphylla* has been reported to be best suited for tropical climate and livestock feeding and used in this present study.

Five isoproteinous (CP-35%) and isolipidic (EE-5%) experimental *Penaeus vannamei* diets were formulated by using 0,7,14,21 and 28% Azolla meal by replacing 0, 1.35, 2.70, 4.05 and 5.40% of the soya protein and fed to *P.vannamei* juveniles for 42 days in 500 litre FRP tanks in triplicate. Weight gain, FCR and PER was found to be similar when soy protein is replaced upto 4.05% level using 21% azolla in the diet beyond which growth and FCR were affected significantly ($P < 0.05$). Hence azolla meal could be used in vannamei feed formulation upto 21% replacing 4.05% soyaprotein.

Utilization of potato waste in vannamei diet

India produces 52.5 million tonnes of potato out of which a significant portion (about 12%) is thrown as wastage in the form of potato waste. Potato waste meal (potatoes, potato pulp and peeling) is a product produced by drying and grinding of culls of potatoes, potato trimming, pulp, peeling and off-colour parts of French fries and potato chips. Potato waste meal contains 12.45 ± 0.11% crude

Performance of *P. vannamei* fed different levels of azolla meal

Parameters	Azolla meal (0%)	Azolla meal (7%)	Azolla meal (14%)	Azolla meal (21%)	Azolla meal (28%)
Initial body wt., g	3.57±0.02	3.59±0.01	3.58±0.02	3.58±0.01	3.58±0.02
Final body wt., g*	7.04±0.43^{b}	7.35±0.27^{b}	6.89±0.35^{b}	6.42±0.07$^{a\,b}$	5.66±0.22^{a}
Wt. gain%*	97.45±12.38^{b}	104.81±7.17^{b}	92.41±9.96^{b}	79.08±2.03$^{a\,b}$	58.12±6.19^{a}
FCR*	2.39±0.11^{a}	2.37±0.07^{a}	2.54±0.05^{a}	2.69±0.05^{a}	3.33±0.38^{b}
PER**	1.02±0.06^{b}	1.21±0.10^{b}	1.12±0.02^{b}	1.05±0.02^{b}	0.87±0.09^{a}

*P<0.05, **P<0.01, a,b values bearing different superscript in a row differ significantly

Potato waste meal

protein, 1.07 ± 0.01% lipid, 1.25 ± 0.05% ash and 53.75 ± 0.21% NFE.

The level of inclusion of potato waste meal (PWM) was evaluated in *P. vannamei* diets for which 15 shrimps of 10.46-10.60g body weight were stocked in 500 litre FRP tanks in triplicate and fed potato waste meal at 0 (control), 8 (T1), 16(T2), 24 (T3) and 32 (T4)% level by replacing 0%, 25%, 50%, 75% and 100% of cereal flour. After 42 days of the experiment, it was found that weight gain and nutrient digestibility were significantly decreased (P<0.05) at 50% and above level of replacement of flour by potato waste meal. It was concluded that PWM can be safely used upto 8% level with the replacement of 25% of cereal flour sources in *P. vannamei* diet.

Development of specific functional formulations to improve the hapatopancreatic health.

The health of hepatopancreas is one of the keys to successful shrimp farming, but the damage of hepatopancreas of shrimp often occurs during the farming process. Currently, there is increasing interest to improve the health of the hepatopancreas through functional nutrients. In this context taurine and bile salts are considered to be the first choice nutrients that could beneficially affect the health of the hepatopancreas in shrimp. Hence two experiments using taurine and bile salts for its effect on the hepatopanceratic health was evaluated.

Taurine supplementation on the growth and health of the shrimp

An 8-week feeding trial was conducted to investigate the effects of different taurine levels on the growth performance of juvenile white shrimp fed with low-fishmeal diets. Test diets containing five levels of dietary taurine were prepared by the supplementation of taurine (0, 3g kg^{-1}, 6g kg^{-1}, 9g kg^{-1}, ^{1} and 12g kg^{-1}) to a control diet .Each diet was randomly assigned to triplicate groups of 15 shrimps (1.00 ± 0.01 g), each three times daily. Shrimp fed the 3g kg^{-1} and 6g kg^{-1} taurine-supplemented diets, showed significantly higher weight gain and survival. The results of the present study demonstrate that the white shrimps require taurine as an essential nutrient for growth

Performance of *P. vannamei* fed diet with different levels of potato waste meal

Parameters	0% PWM	8% PWM	16% PWM	24% PWM	32% PWM
Initial body wt. (g)	10.46±0.17	10.49±0.18	10.60±0.15	10.54±0.16	10.60±0.05
Final body wt. (g)**	15.19±0.13^{d}	14.57±0.09^{cd}	14.39±0.34^{bc}	13.83±0.24^{ab}	13.58±0.13^{a}
Wt. gain%**	45.23±2.61^{d}	38.97±2.70^{cd}	35.81±1.45^{bc}	31.26±0.66^{ab}	28.13±1.80^{a}
FCR	1.69±0.03	1.88±0.10	1.85±0.26	2.02±0.08	2.18±0.10
PER	1.72±0.03	1.55±0.08	1.65±0.26	1.45±0.05	1.34±0.07
Survival%*	68.33±1.67^{b}	65.00±2.89^{ab}	61.67±1.67^{ab}	60.00±2.89^{a}	58.33±1.67^{a}

*P<0.05, **P<0.01, a,b,c,d values bearing different superscript in a row differ significantly

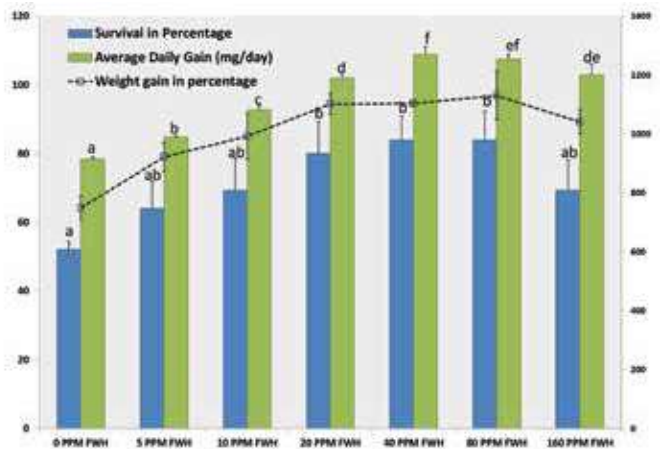
performance. Squash smear preparations also revealed a better and healthy heapatopancrease in 0.3 to 0.6% taurine supplemented diets.

Effect of Tauracholate (Bile acid) supplementation

A7-week feeding experiment was conducted to investigate the effects of dietary bile acids (BAs) on juvenile white legged shrimp *Penaeus vannamei.* The standard CIBA Vanami^{Plus} feed (35% CP and 6.0% fat) without the bile salt (BS0) was the control feed. The experimental diets were prepared by supplementing the bile salt at 0.15,0.3,0.45 and 0.6%. The Vanami^{Plus} diet containing BAs of 0, 0.15, 0.30, 0.45 or 0.6g/100g diet and fed to 15 no. of shrimp in each group with three replicates. The results showed that weight gain (WG) increased significantly with the increase in BAs from 0 to 0.3g/kg diet and then supplementation beyond this level failed to show the beneficial effect. The results of the present study demonstrate that the white shrimps require bile acid, taurocholate as an essential nutrient for growth performance. Squash smear preparations also revealed a better and healthy heapatopancreas in 0.3% tauracholate supplemented diets.

Effect of Fish Waste Hydrolysate (FWH) in *Penaeus indicus*

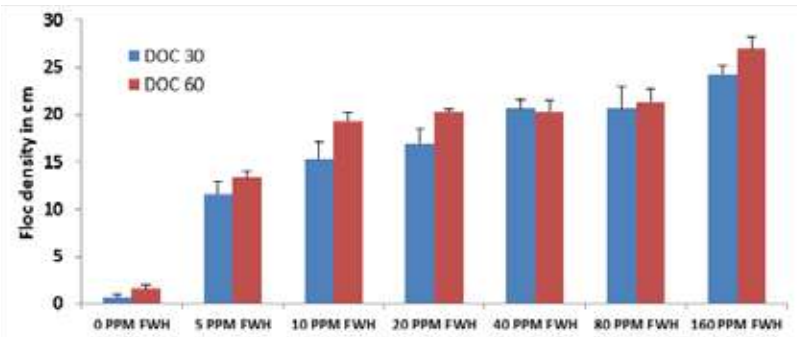
A 60 days experiment was conducted to study the effect of fish waste hydrolysate in *Penaeus indicus* in outdoor tank systems. Different doses of FWH like 0 ppm, 5 ppm, 10 ppm, 20 ppm, 40 ppm, 80 ppm and 160 ppm were used in the trial. Forty per cent of the FWH doses were administered as basal dose and remaining quantity were given as equal weekly dose. The



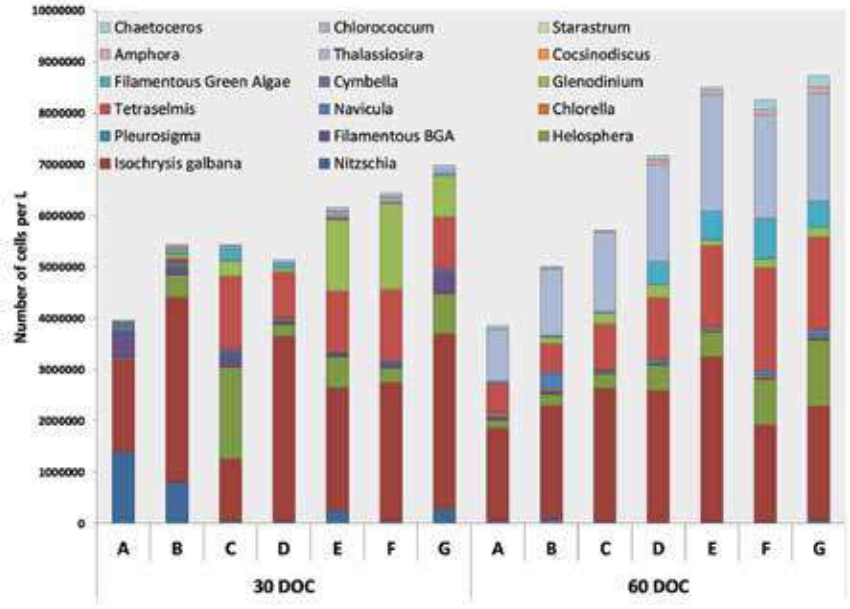
Survival, ADG and Weight gain of *Penaeus indicus* supplemented with FWH

Microscopic view of the floc generated in the FWH supplemented treatments

results of the study showed that the Specific Growth Rate, Weight gain (g) and FCR are significantly (P<0.01) improved when the treatments are supplemented with FWH at the rate of 10 ppm or more compared to the control without FWH supplementation. Average Daily Gain (ADG) and Weight gain percentage of *P indicus* supplemented with FWH were significantly higher (P<0.01) than the control irrespective of the dosage of FWH. There was a significant increase (P<0.01) in survival percentage of *P indicus* in treatments supplemented higher doses of FHW (20 ppm and above). The growth parameters of *P indicus* supplemented with FWH clearly revealed that the 40 ppm FWH dose contributed maximum growth and growth performance of the animals grown in higher doses (80 and 160 ppm) of FWH are not significantly different from that of 40 ppm FWH supplemented treatment. FWH supplemented treatments showed a significantly higher biofloc density compared to control and floc density was increasing with the increase in the FWH dose. The abundance of



Floc density (cm) in *P. indicus* tanks supplemented with FWH



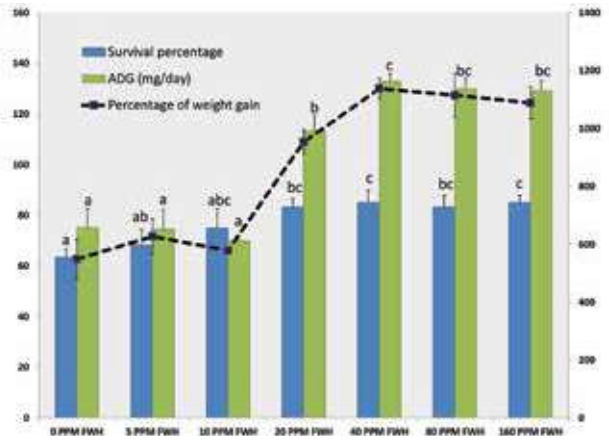
A: 0PPM FWH, B: 5 PPM FWH, C: 10 PPM FWH, D: 20 PPM FWH, E: 40 PPM FWH, F: 80 PPM FWH, G: 160 PPM FWH

Phytoplankton diversity and abundance in FWH supplemented treatments

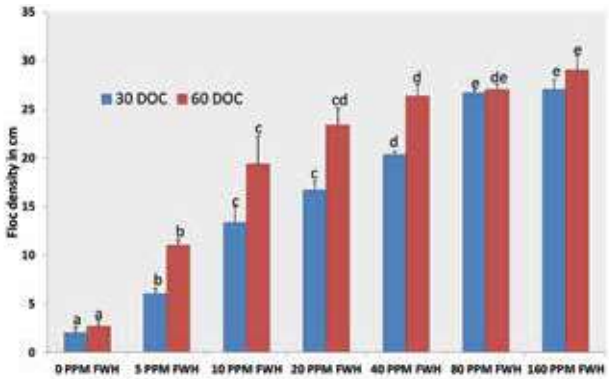
phytoplankton and zooplankton showed significant increase in the FWH supplemented treatments compared to control and number of cells were increasing with the increase in the FWH dose. The abundance of zooplankton like Copepods, rotifers and Nematode worms might have contributed to the growth of *P indicus*.

Effect of Fish Waste Hydrolysate (FWH) in *Penaeus monodon*

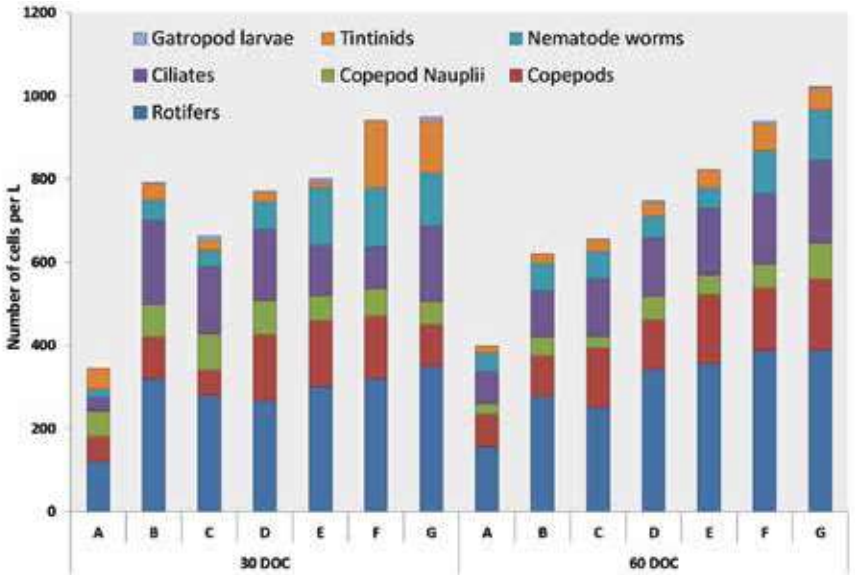
A 60 days experiment was conducted to study the effect of fish waste hydrolysate in *Penaeus monodon* in outdoor tank systems. Different doses of FWH like 0 ppm, 5 ppm, 10 ppm, 20 ppm, 40 ppm, 80 ppm and 160 ppm were used in the trial. The results of the experiment showed that Specific Growth Rate (SGR), Weight gain (g) and FCR of *P monodon* grown in FWH (@ 20 ppm and above) supplemented treatments were significantly improved (P<0.01) than control and lower doses



Survival, ADG and Weight gain of *Penaeus monodon* supplemented with FWH



Floc density (cm) in *P. monodon* tanks supplemented with FWH



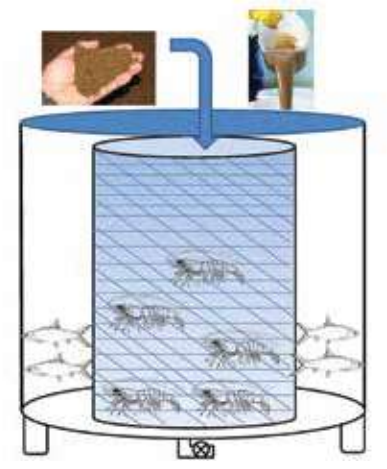
A: 0PPM FWH, B: 5 PPM FWH, C: 10 PPM FWH, D: 20 PPM FWH, E: 40 PPM FWH, F: 80 PPM FWH, G: 160 PPM FWH

Zooplankton diversity and abundance in FWH supplemented *P monodon* culture tank

of FWH @ 5 ppm and 10 ppm. Similar trends were observed in percentage of survival, Average Daily Gain (ADG) and percentage weight gain where in, these growth parameters of *P monodon* supplemented with FWH @ 20 ppm or more were significantly higher (P<0.01) than the control and lower doses of FWH @ 5 ppm and 10 ppm. The results showed that the FWH supplanted @ 20 ppm is significantly enhancing the growth performances of *P monodon*. Significantly higher biofloc densities were noticed in all FWH supplemented treatments compared to control. The floc density was increasing with the increase in FHW dosage. The results showed that the abundance of the phytoplankton and zooplankton were significantly higher in FWH supplemented treatments irrespective of the dose than that of the control. A higher abundance of microalgae and zooplankton might have contributed positively to floc formation and improved growth of *P monodon* in the culture system.

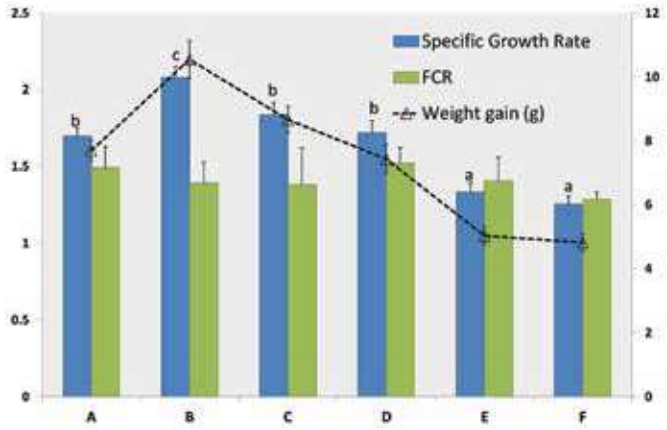
Effect of Fish Waste Hydrolysate (FWH) in modified polyculture system

A 60 days experiment was conducted to study the effect of fish waste hydrolystae in a modified polyculture system with *Penaeus monodon* and *Chanos chanos*. In 500 L FRP tank a circular meshed partition was made to separate shrimp and fish by ensuring the adequate water circulation inside the tank. The feed was given only to shrimps whereas there was no feed given to milk fish. The polyculture experiment revealed that the Specific Growth Rate (SGR), Weight gain and Average Daily Gain (ADG) of *P monodon* supplemented with FWH @ 40 ppm and fed with 100% of required formulated feed was significantly higher (P<0.01) than that of the other treatments. There was no significant difference in growth parameters and survival between animals grown in control and the animals fed with 80% of the required feed as well as supplemented with 40 ppm FWH. So it is clear that in this modified polyculture system, the growth of *P monodon* is on par with control when the formulated feed reduced to 20% but supplemented with 40 ppm FWH. It is interesting to note that *C chanos* from all the treatments in this system which was not provided any formulated feed and supplemented with FHW @ 40ppm showed higher growth performances than control. The formulated feed also contributed for the production of natural food organisms. The treatment with



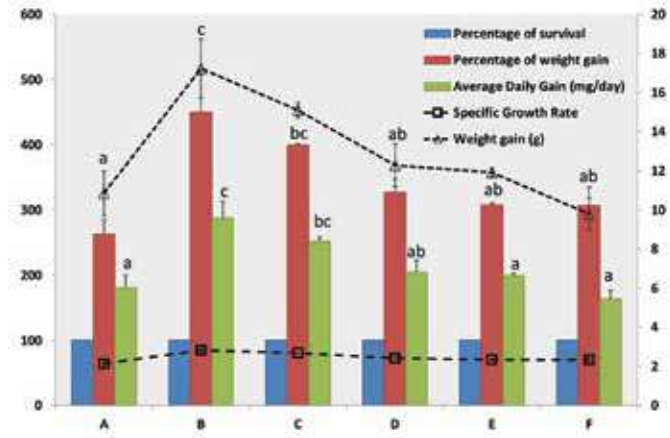
Modified polyculture tank system

Penaeus monodon and *Chanos chanos* grown in FWH supplemented tanks



A: 100% feed + 0 ppm FWH, B: 100% feed + 40 ppm FWH, C: 90% feed + 40 ppm FWH, D: 80% feed + 40 ppm FWH, E: 70% feed + 40 ppm FWH and F: 60% feed + 40 ppm FWH

Growth parameters of *P monodon* supplemented with FWH



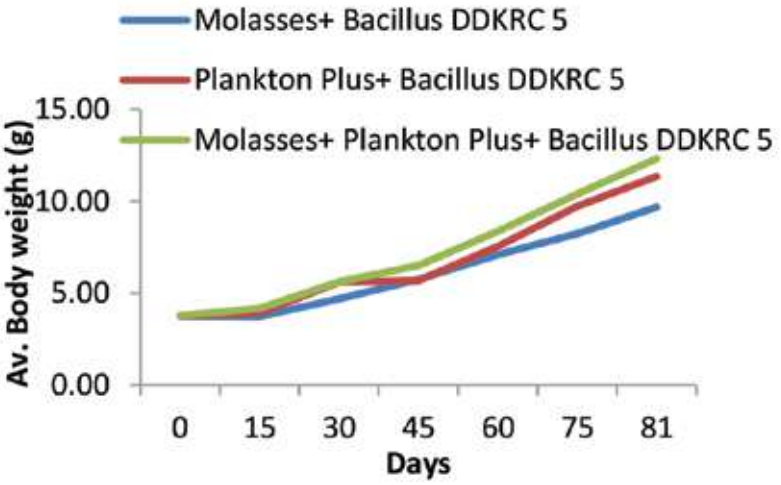
A: 100% feed + 0 ppm FWH, B: 100% feed + 40 ppm FWH, C: 90% feed + 40 ppm FWH, D: 80% feed + 40 ppm FWH, E: 70% feed + 40 ppm FWH and F: 60% feed + 40 ppm FWH

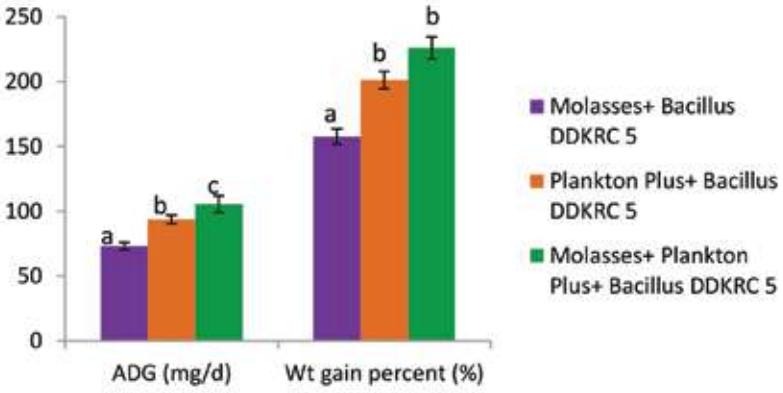
Growth parameters of *C chanos* supplemented with FWH

40% reduction in formulated feed (fed only to shrimps) where showed better growth than control where there was no reduction in formulated feed. Phytoplankton diversity and abundance of the FWH supplemented polyculture system showed a significant increase compared to control. The plankton abundance was highest in the treatment fed with 100% feed and 40 ppm FWH. The results of the study give the baseline information to culture *C chanos* along with *P monodon* in extensive culture systems with separation from shrimps using the meshed net. The FWH supplementation enhanced the growth of shrimps and compensated the nutrient requirement of fish through the production of natural food organisms in the system.

Ecosystem based resource mapping of brackishwater areas in Kannur district, Kerala

Kannur is one of the leading districts in scientific shrimp farming in Kerala; however there are huge underutilized brackishwater areas in the district. Since there are no proper scientific studies regarding the mapping of brackishwater resources in Kannur District, it is imperative to map the untapped brackishwater resources of the district for proper management and sustainable brackishwater aquaculture. In this regard, ICAR-Central Institute of Brackishwater Aquaculture, Chennai has initiated a research programme in collaboration with Kerala University of Fisheries and Ocean Studies (KUFOS), Cochin, Kerala pertaining to the mapping of brackishwater resources in Kannur. Initial studies on the ecosystem based resource mapping in 5 river systems (Perumba, Kuppam, Valapattanam,

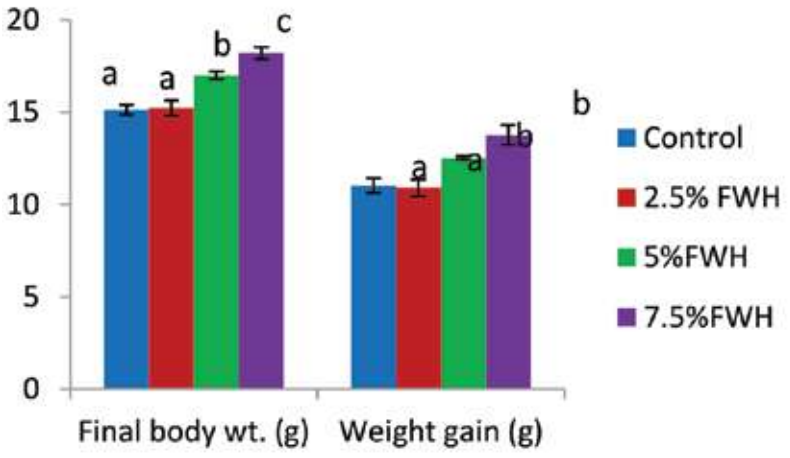


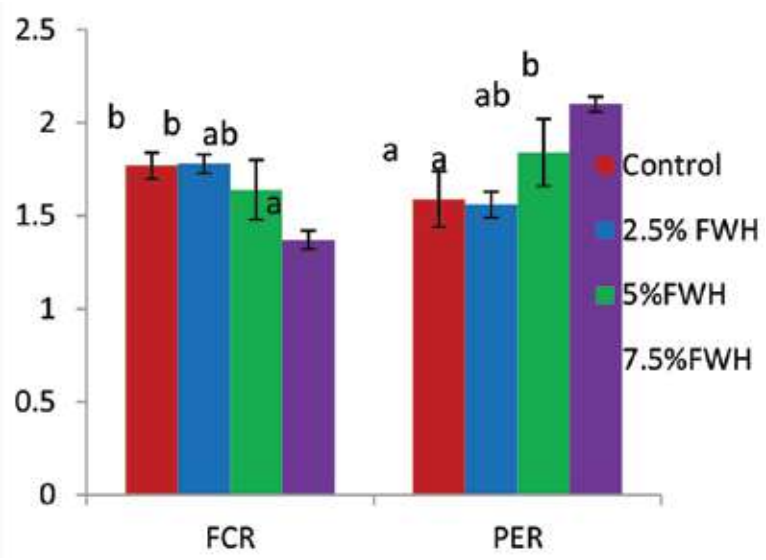


Anjarakkandi and Kuyyali Rivers), associated brackishwater areas as well as aquaculture areas revealed that a total brackishwater area in the district is approximately about 4814 ha and the total area under aquaculture is about 673 ha only.

Development of simplified floc system using Plankton^{Plus} and molasses

An outdoor experiment was conducted for development of floc using Plankton^{Plus} and its effect on growth performance of *Penaeus vannamei* juvenile (ABW 3.77±0.01 g) in 2 tons culture tank with transparent roofing. Shrimp juveniles were stocked @ 100 juvenile per m^3. There was three treatments in the experiment; Control: molasses supplementation, T1: Plankton^{Plus} supplementation, T3: combined supplementation of Plankton^{Plus} and molasses. In all the treatments C:N ratio of 15:1 was maintained. For development of floc, molasses and Plankton^{Plus} were added in respective treatments along with *Bacillus subtilis* DDKRC5 (JN641293) (4.6×10^{9}cfu/ml) @0.05% (v/v) as probiotics one week prior to stocking. Shrimps of all the treatments were offered formulated feed (CP-35 %, EE 5%) at 3-5 % of biomass twice (10 am & 4 pm) daily. At the end of 81 days, shrimps attained significantly (P<0.01) higher body weight in groups supplemented with both molasses and Plankton^{Plus} followed by only Plankton^{Plus} compared to control. The phytoplankton and zooplankton abundance was found to be higher (P<0.01) in groups supplemented with both molasses and Plankton^{Plus} followed by only Plankton^{Plus} and only molasses. Weight gain, SGR and PER was higher (P<0.01) and FCR was significantly (P<0.05) lower in floc system developed using molasses with Plankton^{Plus} and only Plankton^{Plus}. Survival was similar in all the groups. This study suggested that simplified floc system can be developed using Plankton^{Plus} and molasses and *P. vannamei* juvenile can be reared at higher density of 100 no./ m^3 to achieve better growth and feed conversion.





Optimization of dietary inclusion level of fish waste hydrolysate in diet of *P.vannamei*.

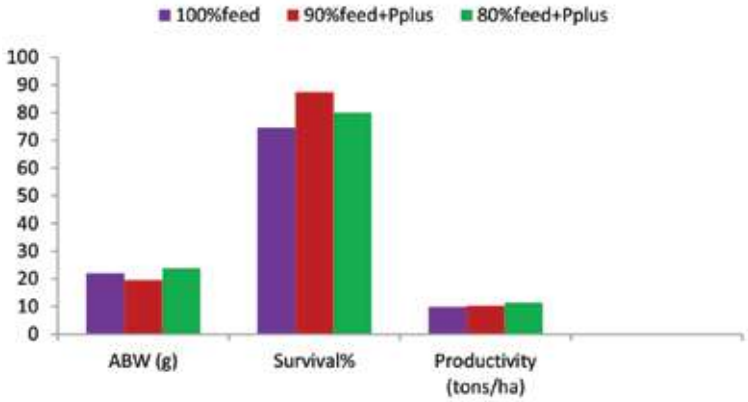
To determine optimum inclusion level of fish waste hydrolysate (FWH) in diet of *P.vannamei* feed (CP-34 %, EE-5%) was prepared with four different level i.e., 0, 2.5, 5 & 7.5 % of FWH on dry basis and evaluated in 10 weeks yard trial with *P.vannamei* juveniles (body wt. 4.33±0.09 g). It was found that average daily gain was higher ($P<0.01$) in groups fed diet with 5 % and 7.5 % FWH. Protein efficiency ratio (PER) was significantly ($P<0.05$) higher and Feed conversion ratio (FCR) was lower ($P<0.05$) when shrimps were fed diet with 7.5% FWH but no significant difference in FCR was observed in shrimps fed 5 % and 7.5 % FWH. Nutrient digestibility and survival did not differ significantly among groups. Body composition analysis revealed higher muscle protein content in groups received diet containing 5 & 7.5% FWH. Therefore it is concluded that FWH can be incorporated up to 7.5 % level with potential to replace 7 % fish meal in diet of *P.vannamei*.

Demonstration of potential of CIBA-Plankton^{Plus} supplementation on reduction of feed requirement in shrimp culture in West Bengal

Potential of Plankton^{Plus} (PPlus) on reduction of feed requirement was demonstrated in farmer's ponds at Haripur, Namkhana, West Bengal under SCSP. Three ponds (1000-2000 sq m) with three different treatments, i.e., control (100 % feed without PPlus), T1 (90% feed & supplemented with PPlus) and T2 (80% feed & supplemented with PPlus) were used for demonstration. Plankton^{Plus} was used at 30 ppm and shrimps were stocked @ 60 pcs/sq m. After 120 days of culture, highest productivity of 11.45 t/ha was achieved when Plankton^{Plus} was supplemented and feed was reduced by 20 % compared to 9.83 t/ha in control. The demonstration clearly showed that Plankton^{Plus} could save 20 % feed as well as could enhance the productivity to the tune of 1.62 t/ha.

Study on the potential of Fish Waste Hydrolysate (CIBA-Plankton^{Plus}) on reduction of feed requirement in shrimp culture during winter

Experiment was conducted to evaluate potential of CIBA-Plankton^{Plus} on reduction of feed requirement in vannamei shrimp culture. Six brackishwater ponds (each of 0.15 ha) were used for

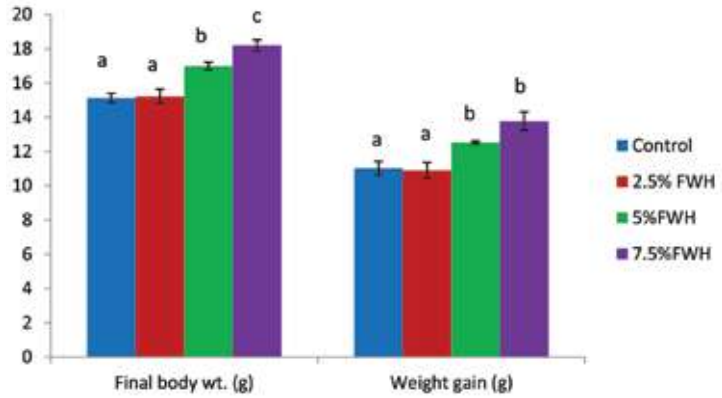


experiment with three different treatments, i.e., control (100 % feed without PPlus), T1 (85% feed & supplemented with PPlus) and T2 (70% feed & supplemented with PPlus). Plankton^{Plus} was used at 30 ppm and shrimps were stocked @ 40 pcs/sq m. Shrimp was stocked on October,2019 and harvested during February, 2020. Culture duration was 172 days. Due to prolonged winter growth was stunted and there was no compensatory growth. At the end of culture average body weight (ABW) was 16.50±4.50, 16.49±1.96 and 16.98±2.10g with a productivity of 3.88±0.38, 3.56±0.15 and 3.46±0.05 t/ha in control, T1 and T2, respectively.

There was no significant difference in ABW, productivity, FCR and survival among the groups. From the experiment it may be concluded that Plankton^{Plus} supplementation has the potential to reduce the feed requirement to the tune of 15-30 % in *P. vannamei* culture without affecting the production.

Study on supplementary effect of CIBA- Plankton^{Plus} in shrimp culture

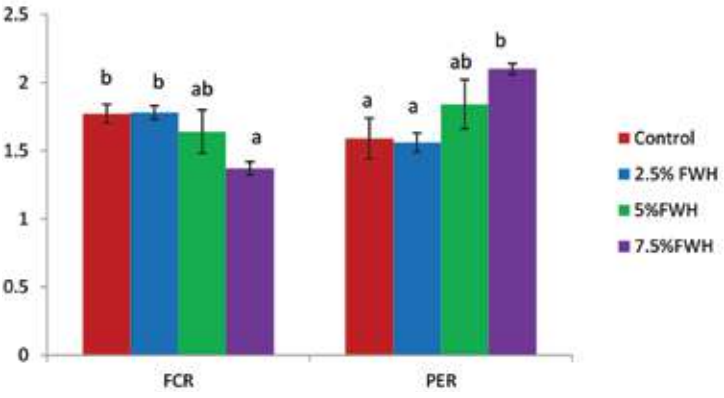
Experiment was conducted to evaluate supplementary effect of CIBA-Plankton^{Plus} (PPlus) and its potential on reduction of feed requirement in vannamei shrimp culture during summer crop. Eight brackishwater ponds (each of 0.15 ha) were used for experiment with four different treatments, i.e., control (100 %



Production Performance of *P. vannamei* culture with different level of feed & Plankton ^{Plus}

	Control (100 % feed without PPlus)	T1 (85% feed with PPlus)	T2 (70% feed with PPlus)
ABW	16.50±4.50	16.49±1.96	16.98±2.10
Production (Kg)	582.30±57.30	534.60±21.90	519.25±6.95
Productivity (t/ha)	3.88±0.38	3.56±0.15	3.46±0.05
Feed intake (Kg)**	1479.23 c ±4.07	1205.85b±35.35	1014.60a±4.00
FCR	2.57±0.25	2.25±0.03	1.95±0.04
Survival (%)	61.84±11.08	54.54±4.27	51.85±7.09

**P<0.01, a,b values bearing different superscript in a row differ significantly



feed without PPlus), T1 (100% feed & supplemented with PPlus), T2 (85% feed & supplemented with PPlus) and T3 (70% feed & supplemented with PPlus). Plankton*Plus* was used at 30 ppm and shrimps were stocked @ 30 pcs/sq m. At the end of 90 days culture average productivity of 2.18±0.15, 2.49±0.04, 2.09±0.02 and 1.95±0.20 t/ha in control, T1, T2 and T3, respectively. Productivity was significantly ($P<0.05$) higher when Plankton*Plus* was supplemented with 100% feed. FCR was significantly ($P<0.05$) lower in all Plankton*Plus* supplemented group.

Phytoplankton and zooplankton population in pond was higher in all Plankton*Plus* supplemented ponds and the population was highest when Plankton*Plus* was supplemented with 100% feed. From the experiment it may be concluded that Plankton*Plus* supplementation can enhance the productivity and it has the potential to reduce the feed requirement to the tune of 15-30 % in *P. vannamei* culture without affecting the production.

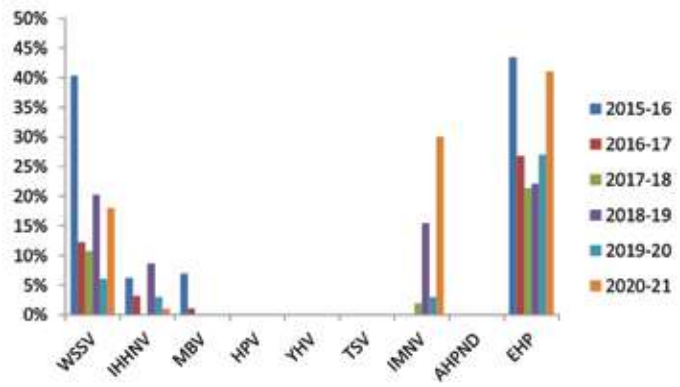
Aquatic Animal Health

The threat of diseases continues as primary constraint to the growth and sustainability of aquaculture sector. The importance of prevention and control of disease risks as a measure to reduce production losses in aquaculture system has been well acknowledged. The researchers of aquatic animal health group have been focusing on prevention, control and management of aquatic animal diseases employing cutting age tools in the field of virology, bacteriology, parasitology, vaccinology and biotechnology.

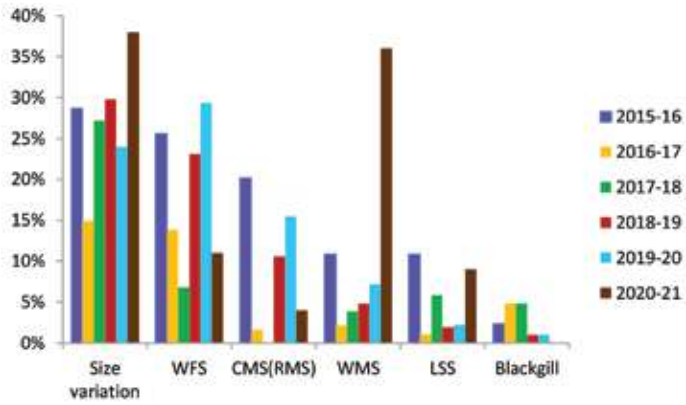
Aquatic Animal Health

Diseases are the major constraints in sustainable shrimp aquaculture

To understand the disease scenario in shrimp farming, surveillance was carried out over the period of five years (2015-21) in 801 shrimp farms covering different shrimp farming states. The analysis indicates that *Enterocytozoon hepatopenaei* (EHP) and white spot syndrome virus (WSSV) continue to pose the highest threats. In the year 2020-21, a total of 98 shrimp farms were investigated and the results indicate that infectious myonecrosis virus (IMNV) is becoming a serious emerging pathogen to Indian shrimp farming. The IMNV prevalence during 2020-21 was 30% compared to only 3% in the preceding year. Similar to the previous year, the highest disease prevalence of EHP was 41%, followed by 18% for WSSV. The incidence of management associated diseases such as running mortality syndrome, white faeces syndrome, white muscle syndrome, size variation etc., in Indian shrimp farming were the major factors for the reduced productivity in the shrimp farms. The Indian brackishwater aquaculture sector during the last five years were free from other OIE listed diseases such as Taura syndrome virus (TSV), yellow head virus (YHV), acute haepatopancreatic necrosis disease (AHPND) and necrotizing hepatopancreatitis (NHP). The



Prevalence of viral, bacterial and microsporidian diseases in Indian shrimp farms during 2015 – 2021 (n= 801 farms)

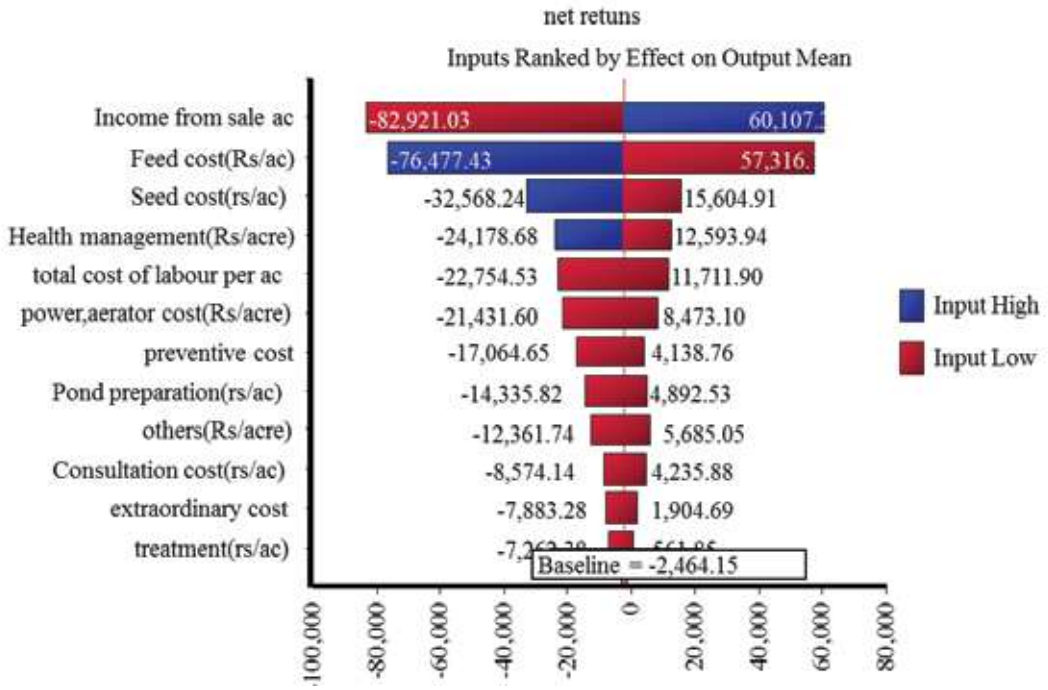


Prevalence of disease syndrome in Indian Shrimp farms during 2015 – 2021 (n= 801 farms)

emergence of pathogens such as IMNV and widespread distribution of EHP requires to be contained through effective control strategies by strictly employing biosecurity and application of BMPs. Seed testing before stocking the ponds must be made mandatory to minimize losses due to such diseases.

Risk analysis of EHP in shrimp farms using Monte Carlo simulation model

Farm level economic loss due to EHP was estimated through survey of shrimp farms in Andhra Pradesh, Tamil Nadu and Gujarat. Stochastic model was used to simulate the difference between the EHP affected and healthy farms.



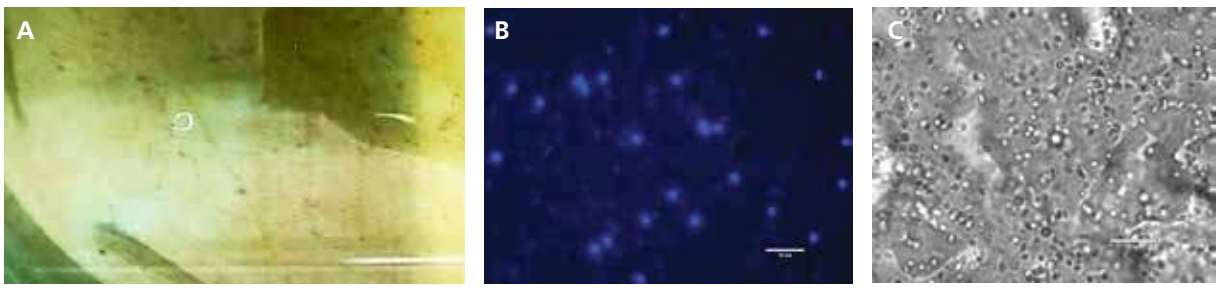
Tornado plot showing the farm level input ranking among various cost factors and production

Regression coefficient estimated using Excel @Risk and expressed through Tornado plot. The EHP affected shrimp farms had losses in the range of 103.6% (Andhra Pradesh) to 115.9% (Tamil Nadu) over the investment cost. However, in Gujarat the EHP affected shrimp farmers could make a small net profit of ₹ 11,870 per ton of production compared to ₹ 93,703/ton in EHP free farms. The magnitude of loss was determined by expenditure on feed and farm gate price prevailing at the time of harvest. More than half of the shrimp farmers from TN and AP lost their investment following the incidence of EHP, while 1/3rd of them were affected in Gujarat.

White fecal threads could be reproduced in shrimp experimentally infected with EHP

Enterocytozoon hepatopenaei is an obligate intracellular microsporidian parasite affecting the shrimp production globally. Since its emergence, the EHP infection is associated with white feces syndrome. However experimental evidence of EHP infection in white feces syndrome (WFS) is still lacking.

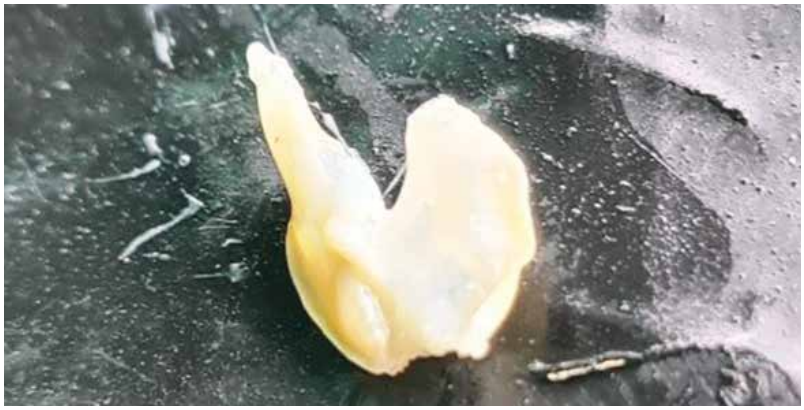
To study the association of EHP with WFS, the PCR tested shrimp (4g) was fed with EHP infected hepatopancreas tissues for two days. After 72 h, hepatopancreas lumen of infected shrimp revealed the presence of aggregated transformed microvilli (ATM). Eight days after the challenge, shrimps were positive for SWP-PCR and by



Experimental induction of white fecal threads after challenge with EHP A. EHP challenged tank with floating white fecal threads. B. EHP challenged shrimp hepatopancreas smear showing EHP spores after staining with calcofluor. C. White faecal thread squash observed with dense mature EHP spores.

15th day shrimp had white gut/ empty gut and floating white fecal threads in the EHP infected tanks. The floating white fecal threads, challenged shrimp HP squash and smear harbored the EHP spores. In this study along with floating white fecal threads, transparent non-floating fecal threads with EHP spores were also observed in the challenged group. Thus it could be concluded that shrimps fed with EHP infected tissues produced floating white fecal threads under experimental conditions post 15 days challenge.

P. vannamei male reproductive organs



P. vannamei male sperm sac

Samples (No.)	Average Size (g)	qPCR for EHP		
		Faeces (n=40)	Hepatopancreas (n=20)	Gonad / Ovary (n=20)
Male (30)	69.8 ± 6	22 +ve	12 +ve	20 -ve
Female (30)	88.5 ± 4	18 +ve	08 +ve	08 -ve
Spent egg (8 females)		Negative		

EHP may not be transmitted vertically

Earlier studies revealed that almost one third of the PL samples screened were positive for EHP by PCR. To rule out the possible transmission routes of EHP other than faecal contamination from broodstock, a case study was taken up in a private hatchery. Imported specific pathogen free (SPF) shrimp broodstock maintained in hatcheries were screened for EHP by qPCR. Of the random samples of 30 male and 30 female shrimp tested, 22 male and 18 female were positive for EHP by real time PCR by non-lethal screening using faecal samples. While 12 and 8 samples, respectively from dead shrimp were also positive in hepatopancreas (HP) samples. Interestingly, none of the gonad samples from male or female were found positive for EHP indicating the specificity of the parasite to the hepatopancreas (HP) tissues and unlikely of vertical transmission. The live polychaete diet supplemented as maturation feed could be the source of infection. A detailed screening of male and female broodstock at different maturation stages by sampling sperm sac and ovary samples, unfertilized and fertilized eggs are being carried out.

Quantitative PCR reveals very low load of EHP infection in polychaetes

A TaqMan based real-time PCR assay developed earlier was used for quantitative detection of EHP in shrimp. The live polychaete sample was used as a maturation diet. Screening of EHP-infected shrimp by qPCR showed moderate to heavy infection of EHP infection with Ct value ranging from 17.48 to 28.9. However, live sample of polychaetes (n=500) used in the

Real-time qPCR suggests that EHP does not multiply in experimentally challenged polychaete worms

Sampling days (Post feeding)	Cycle threshold (Ct) value			
	Pool 1	Pool 2	Pool 3	Mean
1	43.65	24.41	32.16	30.40
3	33.16	33.75	34.65	33.85
5	38.21	33.22	34.43	35.29
7	Not amplified	Not amplified	Not amplified	Not amplified
9	Not amplified	Not amplified	Not amplified	Not amplified

hatcheries often revealed a very low prevalence (5-8%) of EHP with a very low copy numbers (ranging from 1-1000 copies) as indicated by higher Ct value in the range of 33.8 to 36.52. These observations suggest that the polychaetes as live-feed diet could pose a potential risk of transmission of EHP to broodstock shrimps in hatcheries, but it is yet to be ascertained that the microsporidian parasites could replicate in the polychaetes. The findings indicate scope for depuration of polychaetes to make them EHP-free before being used as live feed.

Biosecurity risk of polychaetes as feed for shrimp broodstock

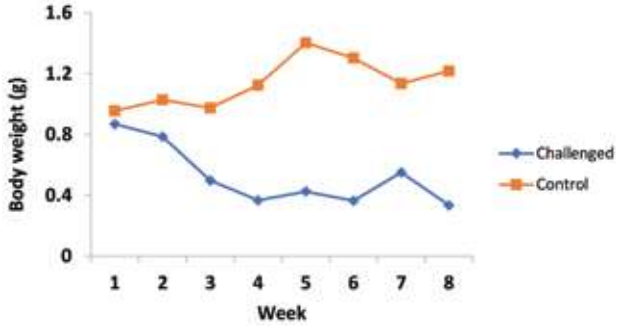
To investigate the propagation of EHP in polychaete, a challenge experiment was conducted by feeding the EHP-infected shrimp hepatopancreas to the polychaetes. The EHP load was quantified by real time PCR. The study revealed that the EHP levels in polychaetes did not increase over time as determined by quantitative PCR and histopathology. This indicates poor establishment of infection and inability of EHP to replicate in polychaete tissues. Hence, it could be concluded that the polychaetes are passive carriers of EHP and that EHP do not multiply in them.

EHP infection affects the shrimp growth, physiology and immunity

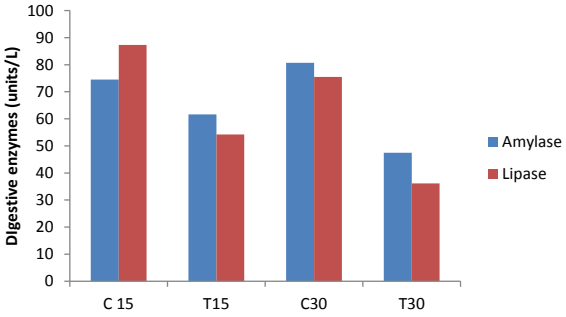
EHP is a severe threat to the global shrimp aquaculture. Since its emergence, the EHP is reported to be associated with the slow growth/ growth retardation in the affected shrimp farms. To study the role and association of EHP on shrimp growth, a challenge experiment was conducted. In addition, physiological and immune response of challenged shrimp was studied by analyzing various enzymes. The EHP negative shrimps (n=30; 3.5±0.1g) were challenged by feeding EHP infected tissues and the growth was monitored for 60 days. After seven days, challenged animals were found positive for EHP by SWP-PCR. After 60 days, the mean body weight in the challenged shrimp was 7.87±0.43g and was significantly lower than the control 12.55±0.6g. The survival rate of EHP challenged shrimp was 77.4%, compared to 93.9% in the control group. The food conversion ratio (FCR) of challenged shrimp (2.93) was significantly higher than the FCR of controlled shrimp (1.74).

The EHP infection was found to significantly affect the digestive enzymes such as α amylase and lipase. The decreased level of digestive enzymes in challenged animals affected the digestion, physiology and metabolism. Decreased triglycerides on the 15th and 30th days and cholesterol at 30th day in the shrimp haemolymph reveals impairment in the energy metabolism and molting respectively. The increased glucose level in the hemolymph at 30th day indicated that challenged animals were under stress. Protein is the primary substrate for metabolism. But there was no significant decrease in the levels of protein in the challenged animals. There was an increased level of prophenoloxidase enzyme in the challenged animals compared to

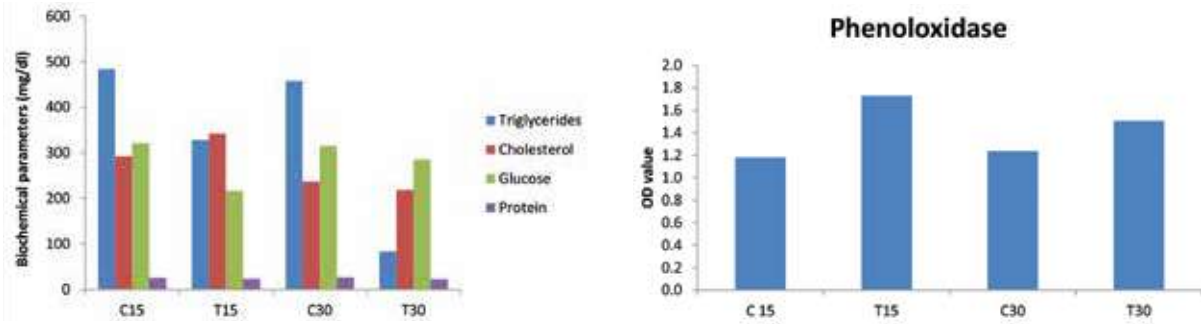
Nature of infection	No. of sample (code)	Ct value (Range)	Copy number (Range)
Naturally infected (farmed sample)	20 (1-20)	20.76±0.22 - 30.25±0.54	114±0.34 x 10^8 - 2.7±1.7 x 10^4
Experimentally infected	20 (21-40)	23.44±0.38 - 30.50±0.10	1.74±0.80 x 10^8 - 1.7±0.24 x 10^4
Uninfected (healthy)	10 (41-50)	32.67±0.60 - 34.05±0.37	0.171±0.12 x 10^4 - 0.028±0.013 x 10^4



Weekly growth of shrimps challenged with EHP and without challenge control group



Digestive enzyme activity in EHP infected treatment and EHP free control group



Biochemical parameters and prophenoloxidase activity in shrimps challenged with EHP and control group at 15 and 30 days post challenge. C15 and C30 are control and T15 and T30 are challenged groups.

control. Thus EHP infection affects the physiology, shrimp growth and induces the immune system.

Mixed infection of WSSV and barnacles (*Octolasmis sps*.) induced mortality in mud crabs

An investigation was conducted on the disease and mortality in mud crab (S*cylla* spp) farms around Ghokarna, Uttara Kannada district, Karnataka. Mud crab samples (N: 30) were collected from disease affected ponds (DOC 60 -180 days). The infected crabs were found lethargic with heavy infestation of barnacles (*Octolasmis spp*). The affected crabs had

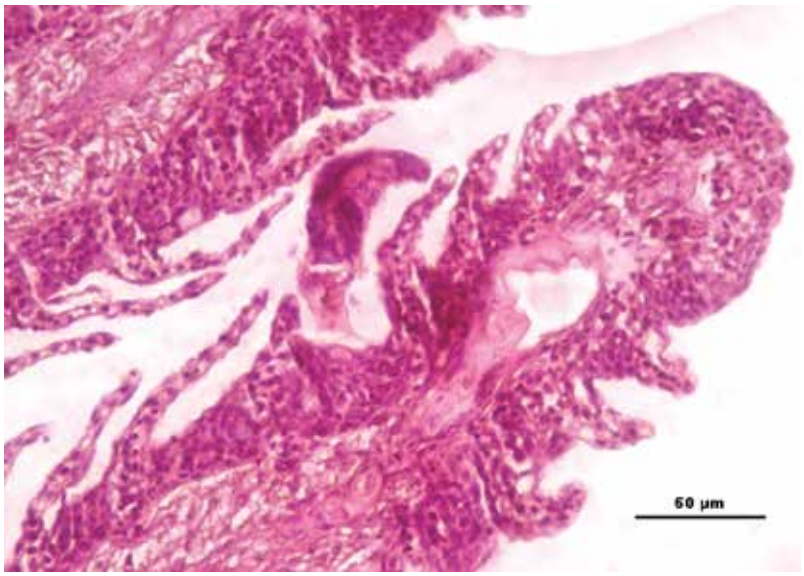
Discoloration of gills and *Octolasmis sps.* infestation in diseased Scylla olivacea

discoloration of gills. The crab samples suffered mortality due to mixed infection of barnacles and WSSV as revealed by PCR.

Ancyrocephalid infestation in Pearlspot, *Etroplus suratensis*

Ancyrocephalidae are the most significant species infesting the gills of cultured Pearlspot, *Etroplus suratensis*. These parasites have distinguishing two pairs of eye spots, two pairs of anchors, transverse bars, and marginal hooks on their haptors. They cause gill damage, dysfunction and anaemia. Respiratory problems with mass mortality were observed in severely affected fish. Other clinical signs were pale gills, low consumption of feed, erratic swimming behavior and mucus production on gills. Gill histopathological lesions included focal hyperplasia, lamellar fusion, haemorrhages and inflammatory infiltration. Degenerative changes were observed in the kidneys.

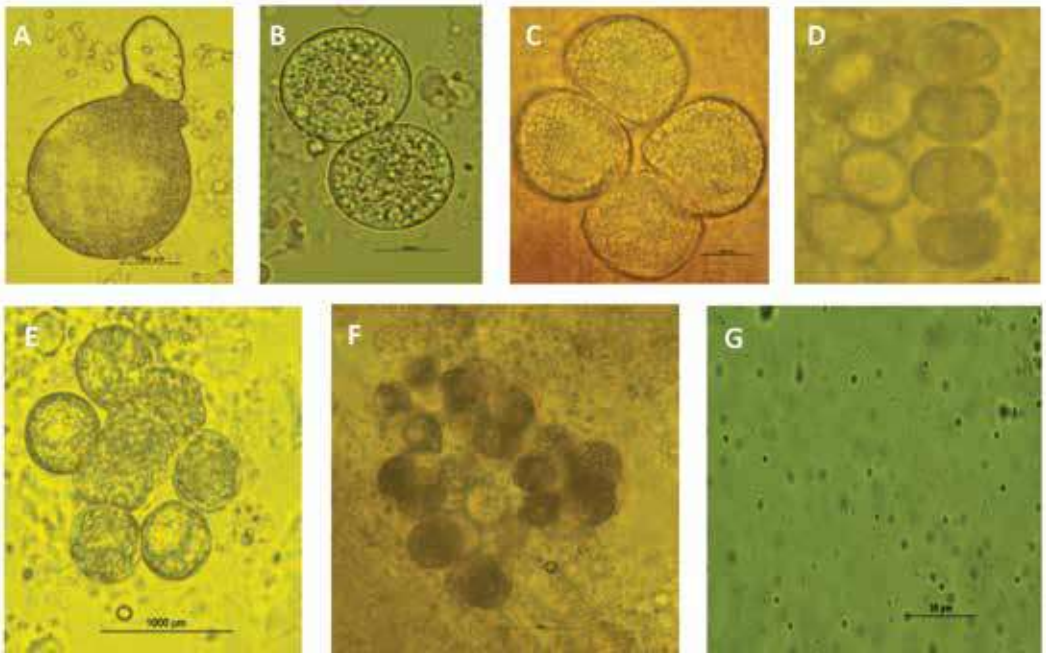
Ancyrocephalid collected from the gill of Pearlspot, E*troplus suratensis.*
Wet mount. Scale bar: 100 µm.



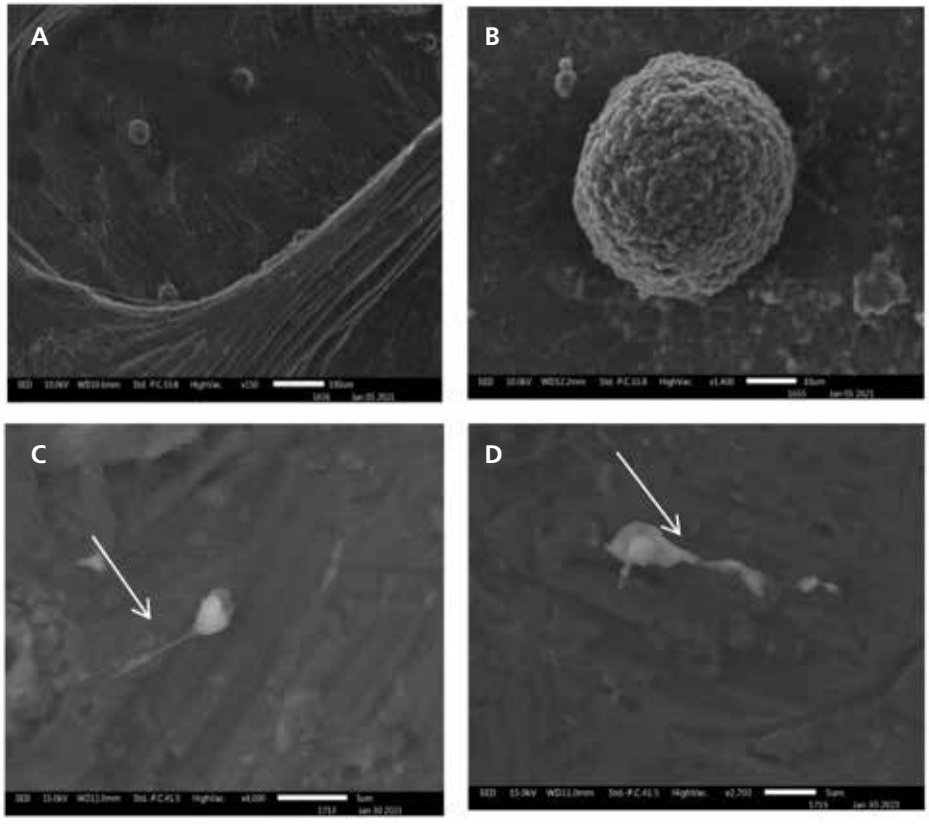
Focal hyperplasia, lamellar fusion, haemorrhages and infiltration by inflammatory cells in the gills of Pearlspot, *Etroplus suratensis* by the Ancyrocephalid H&E.
Scale bar : 50 µm.

Amyloodinium ocellatum infestation in streaked spinefoot Rabbit fish (*Siganus javus*): A First report

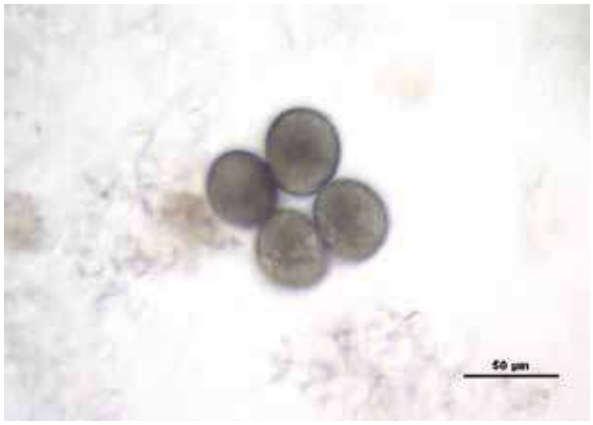
Streaked spine rabbit fishes are delicacies of aquarium due to their iridescent metallic colors, spotted and striped appearance. Adults rabbit fishes (200 g) kept in the Institute's brackishwater aquariums maintained at 25 ppt reported sudden death without any gross signs. Primary diagnosis of smears of gills inspected under light microscope revealed the presence of marine dinoflagellates, *Amyloodinium* in the gill lamellae. Fish was heavily infested with feeding trophonts (less than 500 µ) and reproductive stages (less than 50 µ). *Amyloodinium* is a dinoflagellate and an ectoparasite of numerous aquatic organisms living in brackish and seawater environments. Histopathological observation of gills revealed presence of trophonts and tomonts with the severe damage on respiratory surface of gills. Pathological evidences showed mild to severe lamellar fusion with infiltrated blood cells. The PCR diagnosis as per Marques, et al. (2019) confirmed the parasite as *Amyloodinum ocellatum*. To our knowledge this is the first report of *A. ocellatum* infection in rabbit fish.



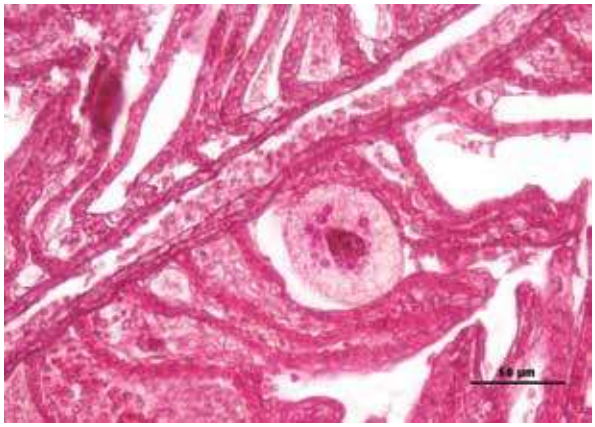
Microscopic examination of various stages of *Amyloodinium ocellatum* infection in Rabbit fish: A: Trophont from the gills. B to F: Reproductive stages of tomonts; B Synchronised first division of tomont; C. 4-celled stage D. 8-celled stage, E.16- celled stage F. 32-celled stage, G. free swimming dinospores produced from tomonts



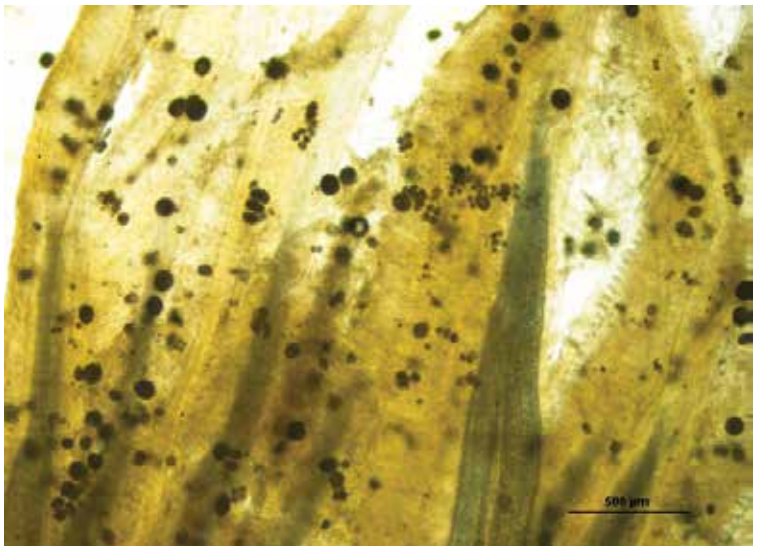
Scanning electron microscopic images of tomonts on gill epithelia of Rabbit fish (A, B), infecting dinospores produced from tomonts (C, D).



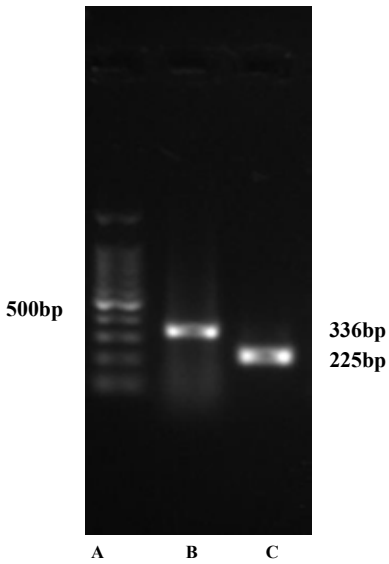
Tomont, the reproductive stage, of dinoflagellate, *Amyloodinium ocellatum* infested in the gills of rabbit fish, Wet mount. Scale bar : 50 µm.



Focal hyperplasia and necrotic gill epithelial cells in the gills filaments with tomont. H&E. Scale bar : 50 µm.



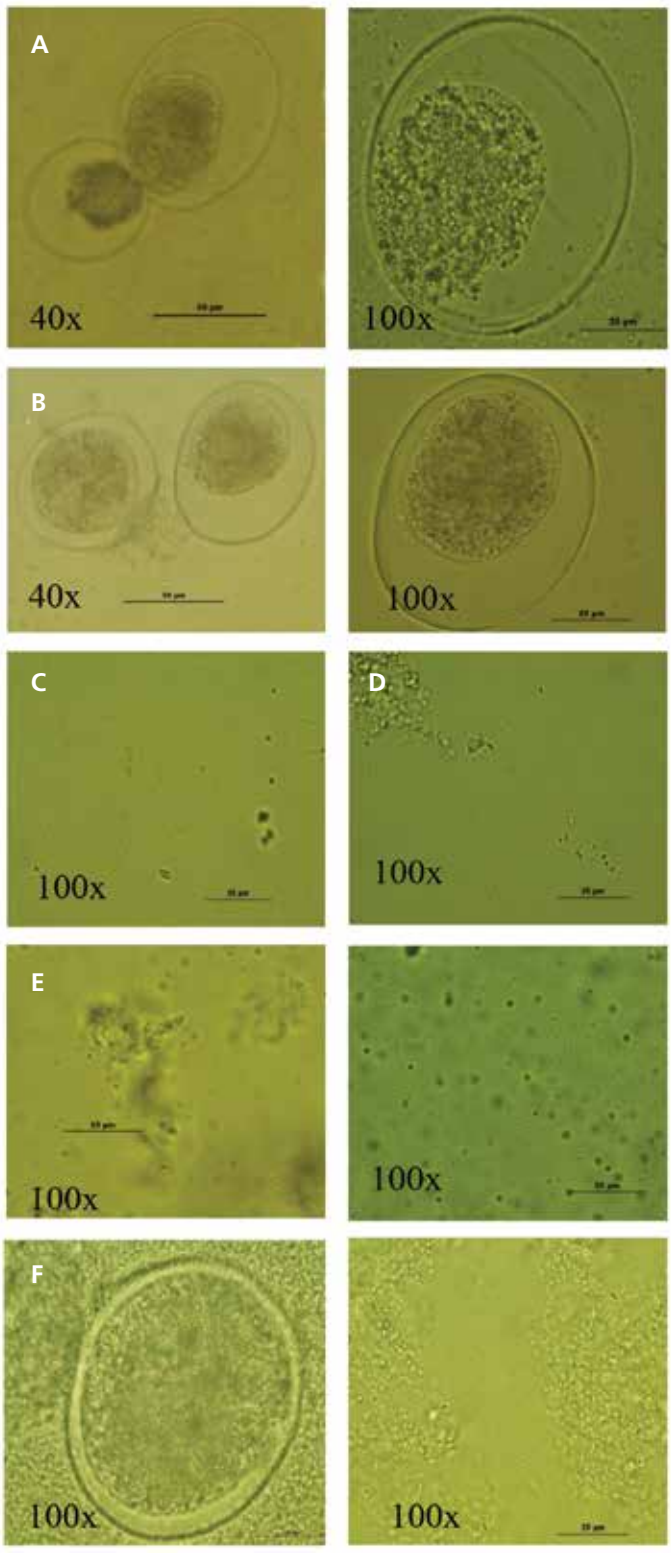
Wet mounts of gill tissues of Rabbit fish showing tomonts under light microscopy



Molecular identification of *Amyloodinium*. A.100bp DNA ladder, B. First step PCR at 336bp C. Second step PCR with 225bp amplicon

Influence of salinity on the life stages of rabbit fish parasite *Amyloodinium ocellatum*

To find management measures for parasitic infection *Amyloodinium ocellatum,* an experiment was carried out to examine the viability of tomonts in water of various salinities viz., 0, 5, 10, 15, 20 and 30 ppt at 30 °C. Viability of parasites was examined every 4 days under 100× microscope. On 14th day, few tomonts and no free-living dinospores could be found in 0 and 5 ppt water. Samples from 10 ppt onwards contained dinoflagellates, however no tomonts stages could be observed in 10 and 15 ppt. Tomonts and free-living dinospores could be found in 20 and 30 ppt. These observations suggests that fishes can be shifted to lower salinities (up to about 5 ppt) for 14 days as a viable option of eliminating *Amyloodinum ocellatum*, provided the fish are able to adapt to these salinities. This study does not conclude the re-emergence of spores from the destroyed tomonts when the favourable conditions return.



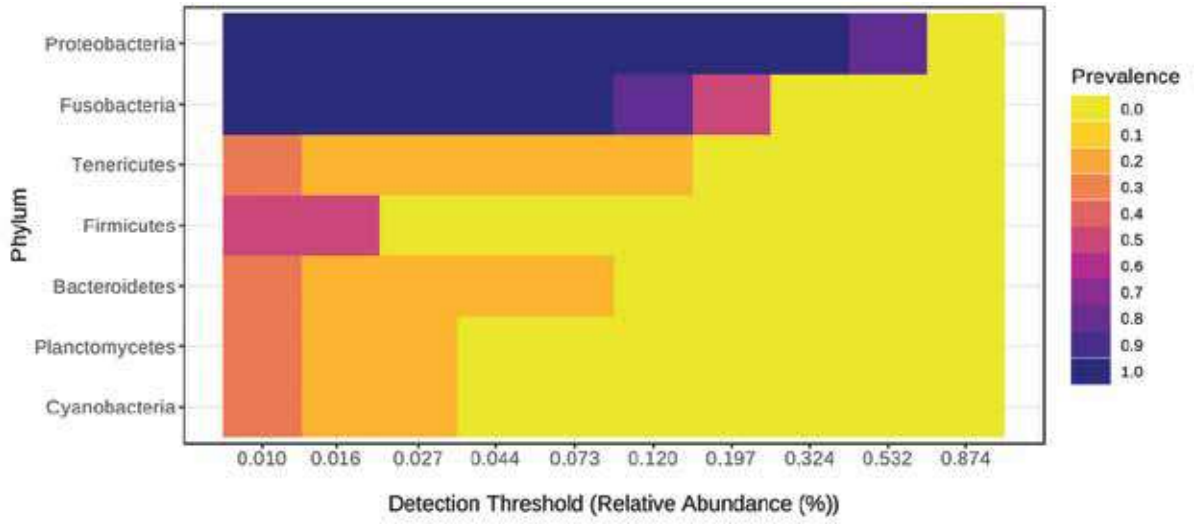
Light microscopic observation of Amyloodinium stages at 0 ppt (A), 5 ppt (B), 10ppt (C),15 ppt(A), 20 ppt(D), and 30 ppt(E) upon 12th day of incubation. A and B contains degrading tomonts with shrinking cell contents. C and D contains active stages of Amyloodinium (free swimming dinospores) observable under 100x and above, E and F contains both actively dividing tomonts and free swimming dinospores.

Use of formalin at the rate of 15-25 ppm as an indefinite bath could be used as a prophylactic measure and can be effectively avoid external parasites. Copper sulphate (0.75 mgL^{-1}, 12-14 days) baths with aeration and daily water replenishment have been suggested as an aid to control the trophonts or dinospores.

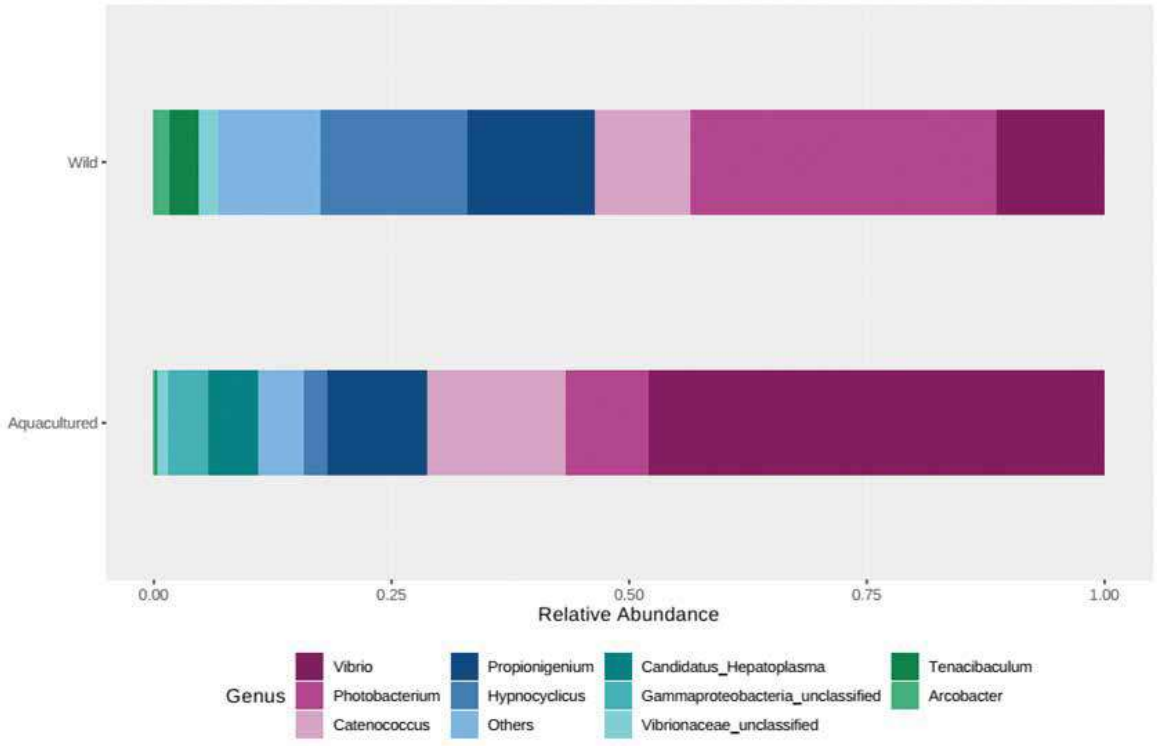
Comparative analysis of gut microbiota in wild and farmed Indian white shrimp (*Penaeus indicus*)

To ensure high-health shrimp seed production and sustainable farming, disease prevention capabilities needs to be improved. Balanced gut microbiota plays a major role in disease control and immune stimulation among other important functions. However, very little is known about the gut microbiota of *P. indicus*, understanding which will provide a big step towards healthy aquaculture practices. An investigation on the microbial diversity using V3-V4 hypervariable regions of 16S rRNA gene was carried out to examine intestinal microbiota in wild and farmed *P. indicus* broodstock. Both groups showed similar core microbiota at phylum level, which consisted mainly of *Proteobacteria*, *Fusobacteria, Tenericutes and Firmicutes*, although significant differences were found in their relative abundances.

The dominant genera in case of wild was *Photobacterium* (29.5%) followed by *Propionigenium* (13.9%), *Hypnocyclicus* (13.7%) and *Vibrio* (11.1%); in case of aquacultured shrimp, it was dominated by *Vibrio* (46.5%) followed by *Catenococcus* (14%), *Propionigenium* (10.3%) and *Photobacterium* (8.7%).



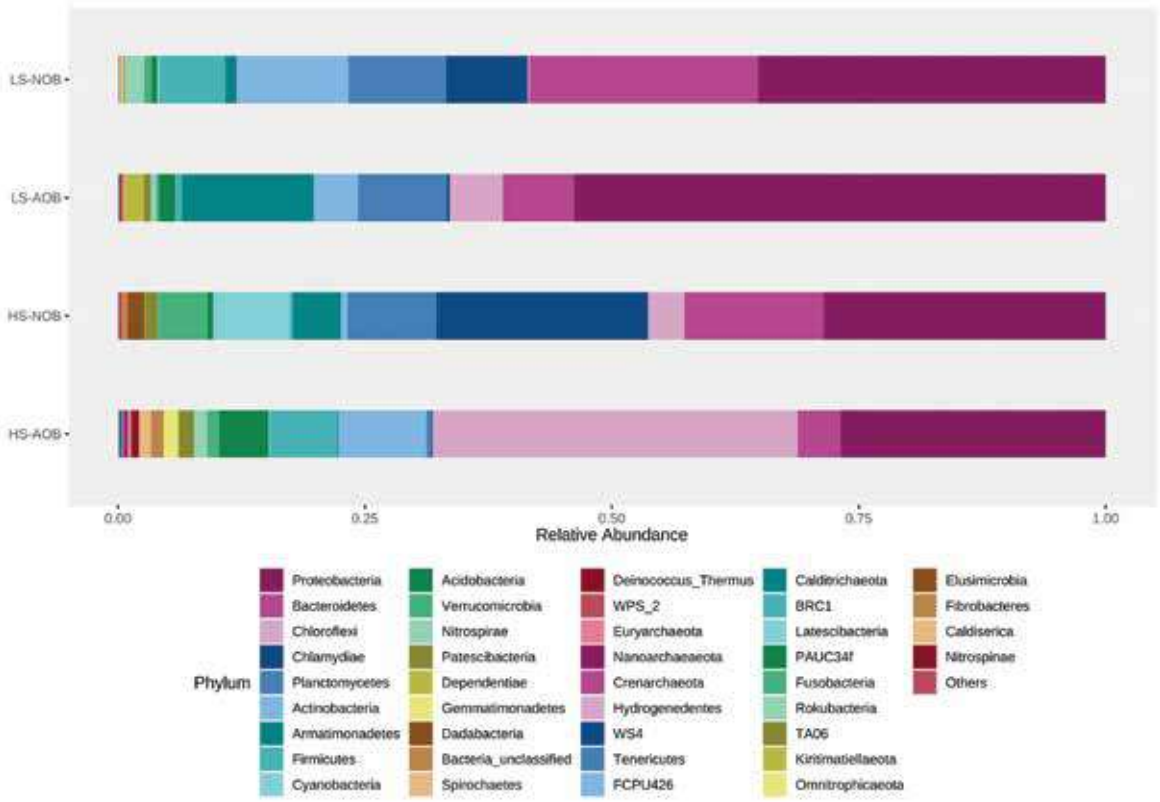
Core gut microbiota of *Penaeus indicus* at phylum level



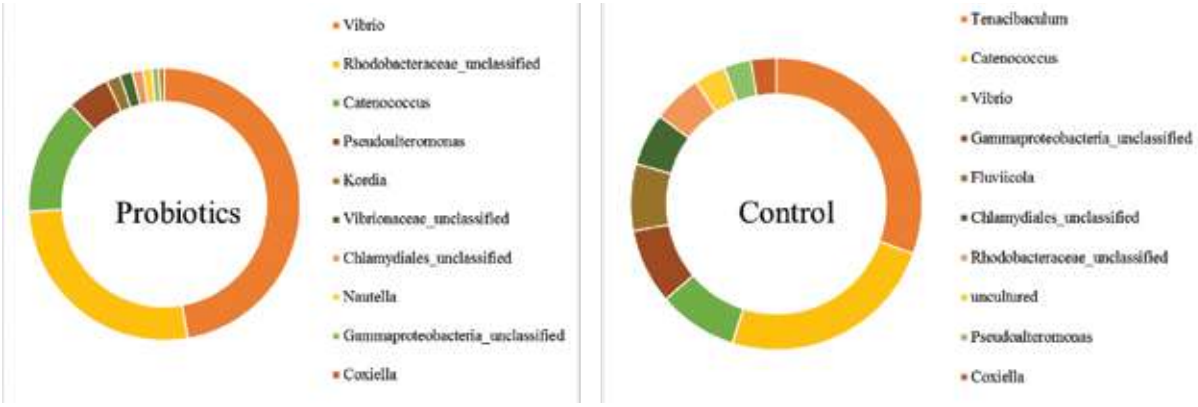
Relative abundance of the bacterial genus in the gut of wild and cultured *Penaeus indicus*

Comparative analysis of nitrifying microbial enrichments from high and low saline environments

The diversity of nitrifying microbial enrichments from low (0.5-5‰) and high (18-35‰) saline brackishwater environments was assessed using illumina Mi-Seq targeting V3 and V4 region of 16S rRNA. The AOB and NOB enrichments from both the environments showed diverse lineage of phyla distributed in both the groups with 38 and 34 phyla from low saline and 53 and 40 phyla in high saline sources respectively. *Proteobacteria, Chloroflexi, Bacteroidetes, Verurucomicrobia, Nitrospira, Actinobacteria, Planctomycetes, Acidobacteria* were found to be most dominant phylum distributed among the AOB and NOB enrichments from both the environments.



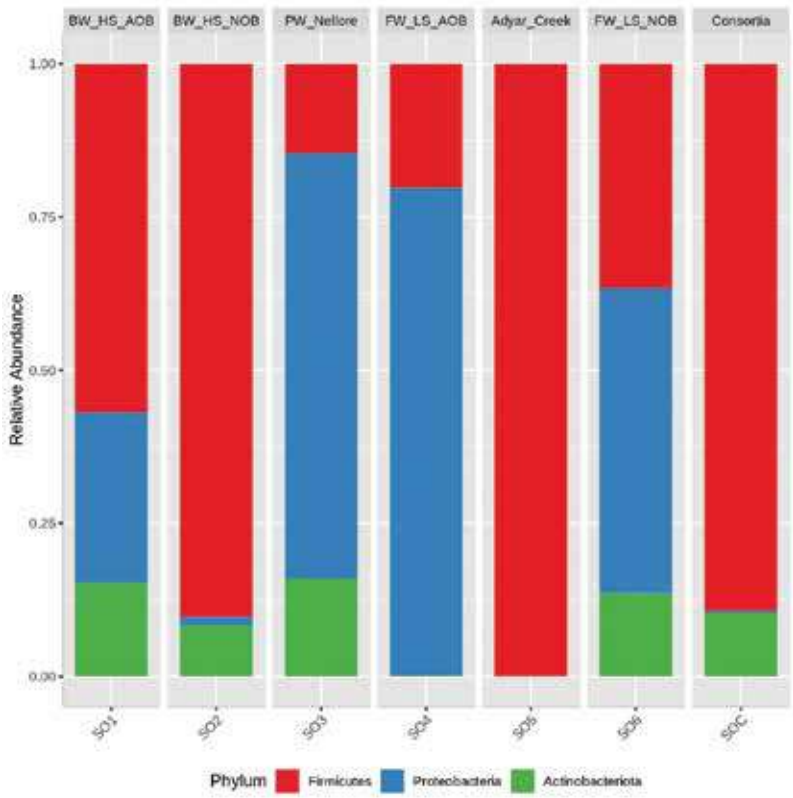
Relative abundance of AOB and NOB enrichments from low and high saline ecosystems.



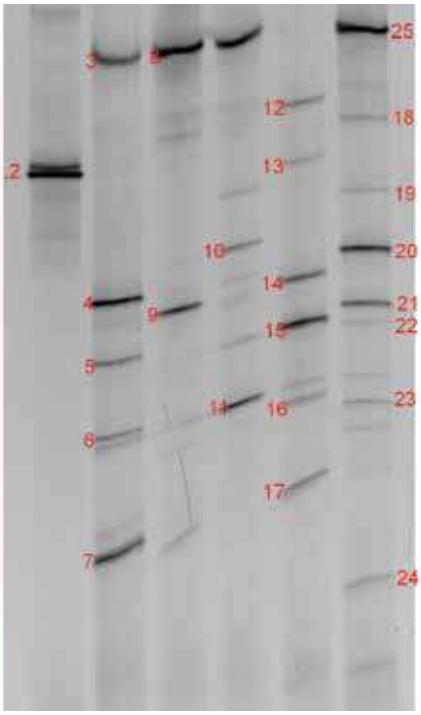
The relative abundance of the top ten bacterial communities (Genus level) associated with Indian white shrimp post larvae.

Application of probiotics affects gut microbiota in the *P. indicus* larval shrimp

Application of probiotic product containing, *Bacillus subtilis, B. lichiniformis and B. pumilus* into the rearing environment of shrimp larvae (5000/500L) showed altered microbial communities. Analysis using 16S rRNA-based Illumina sequencing showed the abundance of *Proteobacteria* in probiotic treated group (94.85%). At the genus level the predominance of *Vibrio* (44.17%), *Rhodobacter* (25.22%) and *Catenococcus* (12.89%) were recorded. Results indicate that probiotic application influenced the microbial profile of larval shrimp. This information helps to understand the beneficial effect of probiotic application in early larval stages of penaeid shrimp hatcheries.



Phylum level distribution in SOB enrichments (n=5) by metagenomics analysis



Bacterial diversity of sulphur oxidising bacteria enrichment (n=6) by Denaturing gradient gel electrophoresis (DGGE)

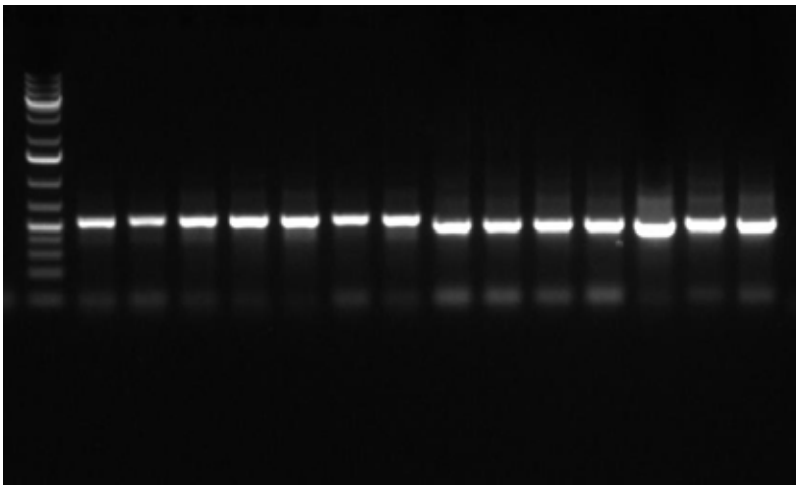
Enrichment of sulphur oxidizing bacteria for mitigation of toxic sulphur metabolite in aquaculture ponds

Sulphur oxidizing bacteria (SOB) play critical role in oxidation of highly toxic hydrogen sulphide formed in the pond bottom. In this regard, CIBAmox, low saline nitrifying enrichment, and creek water collected from Adyar and Nellore were developed into six SOB enrichments for improving pond water and soil quality in shrimp farms. The DGGE analysis of the SOB enrichments revealed the existence of 25 different strains. All the enrichments were capable of reducing the sulphate indicated by reduction of pH and deposition of sulfur granules in the flask. The product was found

stable at room temperature for 3-5 months. Metagenomic analysis of 16s rDNA revealed domination of family Pseudomonadaceae, Brevibacillaceae and Bacillaceae belonging to phylum Firmicutes, and Proteobacteria

Development of consortia of denitrifying bacteria for efficient mitigation of ammonia toxicity in shrimp farm

Denitrifying bacteria (DNB) are heterotrophic bacteria that are

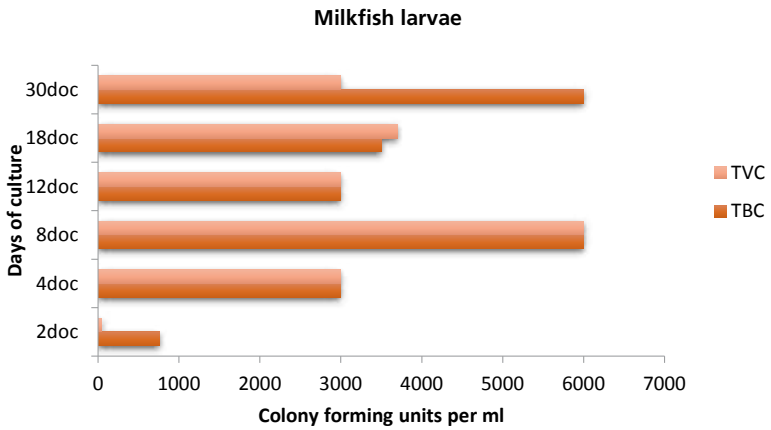


PCR amplification of nirS gene in representative DNB strains

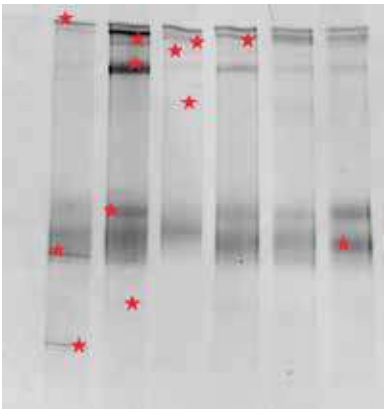
efficient in conversion of nitrate to free nitrogen and highly efficient in improvement of water quality parameters. The DNB *Zobella* CDN10 and *Marinobacter* sp CDN 11 were isolated from CIBAMOX formulation and characterized as per earlier described method (Dineshkumar et al., 2014). Denitrifying activity was measured by reduction in nitrite/nitrate to nitrogen gas and found effective under aerobic and micro-aerophillic conditions. These DNB strains were found to possess *nirK* gene that is responsible for the denitrification process.

Microbial profiling in milkfish larvae

Microbes colonize to fish larvae and fish intestines during the larval development and play a crucial role in successful larval production. Bacteria associated with milkfish during different stages of larval development was examined using culture dependent methods. Maximum number of bacteria were found to be associated in rearing water, outdoor algae and live feeds. Bacteria of the Family Vibrionaceae predominated the milkfish larvae with major representation from *V. alginolyticus, V. littoralis, V. proteolyticus, V. ruber, V. natriegenes, V. neocaledonicus* and *Photobacterium ganghwense* followed by members of the Family Pseudomonadaceae represented by *Pseudomonas spp*.. The microbial diversity of the milkfish larval rearing systems using culture independent methods such as DGGE revealed the uniform presence of *Fusibacter spp*, *Achromobacter spp*, *Candida spp*, *Catenococcus spp* in all milkfish larvae. The 16S rRNA metagenomic analysis of milk fish larvae revealed the dominance of phylum Proteobacteria on the 2nd (82.75%), 8th (83.75%) and 30th (51.28%) day, while Bacteriodes (37.4%) and Firmicutes (31.19%) dominated on 18th day. By 30th day, actinobacteria (23.92%) was progressing towards a significant component of milkfish bacterial flora. The study unraveled the progression and establishment of microbial flora in herbivorous euryhaline milk fish larval development.



Total bacterial (TBC) and total *Vibrio* count (TVC) in milk fish larvae over the culture period.



Denaturing Gradient Gel Electrophoresis (DGGE) profiles of Milk fish larvae at 2, 4, 8, 12, 18 and 30th days of larval rearing.

Bacteria associated with milkfish larval production cycles identified using phenotypic methods and 16s rRNA sequencing

Day	Year	Phenotypic characterization	16s sequencing
1	2018	*V. metschnikovii, V. alginolyticus,V. littoralis, V. proteolyticus*	*V. alginolyticus*
	2020	*V. ruber, V. alginolyticus*	*V. natriegenes*
4	2018	*V. littoralis, V. pontius, V. alginolyticus*	*V. neocaledonicus*
	2020	*V. parahemolyticus, V. litoralis*	*V. ruber*
8	2018	*V. alginolyticus, V. littoralis, V. mimicus, V. proteolyticus, V. calviensis*	*V. parahemolyticus*
	2020	*V. littoralis, V. fisheri, V. alginolyticus, V. metschnikovii*	*V. proteolyticus*
12	2018	*V. alginolyticus, V. proteolyticus*	*Shewanella algae*
	2020	*V. ruber, V. alginolyticus*	*Photobacterium ganghwense*
18	2020	*V. littoralis, V. alginolyticus,V. fisheri, V. ruber, V. natriegens, V. parahemolyticus*	
30	2018	*V. metschnikovii, V. calviensis, V. pontius, V. mimicus*	
	2020	*V. natriegens, V. ruber, V. alginolyticus, V. littoralis*	

Abundance of bacteria (%) based on 16S metagenome of milk fish larvae

Sample	2nd day	8th Day	18th Day	30 Day
Phylum	Proteobacteria (82.63)	Proteobacteria (83.75)	Bacteroidetes (37.40)	Proteobacteria (51.28)
Class	Gammaproteobacteria (56.72)	Gammaproteobacteria (58.72)	Bacteroidia (37.19)	Gammaproteobacteria (32.47)
Order	Pseudomonadales (36.13)	Pseudomonadales (38.51)	Bacteroidales (37.19)	Pseudomonadales (24.27)
Family	Pseudomonadaceae (35.98)	Pseudomonadaceae (38.33)	Prevotellaceae (28.55)	Pseudomonadaceae (24.20)
Genus	*Pseudomonas* (35.47)	*Pseudomonas* (37.75)	*Prevotella* (28.55)	*Pseudomonas* (24.12)
Species	*P. alcaligenes* (22.17)	*P. alcaligenes* (23.61)	*P. copri* (18.90)	*R. ruber* (22.34)

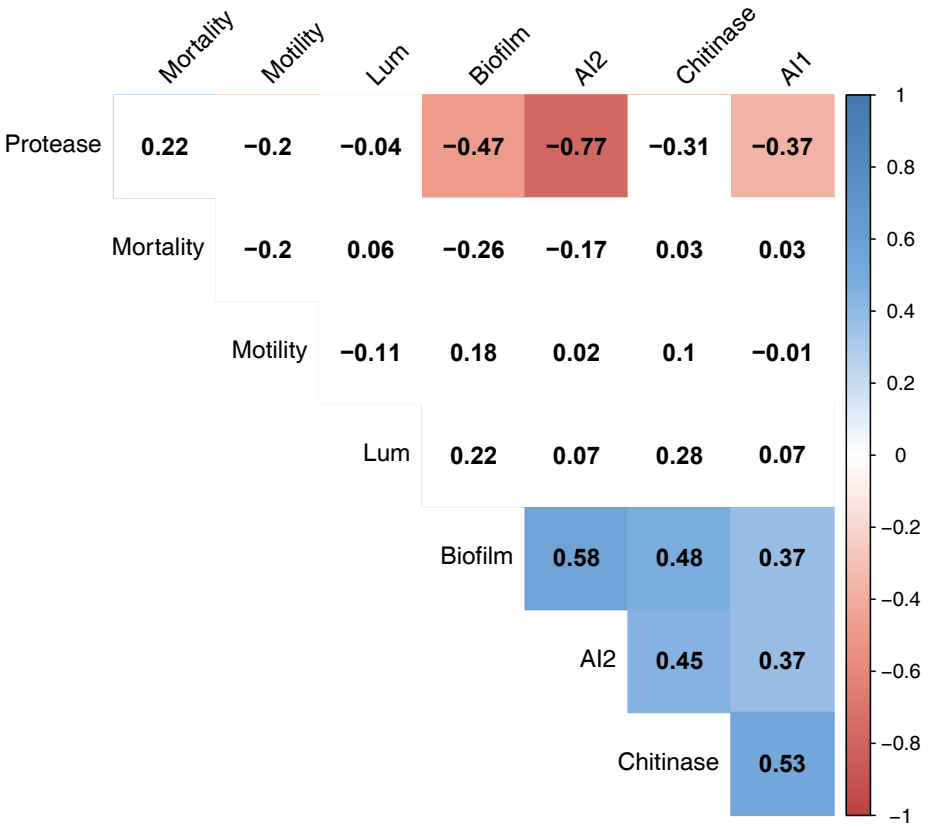
Virulence of Vibrios

Metalloprotease production with virulence association in *Vibrio campbellii*

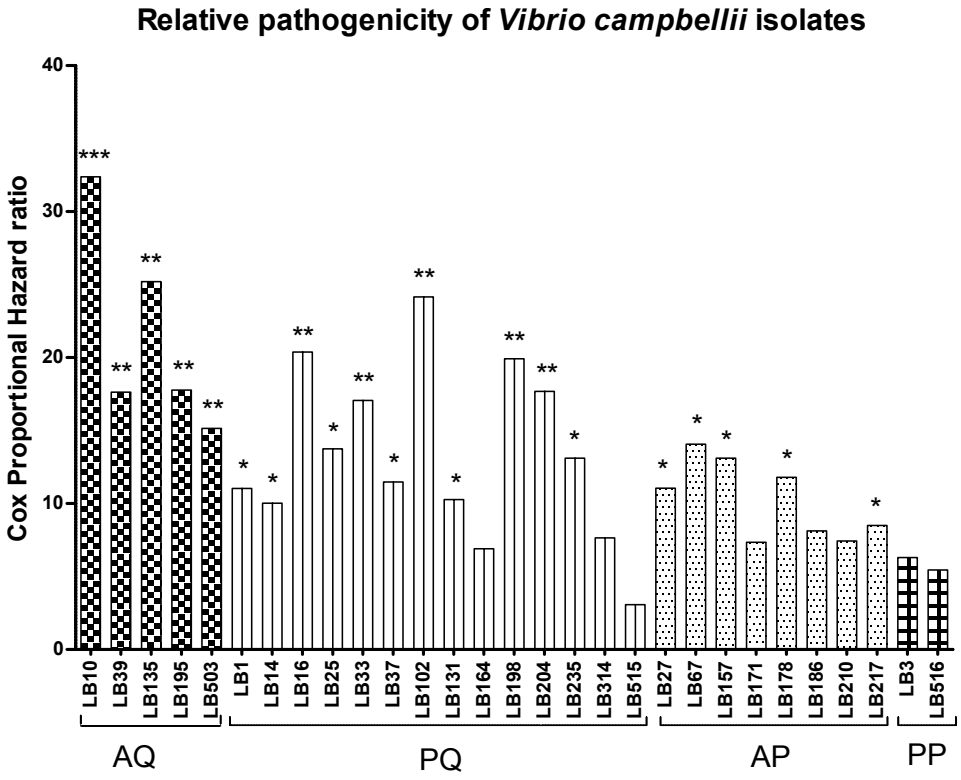
The virulence of bacterial pathogens determines the severity and outcome of bacterial infections. Among the various virulence factors, protease activity has been reported to have a significant role in the virulence of *Vibrio* spp. In the present study, protease production was analysed in 30 *V. campbellii* isolates and it ranged from 3.6 to 22.6 Units. The correlation matrix suggested that the protease was positively correlated with pathogenicity ($p>0.05$) and negatively correlated ($p<0.05$) with autoinducer-2 and autoinducer-1 signals. To find the nature of protease, an inhibitor analysis was carried out. The protease activity was completely inhibited by metalloprotease inhibitor 1,10-phenanthroline. The study suggests that metalloprotease is the major protease with possible role in the pathogenesis of *V. campbellii*.

Virulence regulator ToxR play critical role in virulence of *Vibrio campbellii*

ToxR is a major virulence regulator of *V. cholerae*. To understand its role in aquatic pathogens, toxR gene of 30 *V. campbellii* isolates were partially sequenced. Subsequently, amino acid sequence was deduced from the partial nucleotide sequence of *toxR* gene. The multiple sequence alignment suggested a variable zone in the region of 120 to 170 AA with two critical amino acid substitutions at 123rd (proline to alanine) and 150th positions (glutamine to proline). This resulted from the change at 367th and 449th position of nucleotide leading to a change in codon from CCT to GCT (proline to alanine) and CAA to CCA (glutamine



Correlation matrix among various virulence factors and pathogenicity



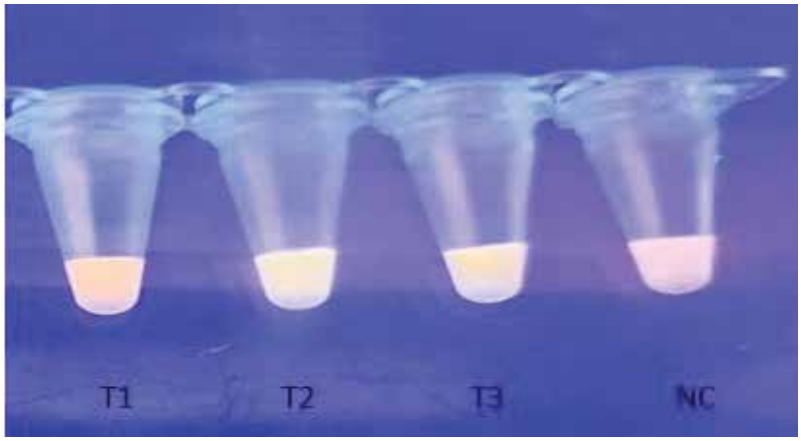
Influence of amino acid substitution at 123rd and 150th position in ToxR on virulence of *Vibrio campbellii*

to proline). Based upon these substitutions, ToxR protein has four variants namely A123Q150 (AQ; 18.9%), P123Q150 (PQ; 54.1%), A123P150 (AP; 21.6%) and P123P150 (PP; 5.4% isolates). The isolates with proline at 150th position (P150) had completely abolished protease activity with significant reduction in virulence. The pathogenicity study in *Penaeus vannamei* juveniles revealed that all the isolates of AQ were highly pathogenic with Cox proportional hazard ratio 15.1 to 32.4 compared to P150 variants; PP (5.4 to 6.3) or AP (7.3 to 14). The study suggests the possible regulatory role of ToxR in the virulence expression of *V. campbellii* especially metalloprotease activity.

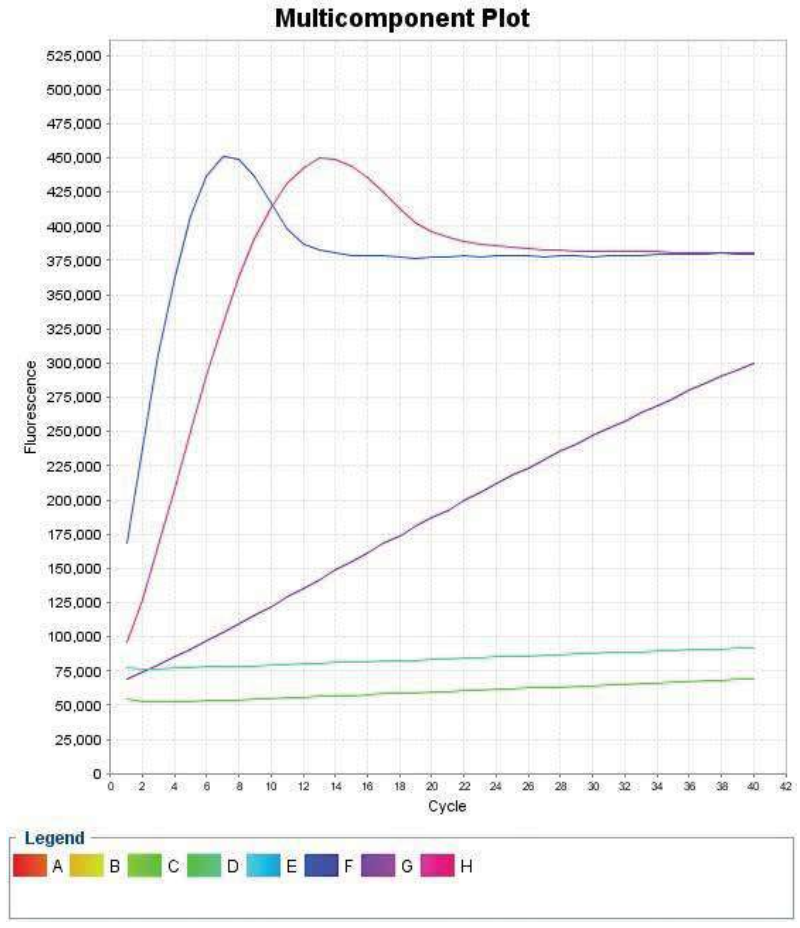
Development of Diagnostics

Development of CRISPR-Cas based Diagnostics for WSD of shrimp

Clustered regularly interspaced short palindromic repeats (CRISPR) based gene editing and diagnostic technology has revolutionized the field of biological sciences. The CRISPR/ Cas 12a based assay is a versatile detection method with the ability to accurately recognise and bind to the specific target sequence and results in the trans- cleavage of the target sequence. Further, it also amplifies fluorescence signal by non-specific cleavage of dual labelled probes. The CRISPR/Cas 12a based assay was developed for the diagnosis of white spot syndrome virus of shrimp. The guide RNA consisting of 23 bp constant region (Loop domain) direct repeats and 21bp target specific region targeting TATA box binding protein gene of WSSV (Protospacer domain) was synthesized. The template DNA for guide RNA along with the T7 promoter was chemically synthesized. The template DNA for guide RNA was amplified using T7 promotor as forward primer and spacer sequence as reverse primer (2µM each) using Taq DNA polymerase. Recombinase polymerase amplification primers



Visual detection of CRISPR/Cas 12a reactions under UV transilluminator.



The Amplification plot showing fluorescence kinetics of RPA amplicons with different copy number (1 lakh, 10 Thousand, 100 copies and negative control)

were designed from the conserved region of the TATA box binding protein gene of WSSV using the program Clustal omega software for sequence alignment. RPA reactions were carried out using Twist Amp liquid basic kit. Cas12a detection method was adopted for FAM-BHQ1-Labeled Reporter Assays. The amplification of viral target DNA visualised as green fluorescence and negative reaction visualised as red in colour

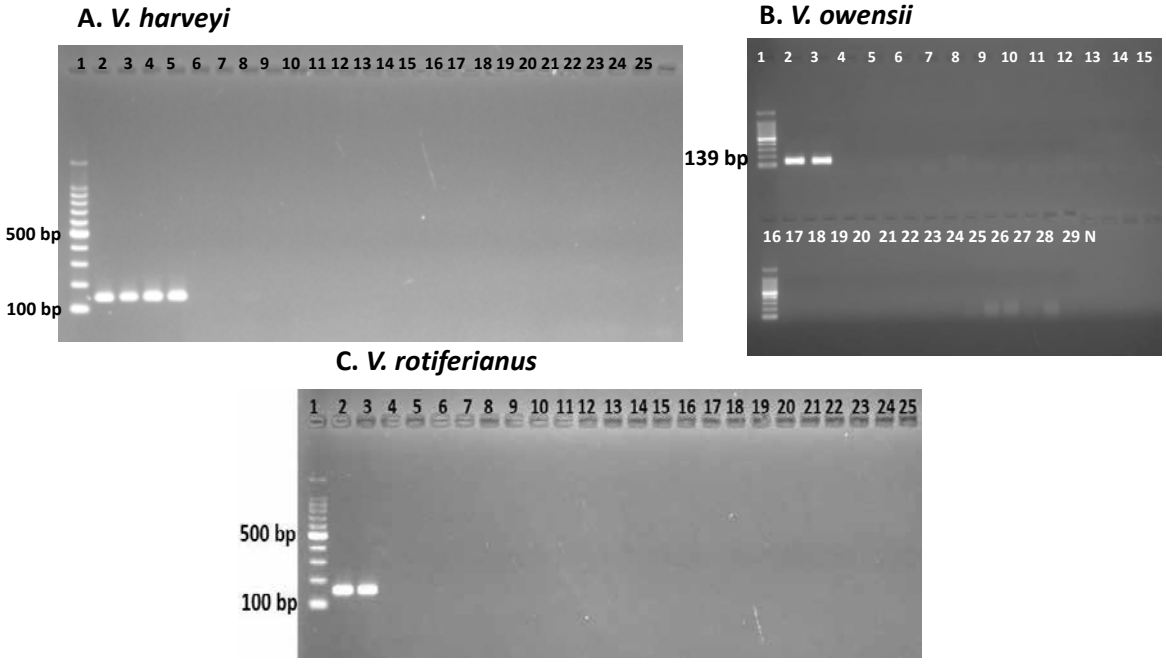
Real time PCR based diagnostics developed for quantification of *Vibrio harveyi, V. owensii* and *V. rotiferianus*

The *Vibrio* species within Harveyi clade such as *V. harveyi, V. campbellii, V. owensi, V. rotiferianus, V. parahaemolyticus, V. alginolyticus* etc have pathogenic significance due to presence of determinants making them virulent in aquaculture settings. In the present study, real time qPCR primer was standardized for three closely related pathogenic species of Harveyi clade namely *V. harveyi, V. owensii* and *V. rotiferianus* using novel diagnostic markers, never have been reported before. The primer developed for *V. harveyi* produces 141 bp amplicon across 54 to 62 °C annealing temperature without dimer formation. The sensitivity testing using four *V. harveyi* strains provided 100% sensitivity. Further, the specificity testing against seven closely related *Vibrio* spp, Gram-negative bacteria (*E. coli, Klebsiella oxytoca, Salmonella Typhi* and *Pseudomonas fluorescens*) and Gram-positive bacteria (*Bacillus* and *Lactobacillus*) found it as 100% specific. Similarly, the primers were designed for *V. owensii* and *V. rotiferianus* using *bar* and *luxM* gene. *V. owensii* and *V. rotiferianus* had amplicon size of 139 and 150 bp respectively. Primers for both the spp were found 100% sensitive and 100% specific. Primer design for *V. campbellii,* multiplexing using TaqMan probe assay and field validation process is under progress.

Prophylactics and therapeutics

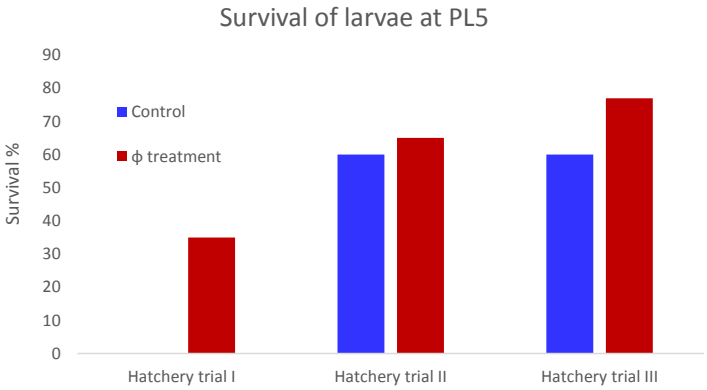
Phage therapy developed and commercialized for the control of luminescent vibriosis in shrimp hatcheries

Phage therapy has emerged as environment-friendly, safe alternative to antibiotics for controlling bacterial diseases. Bacteriophages also called as



Quantitative PCR standardised for *V. harveyi, V. owensii* and *V. rotiferianus*

Sensitivity and specificity of quantitative real time PCR primer for *V. harveyi, V. owensii, and V. rotiferianus.* Lane 1: 100 bp marker; A (Lane 2-5: *V. harveyi*), B (Lane 2-3: *V. owensii*) C (Lane 2-3: *V. rotiferianus*). Rest of the lane denotes specificity test carried out against several Vibrio spp (*V. harveyi, V. campbellii, V. owensii, V. rotiferianus, V. jasicida, V. alginolyticus, V. parahaemolyticus, V. fluvialis*), Gram-negative bacteria (*E. coli, Klebsiella oxytoca, Salmonella Typhi* and *Pseudomonas fluorescens*) and Gram-positive bacteria (*Bacillus* and *Lactobacillus*)



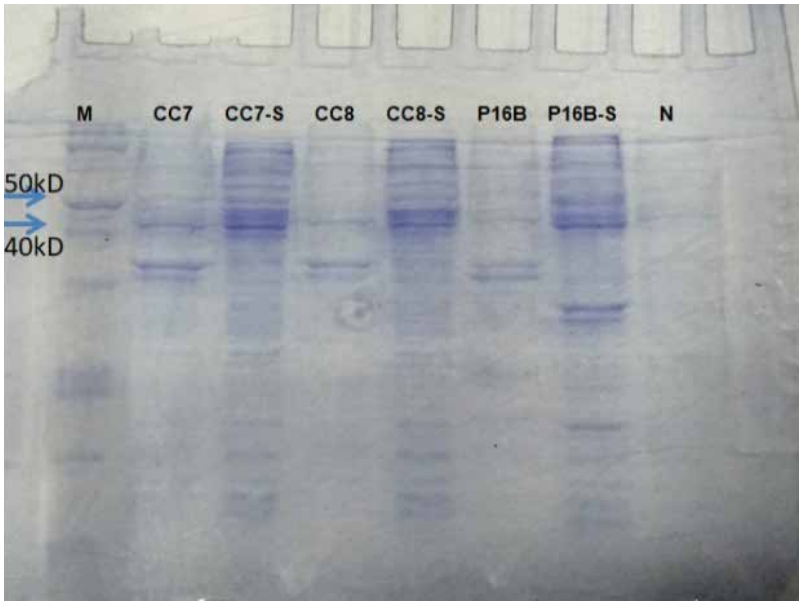
Effect of phage therapy on survival of *Penaeus vannamei* shrimp larvae

Lumiphage, a consortium of four lytic phage for controlling luminescent vibriosis

'phages', are viruses that infect and kill bacteria. Taking the advantage of natural killing behaviour of bacteriophages, Aquatic Animal Health and Environment Division (AAHED) of ICAR-CIBA developed phage therapy for controlling vibriosis problem in shrimp hatcheries which causes upto cent percent mortality during mysis and early-postlarval stages. The efficacy of the phages was confirmed by screening more than 100 bacteriophages against above 100 luminescent bacterial isolates collected over a period of two decades. A cocktail of four phages with broad spectrum of host specificity and complementary lytic behaviour were formulated into a consortium named as 'Lumiphage'. The efficacy of the phage consortium was confirmed by a series of field trials in commercial shrimp hatcheries and found to improve 35 to 53% survival as therapeutic and 15-17% as prophylactic treatment. The phages were able to kill wide range of luminescent bacteria such as *Vibrio campbelii, V. harveyi*. After series of commercial trial the phage technology was commercialised for mass production and distribution to M/s Salem Microbes Private Limited, Salem, Tamil Nadu. The technology is expected to reduce the incidences of larval diseases in shrimp hatcheries and will pave the way for antibiotics-free larval rearing systems in aquaculture.

Development of Virus Like Particle (VLP) from IHHNV capsid protein

White spot syndrome virus (WSSV) is a major threat to global shrimp industry. To develop effective therapeutics against WSSV, an attempt was made to develop Virus like particles (VLPs) from the capsid protein of IHHNV with an aim to use as vehicle for the delivery of immunogenic WSSV genes to the shrimp. The IHHNV capsid gene sequence was retrieved from NCBI database (GenBank ID: AF218266.2). Primer to amplify full length cDNA along with 5' prime 6HIS sequence (F 5'TCGAAGGTCGT CATATGATGTGCGCC GATTCAACA3', R 5'GTTAGCA



Expression of targeted IHHNV capsid protein clone (40 kD) in SDS-PAGE. M. Ladder, CC7: Solubilized protein, CC7-S: Supernatant, CC8: Solubilized protein, CC8-S: Supernatant, P16B: Solubilized protein, P16B-S: Supernatant, N: Negative control (Non-induced strain)

GCCGGATCCA TGATGAT GATGATGAT GGTTAGT3') was designed using GeneArt® Primer and Construct Design Tool (https://www.thermofisher.com/order/oligoDesigner). All parameters were set to default and pET16 was used vector backbone. The designed primers were amplified using cDNA from infected IHHNV tissue as template. The pET16b vector was restriction digested with Nde and BamHI followed by gel elution and purification by EZ-10 Spin Column DNA Gel Extraction Kit (Biobasic). Homologous recombination cloning was performed using GENEART seamless cloning and assembly Kit (Thermo Fischer Scientific) following manufacture's instruction. A small-scale induction was tried by inoculation of 5ml LB+AMP with single recombinant colony and incubated overnight at 37°C. Overnight culture was diluted 10 times into a fresh 10 ml LB+Amp and incubated until it reaches 0.3-0.4 OD at 600. 1mM IPTG was added and incubated further for 3 hours at 37°C. Bacterial cells were pelleted down and resuspended and lysed with Tris-HCL pH 8. After centrifugation pellet was mixed with 8M urea and sonicated with 30% pulse for 60 seconds and 30 seconds off – 5 cycles and centrifuged at 10000 rpm for 10 minutes at 4°C. Both Supernatant and pellet was loaded on to 12% SDS-PAGE. Expression of desired protein (40 kDa) was observed only in IPTG induced positive clones and this will be further characterized.

Impact of antimicrobial agents on non-targeted indicator organisms in brackishwater system

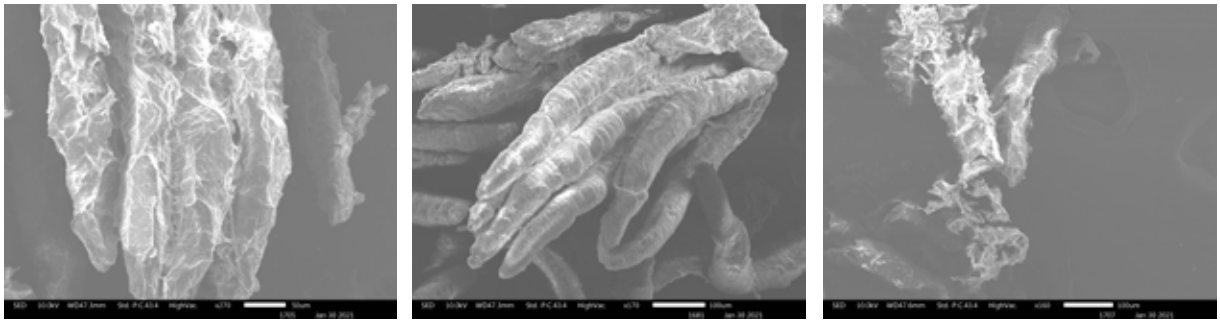
Antimicrobial substances are important for treatment of bacterial infections in food animals including aquaculture. However, improper usage of these substances can become environmental and public health hazard. Environmental safety of the medicines and chemicals used in aquaculture are determined by studying their effect on indicator organisms as per the international guidelines. Study using indicator organism *Chlorella* sp suggests that the florfenicol (IC_{50} 666.29 ppm) was most safe followed by oxytetracycline (IC_{50} 487.75 ppm) and Sulphadimethoxine (IC_{50} 461.44 ppm). Results confirm environmental safety of these antimicrobials when used at the recommended doses.

Evaluation of benzalkonium chloride (BKC) as a disinfectant of white spot syndrome virus (WSSV)

Benzalkonium chloride (BKC) is a detergent, well known for its disinfection property. In the present study, efforts were made to evaluate the efficacy of BKC as a disinfectant for WSSV neutralization. *In vitro* study confirmed the complete inactivation of WSSV (10^7 copies/µl) when exposed to 4 ppm of BKC for 1 h. In simulated pond conditions the virus in water was found to get inactivated with 4 ppm of BKC in the absence of subsurface soil while 18 ppm of the BKC was effective in the presence of soil.

Residual effect of florfenicol in leg white shrimp *Penaeus vannamei*

To study the residual effect of florfenicol, an experiment was conducted in triplicate on 162 *P. vannamei* shrimps weighing about 3.4 to 6.0 g. Shrimps were screened for OIE listed pathogens before the start of the experiment. The medicated feed was given to shrimps in triplicates @ 10 mg/kg bwt, 25 mg/kg bwt, 50 mg/kg bwt, 100 mg/kg bwt and 200

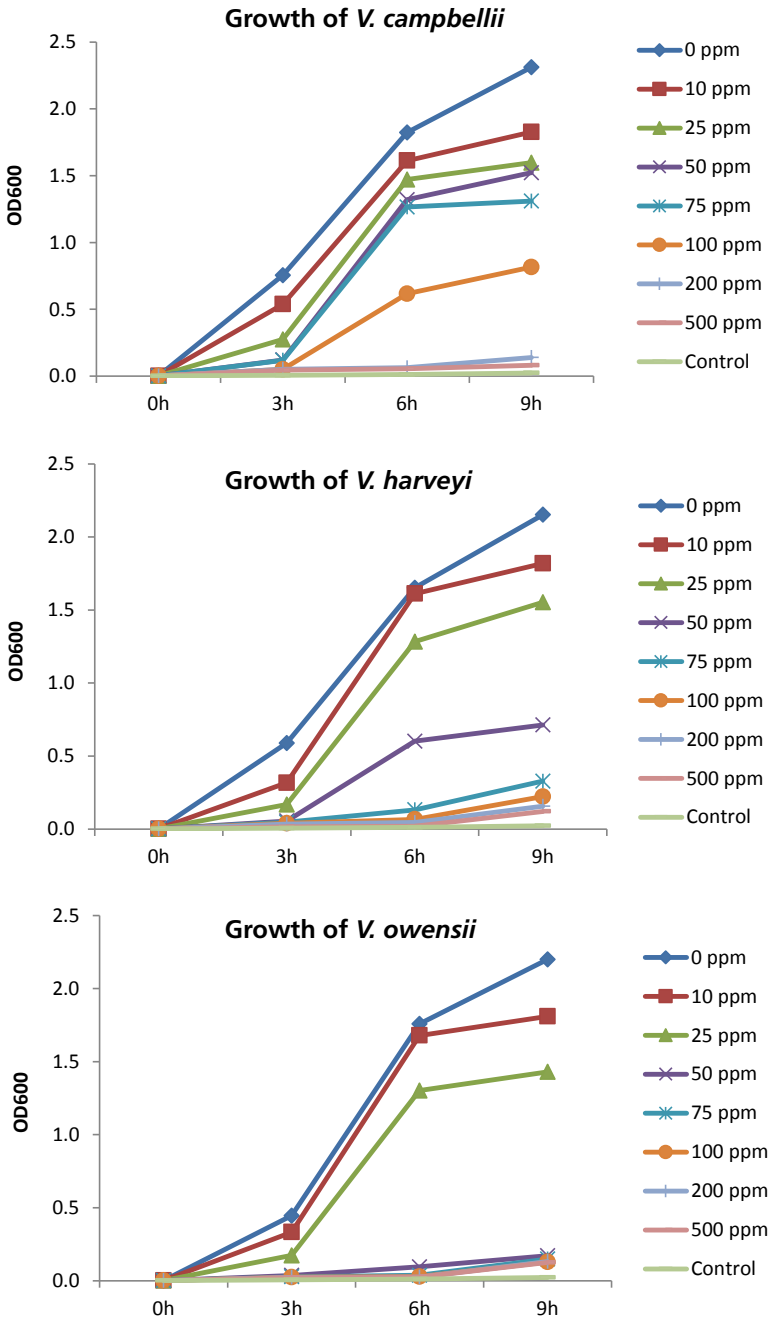


Scanning electron micrographs showing effect of fluorfenicol treatement in shrimp: control shrimp with normal hepatopancreatic tubules; Shrimp treated with 100 mg of florfenicol at 24 h; shrimp treated with 200 mg of florfenicol at 24 h

mg/kg bwt. The tissues samples were collected at 2, 4, 8, 12, 18, 24, 32 hours and analysed to understand the impact of the drug on various tissues. The Scanning electron microscopic analysis on hepatopancreatic tissues revealed fusion of the tubules with damaged and wrinkled tubular surface at many places in animals treated with florfenicol and the severity of the lesions was more in 100, 200 mg/kg bwt @ 24h treatment. While in control the tubules appeared normal.

Ethylenediamine tetraacetic acid (EDTA) for the control of luminescent vibriosis in shrimp hatcheries

Luminescent vibriosis is a major challenge in shrimp hatcheries. Our earlier work suggested that vibriosis in shrimp hatcheries is caused by *V. campbellii*. The genomic analysis of this bacterium suggested a large genomic diversion for iron sequestration with the presence of vibriobactin and powerful anguibactin siderophore system. As iron in an essential element for all the life forms, a growth kinetics experiment of *V. campbellii, V. harveyi* and *V. owensii* was carried out in Luria Bertani (LB) medium in presence of different concentrations of iron chelator Ethylenediamine tetraacetic acid (EDTA). The study indicated that presence of iron chelators significantly reduced the growth in dose dependent manner and diverted its growth trajectory. Among the three species, *V. campbellii* was most resilient followed by *V. harveyi* and *V. owensii*. For *V. campbellii* 100 ppm and for *V. harveyi* and *V. owensii* 50 ppm of EDTA changed the growth trajectory. This corroborated with genomic data

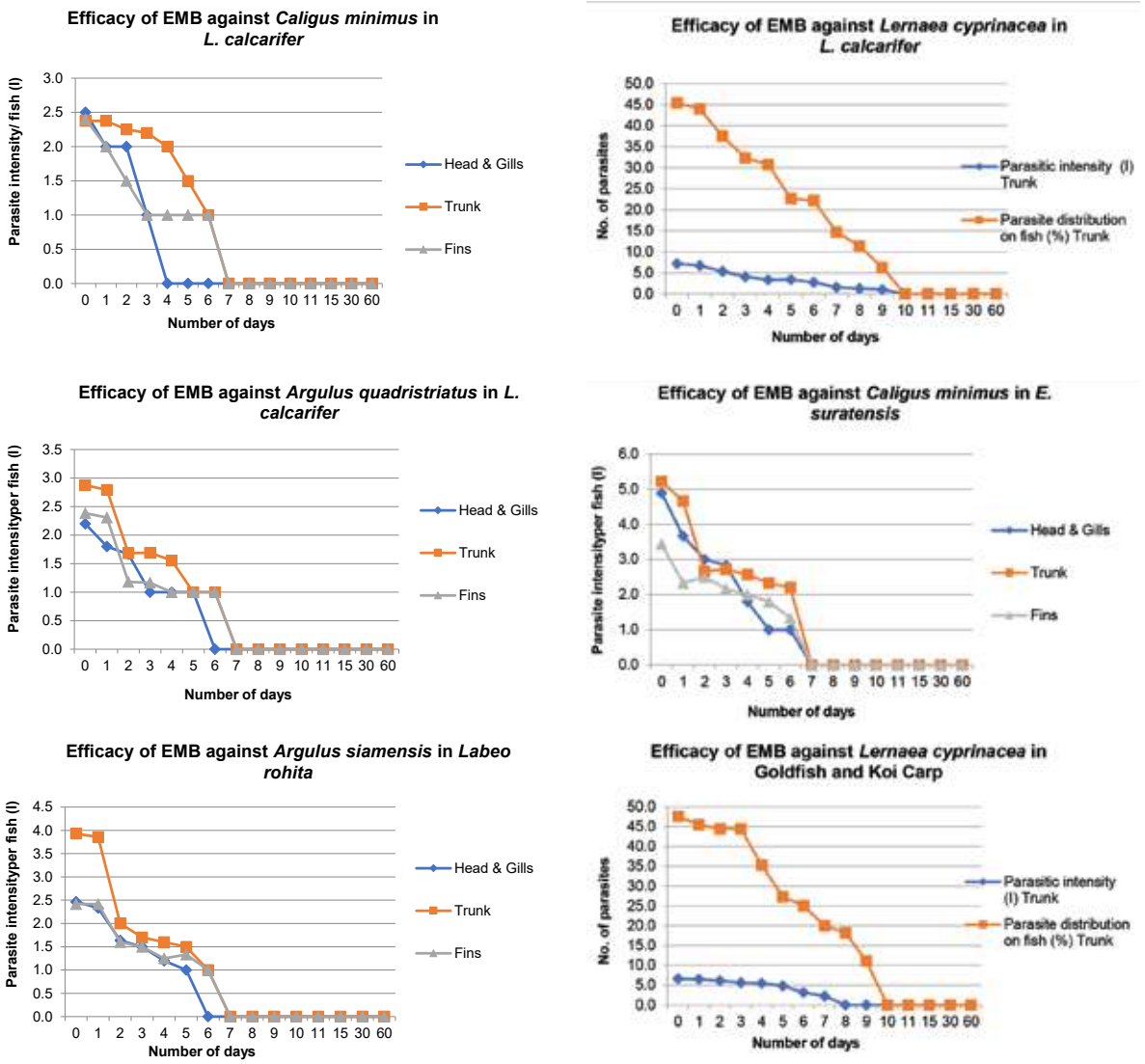


Growth kinetics of *V. campbellii, V. harveyi* and *V. owensii* in presence of different concentration of EDTA

which suggested the presence of dual siderophore system in *V. campbellii* viz anguibactin and vibriobactin. Based upon these data, EDTA was applied to control luminescent vibriosis in shrimp hatcheries and was found effective as prophylactic and therapeutic.

Field evaluation of emamectin benzoate (EMB) against economically important parasitic infestations in different fish species

Field efficacy of an anti-parasitic drug, emamectin benzoate (EMB) at the proposed therapeutic



Efficacy of EMB against different parasites *(Caligus minimus)* and fishes (Asian Seabass *(Lates calcarifer),* pearl spot, Indian major carps and goldfish.

treatment regimen of 50 µg of EMB kg^{-1} fish body weight (BW) day^{-1} for seven consecutive days was investigated. Field efficacy of the EMB was conducted in different culture systems (pond, tank, cage, lake and aquarium), rearing different fish species (Asian Seabass, Grey Mullet, Pearlspot, Indian Major Carps, Gold Fish and Koi Carp) and infected with various parasites (*Caligus* spp., *Argulus* spp., *Lernanthropsis* spp. and *Lernaea* spp.). Results showed that there was 100% efficacy against *Argulus* spp., *Caligus* spp. and *Lernanthropsis* spp. on 7th day, and against *Lernaea* spp. on 10th day of treatment. No re-infestation of parasites was reported for a period of 60 days post medication.

Effect of salinity on environmental degradation of anti-parasitic drug Emamectin Benzoate (EMB)

The study evaluated the rate of EMB (1 ppm) degradation at 2, 15 and 30 ppt of salinity under sunlight and dark condition with a photo period 12 h 12 mins and the light intensity of av. 34,845 lux. The rate of EMB degradation was inversely proportional to salinity.

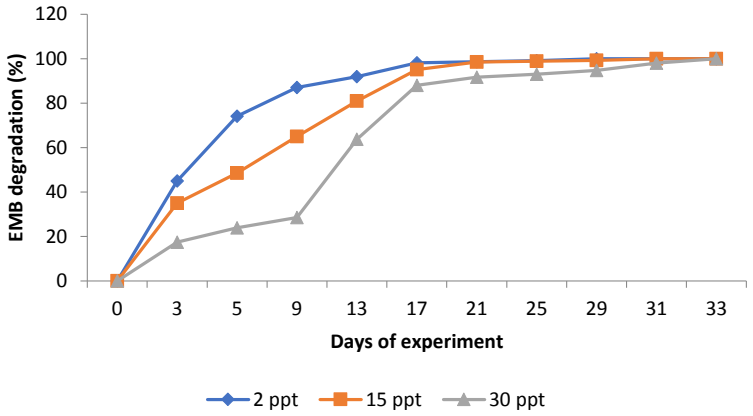
Evaluation of disinfectants for control of Sea lice, *Caligus minimus* in Pearlspot, *Etroplus suratensis*

Pearlspot, *Etroplus suratensis* was cultured by a group of farmers at Ponneri village, Tamil Nadu. During the culture, a parasitic

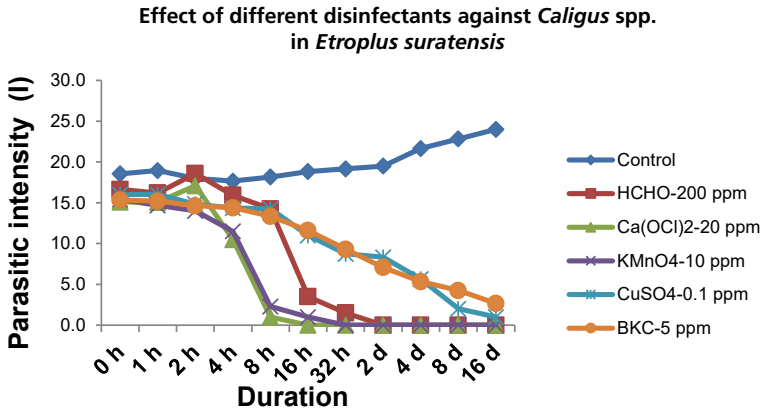
infestation of *Caligus minimus* was recorded with mortality and clinical signs such as lethargy, poor body condition, emaciation, inappetence, erratic swimming, gasping, flashing and rubbing against surfaces, loss of equilibrium and anaemia. As therapeutic measure, different disinfectants such as formalin (HCHO), calcium hypochlorite [$Ca(OCl)_2$], potassium permanganate ($KMnO_4$), copper sulphate ($CuSO_4$) and benzalkonium chloride (BKC) was evaluated against *Caligus minimus*. The fishes were grouped into six groups [control, HCHO, $Ca(OCl)_2$, $KMnO_4$, $CuSO_4$ and BKC] of 30 fish each in triplicate and treated with a single dose rate of 200 ppm, 20 ppm, 10 ppm, 0.1 ppm and 5 ppm, respectively. The initial parasitic intensity (I) per fish was 19.75±0.64. After treatment, parasitic intensity and fish mortality were significantly reduced among the treated groups except $Ca(OCl)_2$ over a period of 16 days against significant increase in control. It was concluded that different disinfectants such as HCHO, $KMnO_4$, $CuSO_4$ and BKC can be used to control the sea lice in water at a single dose rate of 200 ppm, 10 ppm, 0.1 ppm and 5 ppm, respectively.

Analysis of drug usage pattern in shrimp farms of India

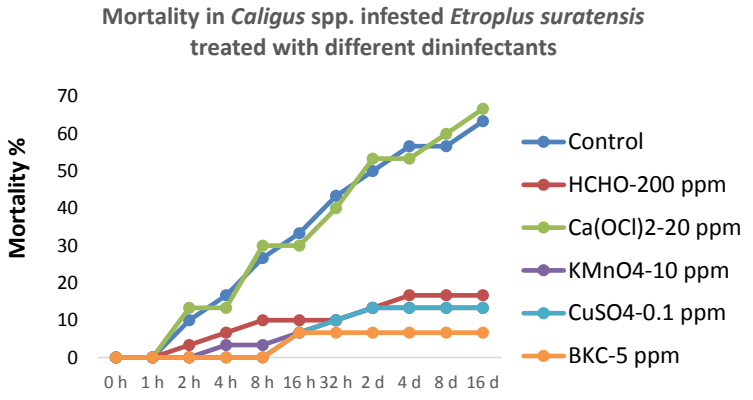
It is essential to understand the usage pattern of healthcare products in Indian aquaculture to monitor and regulate their scientific application. The survey conducted in the major aquaculture states of the country revealed that, environmental modifiers constitute 44% of the total products followed by probiotics (20%), disinfectants (7%) and nutritional supplements (6%). Results of the detailed study on the usage pattern in shrimp farms showed that an average of environmental modifiers, probiotics, nutritional supplements and disinfectants used was 57.2 kg, 15.1 kg, 2.39 kg and 7.8 kg per tonne respectively.



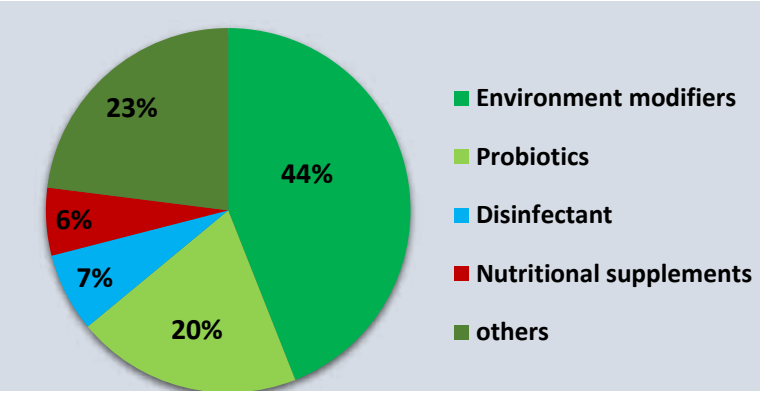
Effect of salinity on the degradation of EMB under sunlight



Efficacy of different disinfectants against *Caligus minimus* in Pearlspot, *Etroplus suratensis*.



Mortality pattern in *Caligus minimus* infested Pearlspot, *Etroplus suratensis* treated with different disinfectants.



Different types of drugs used by farms (%)

Multiple regression estimates suggest the significant impact of socio-economic factors like, education and experience and farming practices like, stocking density, culture period, average body weight, survival and production on the usage pattern of medicines and chemicals in shrimp farming. Further, significant variation between the states was observed on usage pattern of medicines and chemicals and factors influencing them.

Leaf extract of guava and other locally available plants have strong antimicrobial activity against aquatic pathogens

From the ancient times, the plant species are known to possess bioactive compounds including antimicrobial agents. In this study, six locally available plants viz. guava (*Psidium guajava*), moringa (*Moringa oleifera*), Indian penny wort (*Centella asiatica*), tamarind (*Tamarindus indica*), bani

Bani

Guava

Tamarind

Large leaved orange mangrove

Moringa

Indian penny wort

Mangrove plant used for antimicrobial activity

Inhibition of different aquatic organisms by different plant extract (Zone of inhibition in mm) (Mean ± SE)

Microorganism	Extract types	Moringa	Bani	Tamarind	Indian penny wort	Guava	Large leaved orange mangrove
V. campbellii	Ethanolic	18.75±0.85^{a}	8.5±1.50^{c}	19.25±0.48^{a}	13.75±0.48^{b}	20.75±0.75^{a}	15.25±0.48^{b}
	Methanolic	15.75±0.75^{a}	12.25±0.25^{b}	15.25±0.48^{a}	11.75±0.48^{b}	19.75±0.48^{c}	13.25±0.48^{b}
	Aqueous	13.50±0.50^{a}	10.50±0.29^{b}	18.25±0.85^{c}	10.25±0.48^{b}	18.75±0.25^{c}	13.25±0.48^{a}
V. mimicus	Ethanolic	14.25±0.63^{a}	No Zone	12.00±0.41^{ab}	No Zone	12.75±0.25^{a}	9.75±2.17^{b}
	Methanolic	13.00±0.41^{a}	11.25±0.48^{b}	11.25±0.48^{b}	10.00±0.41^{b}	17.25±0.25^{c}	7.5±0.87^{d}
	Aqueous	11.5±0.29^{a}	7.75±1.18^{b}	No Zone	No Zone	11.00±0.70^{a}	No Zone
E. tatrda	Ethanolic	17.75±0.63^{a}	18.5±0.87^{ab}	20.25±0.25^{b}	13.0±0.91^{c}	27.2 ±0.25^{d}	16.5±1.19^{a}
	Methanolic	16.5±0.65^{a}	19.0±0.41^{b}	18.75±0.48^{b}	10.25±0.48^{c}	25.5 ±0.29^{d}	16.5±0.29^{a}
	Aqueous	16.50.96^{a}	14.0±1.35^{a}	14.25±0.85^{a}	No Zone	27.25±0.75^{b}	14.00±0.4^{a}
Aeromonas hydrophilla	Ethanolic	22.75±0.75^{a}	21.75±0.63^{ab}	19.5±0.87^{c}	16.5±0.29^{d}	20.25±0.25^{bc}	No Zone
	Methanolic	19.25±0.25^{a}	24.00±0.70^{b}	16.50±0.29^{c}	14.00±0.58^{d}	21.00±0.41^{e}	No Zone
	Aqueous	11.75±3.38^{a}	17.75±0.63^{b}	17.50±0.87^{b}	No Zone	18.50±1.32^{b}	8.25±1.31^{a}

$p < 0.05$

Minimum inhibitory concentrations (MICs) of different plant extracts against aquatic pathogens

Sample		*V. campbelli*	*V. mimicus*	*E. tarda*	*A. hydrophila*
Guava	Ethanolic	1.25mg/ml	20 mg/ml	1.75mg/ml	20 mg/ml
	Methanolic	1.50 mg/ml	20 mg/ml	1.75mg/ml	22 mg/ml
Bani	Ethanolic	22 mg/ml	no zone	60 mg/ml	70 mg/ml
	Methanolic	34 mg/ml	90 mg/ml	90 mg/ml	90 mg/ml
Moringa	Ethanolic	32 mg/ml	90 mg/ml	106 mg/ml	50 mg/ml
	Methanolic	20 mg/ml	68 mg/ml	114 mg/ml	124 mg/ml
Indian penny wort	Ethanolic	60 mg/ml	no zone	112 mg/ml	124 mg/ml
	Methanolic	70 mg/ml	88 mg/ml	112 mg/ml	112 mg/ml

Qualitative phytochemical analysis of different plant extract:

Chemical constituent	Moringa		Bani		Guava		Indian penny wort	
	Methanol	Ethanol	Methanol	Ethanol	Methanol	Ethanol	Methanol	Ethanol
Sapononis	-	+	+	+	+	+	+	-
Alkaloid	+	+	+	+	+++	+++	++	+
Anthraquinones	-	-	-	-	-	-	-	-
Phenolic compounds	+	++	+	+	+++	+++	+	+
Tannin	-	-	+	+	+++	+++	+	+
Quinines	-	-	+	++	++	+++	-	+
Terpenoids	-	-	+	+	++	+++	+	++
Cardiac glycosides	+	+	+	+	-	-	+	+

Anti-oxidant potential of different plant extracts by DPPH assay:

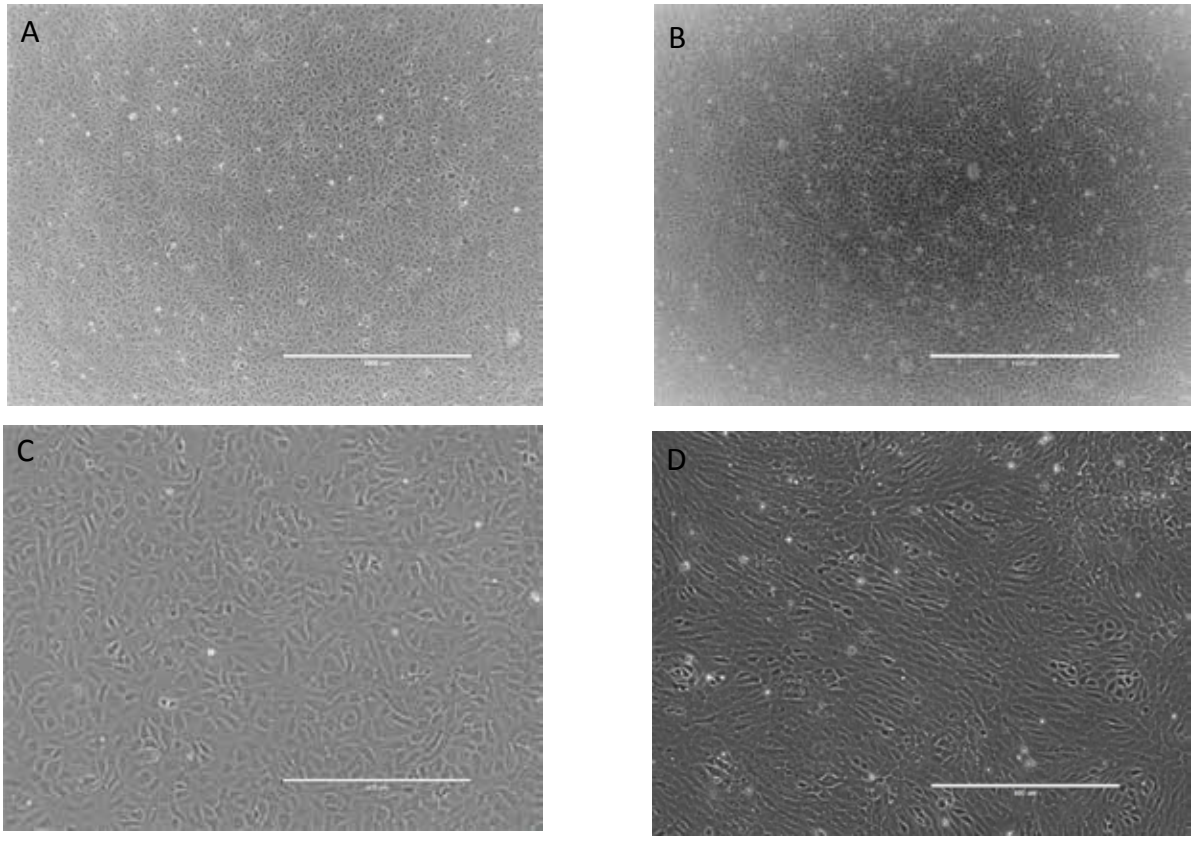
Extract type	DPPH scavenging activity of different plant leaf extracts (IC50 values in µg/ml) (Mean ± SE)			
	Guava	Bani	Indian penny wort	Moringa
Ethanolic extract	11.23 ± 0.12[a]	176.4 ± 0.89[b]	110.15 ± 0.36[c]	139.48 ± 0.5[d]
Methanolic extract	11.23 ± 0.11[a]	155.69 ± 1.93[b]	112.21 ± 0.46[c]	153.44 ± 2.26[b]

$p < 0.05$

(*Avicennia alba*) and large-leaved orange mangrove (*Bruguiera gymnorhiza*) from Sundarban area of India were studied for their antimicrobial effects on selective aquatic pathogens viz *Vibrio campbellii*, *V. mimicus*, *Edwardsiella tarda* and *Aeromonas hydrophila*. The extracts from each plant was prepared separately in three different extraction solvents viz. ethanol, methanol and aqueous (distilled water). Overall, the aqueous extract showed lower efficacy than ethanolic and methanolic extracts. Among six plants tested for this study, the guava was found as the most potential in inhibition of aquatic pathogens as evidenced by wide zone of inhibition and low minimum inhibitory concentrations (MICs)**.** Apart from guava leave extracts, the moringa leave extract also exhibited a strong anti-bacterial potential especially against *A. hydrophilla*. Phytochemical analysis of ethanolic and methanolic extracts of medicinal plant revealed the presence of saponines, alkaloid, flavonoid, phenolic compounds, tannins, quinines, terpenoides and cardiac glycosides, which could be responsible for the observed antibacterial property. The antioxidant potential of leaf extract of four plants viz. moringa, bani, Indian penny wort and guava was determined by 2,2-diphenyl-1-picrylhydrazil (DPPH) radical scavenging assay and IC50 was determined. The guava leaf was found to possess potent antioxidant properties in DPPH radical scavenging assay as evidenced by low IC50 values. Both ethanolic and methanolic extract of guava leaves showed the lowest IC50 values as compared to other three plants indicating highest anti-oxidant potential of guava leaf. Considering all the beneficial properties, it may be stated that guava leaf may be considered as a potential candidate for preparation of commercial medicine in aquaculture.

Development of brain cell line MFB-1 from milkfish

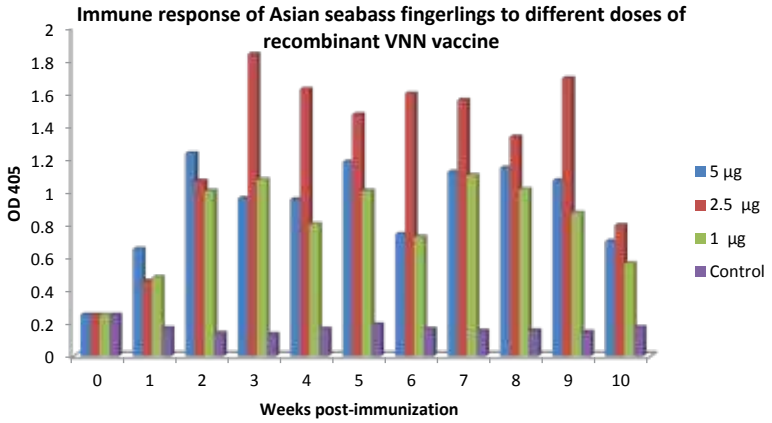
The established adherent MFB-1 cell line from brain tissue of milk fish (*Chanos chanos*) showed stable growth for >65 passages over a period of three years. The MFB-1 cells were characterised by karyotyping (2n=32). Further, 50th passage cells were confirmed using mitochondrial cytochrome oxidase subunit 1 (cox1) marker gene and sequence submitted to NCBI database (Genbank accession no. MN836380) showed maximum identity for *Chanos chanos* origin. The continuous propagation in TC treated flask with plug seal (Nunclon delta surface) from 40th passage to 50th passage level using L-15 medium with 15% FBS at 27°C (osmolality ranges from 250 to 270 mOSM/kg) showed gradual changes of predominant epithelial like than fibroblast cells. Uniform cell morphology, cell viability and proliferation from 57th passage to 65th passage with split ratio of 1:2 reaching 100% confluency in 24 -36 hrs with the population doubling time of 36 hrs were observed. The confluent monolayer of MFB-1 cells can be maintained for 20 days with L-15 medium supplemented with 2% FBS without any changes in cell morphology and peeling of monolayer. Standard growth of MFB-1 was attained using L-15 medium from different sources (Gibco and Himedia) supplemented with 15% FBS. The confluency of 80% reached within 24 hrs of incubation in TC treated flask of any make, whereas only 20 to 40% confluency attained in non-treated tissue culture flask with changes in cell morphology and early detachment of cell in 48 to 76hrs of incubation. The sterility testing of cell line for bacterial, fungal, mycoplasmas and adventitious viruses were tested and found negative by PCR at various passage levels. The cells were tested and found negative for endogenous retro virus.



Morphology of MFB-1 cell line under phase contrast microscope - A: MFB-1 cells at 65th passage (10 X); B: MFB-1 cells at 45th passage (10 X); C: MFB-1 cells at 65th passage showing uniform epithelial like cells (40 X); D: MFB-1cells at 45th passage showing fibroblast and epithelial like cells (40 X).

Dose optimization of recombinant vaccine against viral nervous necrosis in Asian seabass

Viral nervous necrosis is a serious disease of brackishwater finfishes. The disease is caused by nervous necrosis virus (NNV) of the genus betanodavirus. The disease is transmitted both horizontally and vertically making the disease control more difficult. Earlier, a recombinant capsid protein and inactivated viral vaccine was developed and administered to Asian seabass broodstock. Recombinant capsid protein vaccine gave better immune response compared to inactivated viral vaccine. The



Immune response of Asian seabass fingerlings to different doses of recombinant VNN vaccine

dose of the recombinant vaccine was optimized in the present study. The recombinant protein was purified and emulsified with commercial adjuvants. The vaccine was administered to Asian seabass fingerlings at three different doses viz., 1, 2.5 and 5 µg g^{-1} body weight of fish. The fish were maintained in flow through

system at 27± 1° C. Blood samples were collected from the caudal vein before and every week up to 10 weeks post vaccination. The serum was used to assess the antibody titre by indirect ELISA using anti-seabass IgM monoclonal antibodies. The 2.5 µg g^{-1} body weight dose gave better immune response compared to the other two doses. The immune response was above the protective levels in all the three doses up to 10 weeks post-immunization.

National Referral laboratory for Brackishwater Aquaculture

ICAR-CIBA aquatic animal health and environment lab is a National Referral Laboratory for brackishwater aquatic animal disease (NRLD) and has been serving the stakeholders such as Aquatic Quarantine and Certification Services (AQCS, GOI), broodstock multiplication centres (BMCs), shrimp hatcheries. Aqua farmers from all over India also utilized the diagnostic services rendered by the lab during the COVID times. During 2020-21, a total 185 samples tested with revenue generation of ₹ 11,240,844/-. The samples received includes Artemia cysts, brine shrimp flakes, shrimp/prawn feed, pond soil for EHP testing, shrimp and fish brooders and live imported polychaete for testing the OIE listed pathogens. The samples screened and the details of the results are given in tabular form.

Sample Tested	No Tested	WSSV	IHHNV	IMNV	TSV	YHV	AHPND	NHPB	EHP	VNN
ArteGold Medium Artemia capsules	1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	NA
Artemia cysts (Brine shrimp eggs, Vitellus standars, Vitellus small, Enriched adult Artemia)	38	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve (1)	NA
Brine shrimp flakes	03	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	NA
Shrimp feed/ Prawn feed	65	-ve	ND	ND	ND	ND	ND	ND	ND	NA
Live Cultured Marine Polychaetes (Nereis virens)	02	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	NA
Pond Soil	05	-ve	-ve	-ve	-ve	-ve	-ve	-ve	+ve (3)	NA
Seabass brooders	48	NA	NA	NA	NA	NA	NA	NA	NA	34(+)
Total samples Tested										185

Aquaculture Environment and Climate Change

Research on aquaculture environment and climate change is aimed to provide deeper understanding of ecological system associated with aquaculture operations. We focus on environmental performance of diverse brackishwater resources. Climate change increases the complexity and understanding of various aquaculture systems. We, therefore, further focus climate resilient brackishwater aquaculture production systems

Aquaculture Environment and Climate Change

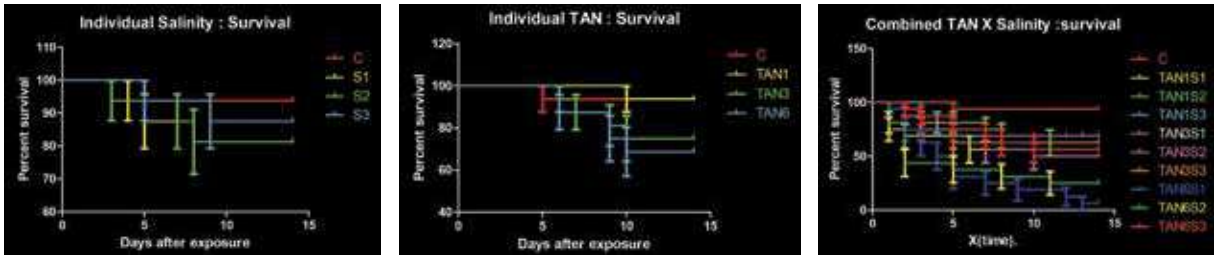
Individual and combined effect of salinity and ammonia stressors on *Penaeus vannamei*

Shrimps were exposed for two weeks to individual salinity (ppt): S1-3; S2-20; S3-35; individual TAN (mg/L): TAN1, TAN3, and TAN6; combined treatments - TAN1S1, TAN1S2, TAN1S3; TAN3S1, TAN3S2, TAN3S3; TAN6S1, TAN6S2, TAN6S3 and control (salinity: 10 ppt; TAN: 0.0112 mg/L). Cox's regression Exp (B) values indicated that individual treatments had significantly high survival rate with risk factor of about 1-5 times in individual TAN and 2 to 4 times in salinity compared to combined treatments. The combined treatments of salinity S1, S2 and S3 with TAN1, TAN 3 and TAN6 showed 6 to 10.2 times, 7 to 12 times and 8 to 29 times more risk of dying compared to control. Among the combination treatments risk factor increased with decreasing salinity. The highest risk of dying was observed in TAN6S1 (29.6) and TAN6S2 (24.7) compared to control.

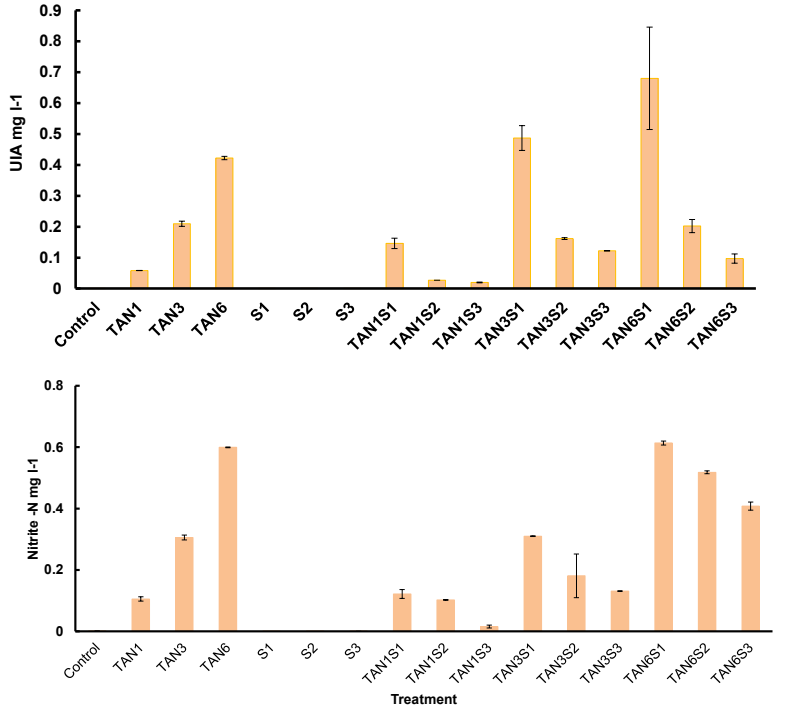
Unionised ammonia (UIA) increased from TAN1 to TAN6 and no significant changes were observed among the salinity treatments. Among the combined treatments, UIA decreased with increase in salinity. Nitrite-N increased with increase in ammonia concentration from TAN1 to TAN6 and it showed inverse relationship with increasing salinity. Compared to individual treatments, combined treatments reported significantly less immunological activity. Overall, activity of THC, PO and SOD were significantly high in S3 throughout the experiment compared to all other treatments. Among the combined treatments, higher immunological activity was observed in TAN1S3 compared to other treatments. Overall, the immunological activity in terms of THC, PO and SOD decreased with increasing TAN and decreasing salinity.

Post challenge survival graphs showed that individual TAN treatments had median survival of 5 to 5.5 days, whereas salinity treatments showed 4 to 5 days.

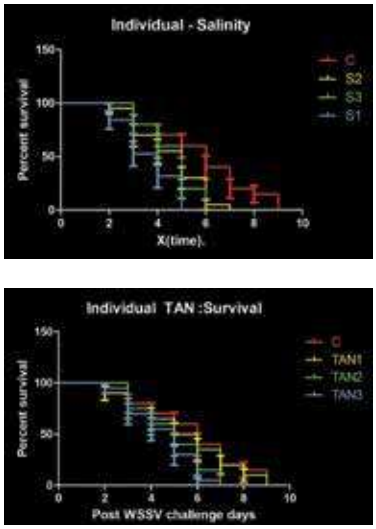
All the combined treatments showed 2.5 to 4 days of median survival except TAN3S3 (5.5 days) indicating more susceptibility to WSSV than individual treatments. The calculated cox proportional hazard, Exp (B) values showed that shrimp in combined treatments of S and TAN showed 1 to 11 times risk of dying and are more susceptible to WSSV than shrimps in individual treatments, which showed 1 to 4 times risk of dying. Among the combination treatments, S3 and TAN combination treatments showed less susceptibility to WSSV. Among the salinity combined treatments, S3 with all TAN combination showed better median survival and less Exp (B) risk of dying compared to other salinity combinations (S1 and S2). Among combined treatments, highest risk of dying in terms of Exp (B) was in TAN3S1 (11.41) followed by TAN6S2 (9.24) and lowest risk in TAN3S3 (1.36 times) followed by TAN1S3 (2.42 times). In individual treatments the risk of dying increased with increasing TAN concentration and decreasing salinity.



Survival proportions (%) of salinity (a), TAN (b) and S X TAN (c) treatments at different days of experiment.



Effect of TAN, salinity and TAN X S stressors on metabolites concentration

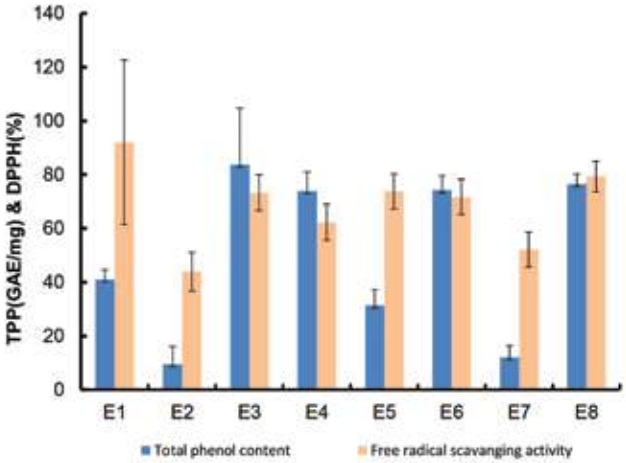


Post WSSV challenge survival proportions (%) of individual salinity and TAN

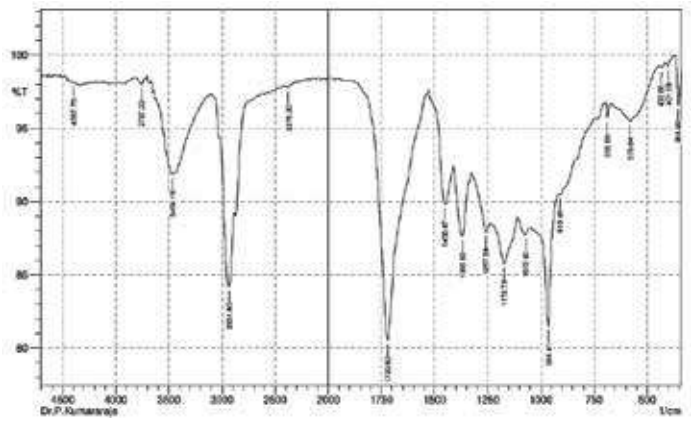
Extraction and characterisation of herbal based adaptogens

Adaptogens helps the animal to adapt to biological and physiological stress by building more resilience to stress by providing energy and strength to manage stress response. Eight active compounds were extracted from herbs/algae/fungi having adaptogenic properties such as anti-bacterial, anti-viral, anti-oxidant, anti-inflammatory and immunostimulant. The eight extracts were primarily screened for total polyphenol content and free radical scavenging activity. Out of eight extracts, two extracts (E5 and E8) were characterized by Gas Chromatography and Mass spectrometry and other six purified extracts were screened in Fourier Transform Infrared Spectroscopy for identification of functional groups.

The total poly phenol (TPP) content of crude extracts in terms of gallic acid equivalents (GAE/g) ranged from 9.43 to 83.8 and highest poly phenol content were observed in E3 (83.8) followed by E8 (76.6) and E4 (73.9), and lowest in E2 (9.43). Free radical scavenging activity by DPPH (1,1-diphenyl-2-picrylhydrazyl) radical method revealed that the extracts are capable in scavenging toxic free radicals with inhibition rate of 43.9 to 92%. Among the 8 extracts, E1 showed highest scavenging activity with 92% inhibition rate followed



TPP and Free radical scavenging activity (DPHH) of eight crude extracts



FT-IR Characterisation of E2 active component

Peak	Area%	Functional group
1	67.8	1,2,3-Benzenetriol
2	32.2	1,3,7-Trimethyl-3,7-Dihydro-Purine-2,6-Dione

Peak	Functional group
3757	O-H stretching vibration
3464	N-H Stretching vibration
2932	C-H Stretching vibration
2376	C=C aromatic stretching
1720	C=O Stretching vibration
1450	CH_2 bending
1366	CH_3 bending
1258	C=O keto group
1173	C-O stretching
1072	C-O-C stretching
964	CH out-of-plane wagging
910	C-H vibration trans in benzoate ring

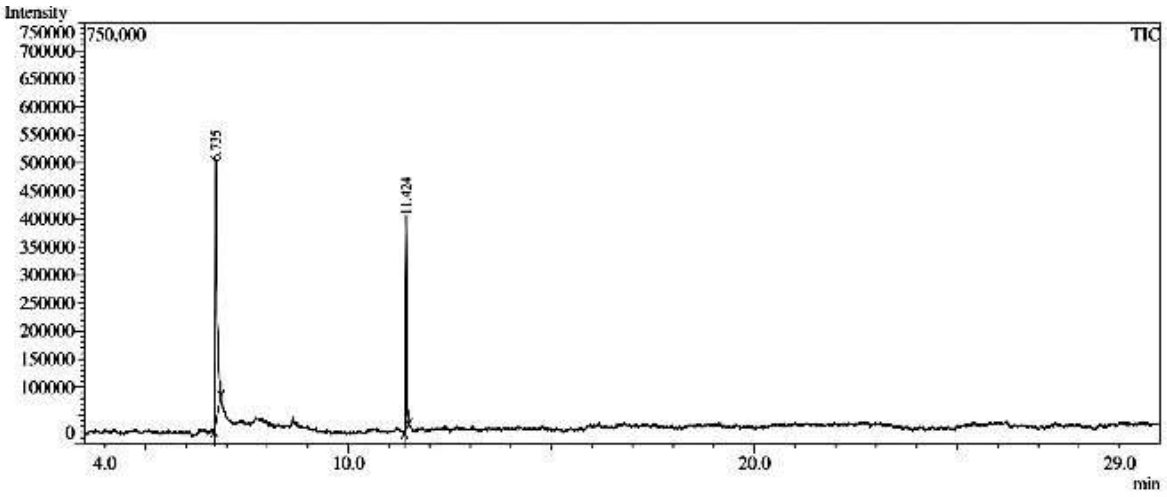
by E8 (79.3). Except E2 (43.9), all the extracts showed greater than 50% inhibition rate.

The spectrum of purified extract E2 revealed different peaks in the spectral regions corresponding to the absorption at active functional groups. Different peaks corresponding to various functional groups indicates the presence of secondary amines, esters and amino acids, carbonyl β-unsaturated ketone amides, antioxidant enzyme and confirms the presence of protein.

The E5 mass spectra were matched with the standard National Institute of Standards and Technology (NIST) Library, revealed the presence of two active components. Plant metabolite benzenetriol carrying hydroxyl groups at positions 1, 2 and 3 and has a role as an antioxidant and 1, 3, 7-Trimethyl-3, 7-Dihydro-Purine-2, 6-Dione known to act as a stimulant on the central nervous system.

Effect of adaptogen feed on shrimp growth

The extracts were grouped into two adaptogen groups (A1 and A2), coated on nutritionally suitable feed with four different concentrations and tested for



GC–MS chromatogram of purified extract of E5

Growth performance of *P.vannamei* fed with adaptogen coated feeds. Columns with same superscript do not differ significantly (P<0.05)

Treatment	ADG	SGR	ABW	FCR
A1 – 100 mg	$0.198^{b}\pm0.008$	$0.83^{a}\pm0.1$	$1.52^{a}\pm0.033$	$2.28^{a}\pm0.09$
A1 – 250 mg	$0.205^{a}\pm0.01$	$0.88^{b}\pm0.1$	$1.54^{bc}\pm0.008$	$2.25^{ab}\pm 0.39$
A1 – 500 mg	$0.222^{a}\pm0.012$	$0.91^{c}\pm0.1$	$1.55^{C}\pm0.002$	$2.21^{b}\pm0.11$
A1 – 750 mg	$0.219^{a}\pm0.017$	$0.88^{b}\pm0.1$	$1.23^{a}\pm0.011$	$2.27^{a\pm}0.01$
A2 – 100 mg	$0.194^{ab}\pm0.009$	$0.83^{b}\pm0.1$	$1.50^{a}\pm0.003$	$2.72^{ab}\pm0.24$
A2 – 250 mg	$0.202^{b}\pm0.002$	$0.87^{c}\pm0.1$	$1.53^{ac}\pm0.005$	$2.20^{c}\pm0.61$
A2 – 500 mg	$0.231^{a}\pm0.008$	$1.01^{b}\pm0.1$	$1.61^{b}\pm0.002$	$1.80^{c}\pm 0.09$
A2 – 750 mg	$0.221^{a}\pm0.006$	$0.094^{b}\pm0.1$	$1.51^{b}\pm0.018$	$1.97^{c}\pm 0.11$
CONTROL	$0.194^{c}\pm0.009$	$0.82^{a}\pm0.1$	$1.50^{d}\pm0.024$	$2.42^{b}\pm0.31$

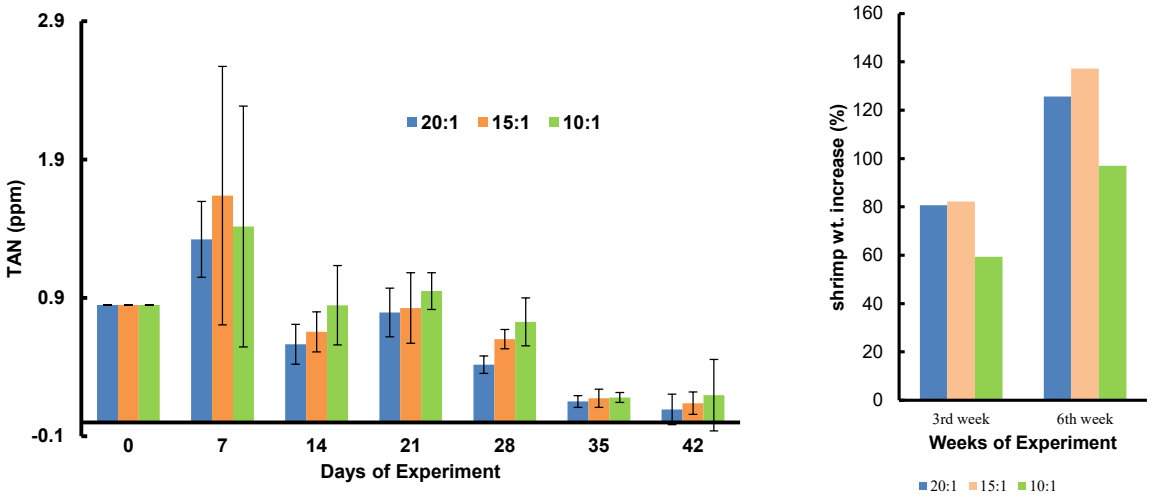
Average daily growth (ADG), Specific growth rate (SGR), Average body weight (ABW) and Food conversion ratio (FCR).

their aqua stability. Shrimps fed with adaptogen groups (4 levels for each adaptogen group) for 45 days in triplicate were assessed for the survival rate and the growth parameters viz., average body weight (ABW), average daily growth (ADG), specific growth rate (SGR) and food conversion ratio (FCR). There was no mortality in any of the treatments.

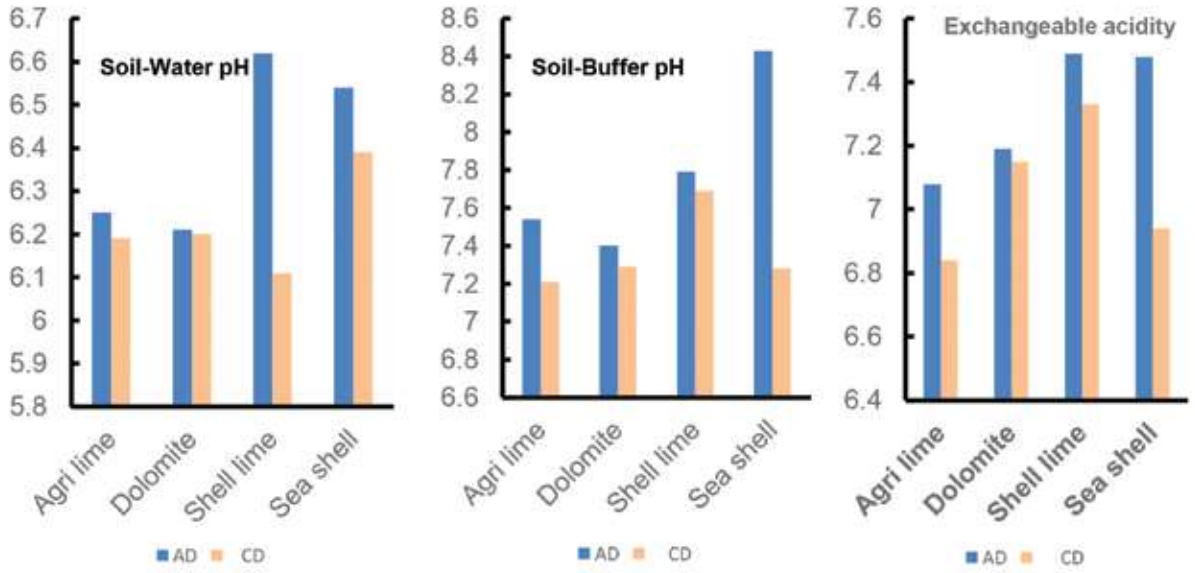
Among all the growth factors studied, inclusion of adaptogen level of 500 mg/kg in both the adaptogen groups showed higher performance compared to other levels and control. Between these two effective adaptogen groups, A2 treatment @ 500 mg/kg showed comparatively better performance.

Effect of varying theoretical and analysed C:N ratios on shrimp growth and water quality

In an attempt to understand the theoretical and analysed C:N ratio concept on shrimp growth and water quality, an experiment was carried out with theoretical C:N ratios of 20:1, 15:1 and 10:1 using specially formulated feeds



Influence of C:N ratio on TAN concentration in water and shrimp growth



Comparative efficiency of lime materials applied based on their calcium carbonate equivalent and the dose calculated with different lime requirement methods

at the rate of 6% of shrimp body weight in *P.vannamei* culture with a stocking density of 80 m^{-2} for six weeks. Among the treatments, C:N ratio of 20:1 recorded the highest increase in biofloc volume at 478% followed by 394% and 252% in 15:1 and 10:1 formulated feeds. The weekly analysis of water samples showed a decrease in TAN with the increasing C:N ratio. Higher shrimp growth was recorded in 15:1 ratio followed by 20:1 and 10:1. Further analysis of carbon and nitrogen fractions will indicate the relation between corresponding analysed C:N ratios and water quality.

Re-examining the lime requirement estimation procedures for aquaculture pond soils

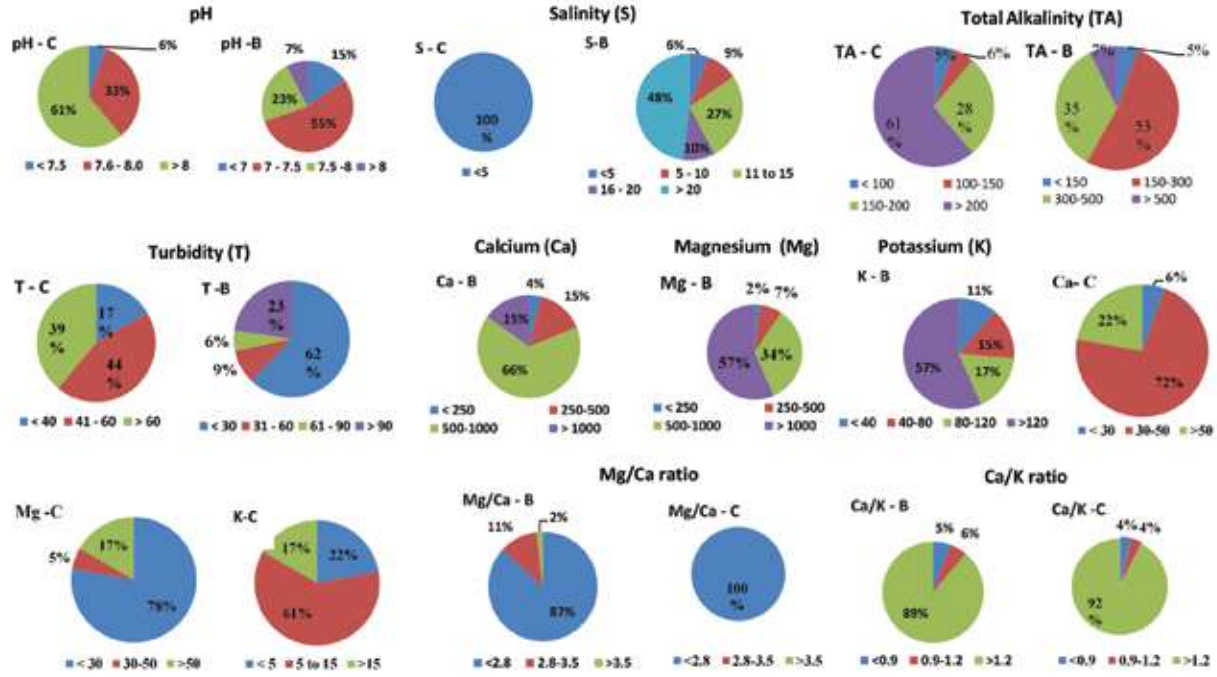
The accurate estimation of lime requirement for aquaculture ponds to increase pH of pond bottom soil has been a major concern for many farmers, particularly to increase the soil pH to 10 as a remedial measure to prevent EHP. Mostly soil-water pH method is used to recommend the dose of lime material. However, this method is being criticized for not suggesting the exact lime requirement dose. Commercial lime materials in general are not effective and pure, and their effective calcium carbonate equivalent (ECCE) value, which depends on the neutralizing values and fineness rating differ depending on the type and quality of the product.

Three methods *viz*., soil-water pH (1:2.5), soil-buffer pH (Shoemaker-McLean-Pratt buffer) and exchangeable acidity by titration were tested for calculating the lime requirement of four lime materials viz., agricultural lime, dolomite, shell lime and sea shell to raise the soil pH from 5.5 to 7. The calculated dose (CD) for lime materials was taken in terms of pure calcium carbonate with neutralizing value and fineness rating of 100%. Among four lime materials, the efficiency of shell lime was more. Actual dose (AD) of lime requirement was calculated based on ECCE value. All the three methods and the dose significantly differed in increasing the soil pH ($p \leq 0.05$). The average soil pH was found to be 6.23 & 6.11 by soil-water pH, 7.79 & 6.9 by soil-buffer pH and 7.27 & 6.8 by exchangeable acidity from actual & calculated doses respectively. Exchangeable acidity method exactly estimates the lime requirement of soil, whereas soil-water pH and SMP buffer methods slightly lower and over estimates the lime requirement, respectively. Actual dose of lime material based on ECCE was significant in increasing the pH compared to the calculated dose. This study will provide valuable information on correct calculations for application of lime material to farmers.

Characterisation of shrimp culture source waters and pond soils of Gudur Mandal, Andhra Pradesh

Source waters (Creek and bore well waters) and soil quality of shrimp culture ponds were investigated

Physico-chemical characteristics of shrimp culture pond soils of Chillakur Mandal, Gudur aquaculture division



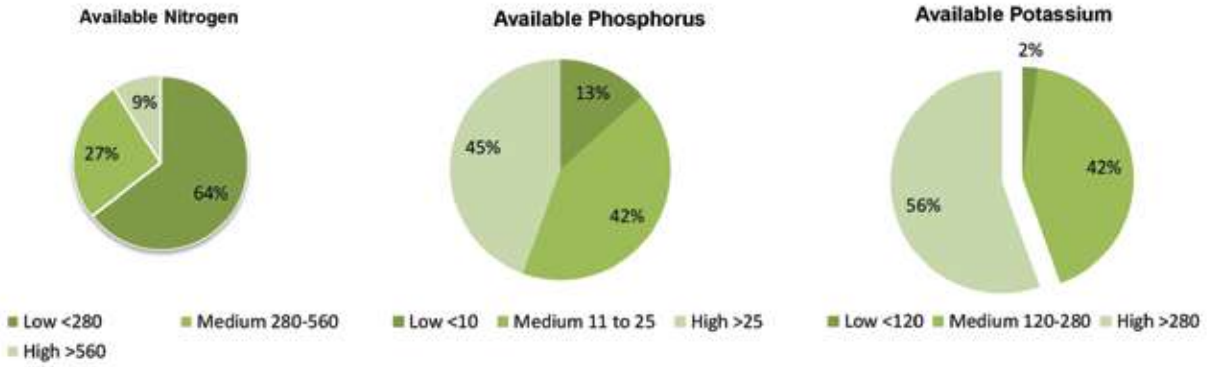
Physico-chemical characteristics of shrimp farm source waters, Creek (C) & Bore well (B), Gudur Mandal, Andhra Pradesh

in Chillakur Mandal of Gudur aquaculture division, Andhra Pradesh. Out of 71 samples, about 40 per cent soils were of clay loam texture followed by clay (33%). Most of the soils were in alkaline range with about 58% in 8.0-8.5 and 41% in 8.5-9.0 range. About 93% soils had less than 0.25% organic carbon. All soils had less than the optimum available N (11-21 mg/100g soil) and about 58% soils were in the range of available phosphorus (0.5 -1 mg/100g soil).

The source and creek water parameters differed significantly. The salinity of all the creek waters was less than 5 ppt and about 94% had pH more than 7.5, whereas bore well waters had wider salinity range and about 30% samples had more than 7.5 pH. Bore well waters had much higher alkalinity than creek waters. Comparatively, the concentration of minerals calcium, magnesium and potassium were much higher in bore well waters than creek waters. None of the creek waters and only 11% of bore well waters had optimum Mg/Ca ratio, and only 6% of bore wells and 4% of creek samples had optimum Ca/K ratio.

Fertility status of inland saline soils

Salt affected soils in inland areas of India occupy 8.7 million ha, which are not suitable for agriculture due to the underground saline water, but potential sites for brackishwater aquaculture. The fertility status inland saline soils (n = 45) of Rajasthan, Haryana and Punjab was evaluated by estimating the available major nutrients nitrogen, phosphorus and potassium. About 64% soils are deficient in nitrogen status represented as low followed by 27% as medium and 9% as low.



Fertility status of inland saline soils

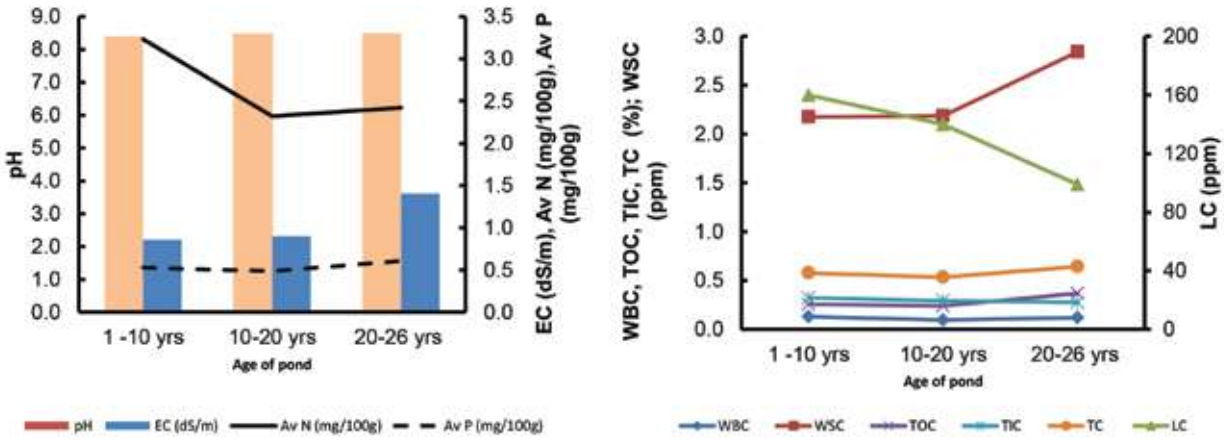
The soils are rich in available phosphorus (45% in high and 42% in medium category) as well as available potassium (56% in high and 42% in medium category). Fertility status of the soils indicates that they could be potential suppliers of potassium to mitigate the ionic imbalance in inland saline waters, which are invariably deficient in potassium.

Characterization of pond sediments of varying age

The pond sediments varying in age (<10 yr, 10 - 20 yr and > 20 yr) were characterised for soil texture, pH, electrical conductivity (EC), Available N, Available P, soil organic carbon represented as Walkley black carbon (WBC) and carbon fractions. The soil texture varied from sandy loam, loamy, clay loam to clayey soil. The pH ranged from 8.1 to 8.9 and did not show any significant difference among the sediments samples. The EC of the sediments was observed to increase with ageing (0.11 to 4.67 dS/m). The soil available N decreased with ageing of ponds, whereas no particular trend was observed in the soil available P. The WBC ranged from 0.09 to 0.13%, labile carbon (LC), which is the easily mineralizable form of carbon decreased with ageing, whereas the water soluble carbon (WSC) was observed to be higher in aged ponds compared to younger ponds. Among the different carbon fractions, total inorganic carbon fraction was higher in the younger ponds compared to the older pond and the total carbon content was higher in the aged ponds. The non-labile form of carbon constituted the major portion of the total carbon in the aged ponds, which thereby enhanced carbon storage and sequestration.

Damage to shrimp aquaculture due to Cyclone Nivar

Assessment of damage to shrimp aquaculture due to severe cyclonic storm 'Nivar' during November 2020 in Nellore District, Andhra Pradesh indicated that about 5000

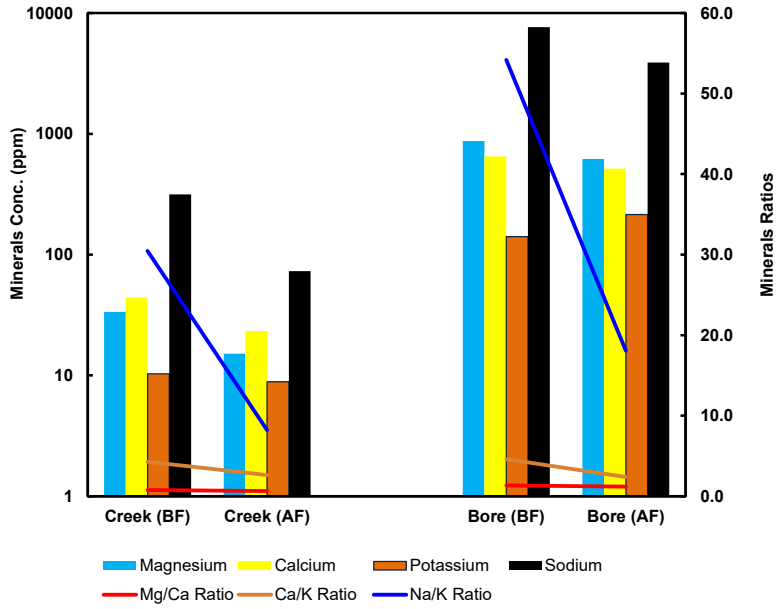


Physico-chemical properties and carbon fractions in pond sediments of varying age

acres of shrimp culture ponds were affected with an estimated loss of 34 crores. The infrastructure in shrimp culture ponds such as pond bunds, storage structures, aerators and electrical lines were damaged due to strong gales of 100-110 km/hr. The interrupted power supply for more than two days affected the shrimp. The flood induced by post-cyclone heavy rainfall of 19 to 24 cm on 26th Nov and 16-27 cm on 27th Nov followed by heavy rains due to low pressure in the first week of December in shrimp farming Mandals of the district, inundated shrimp culture ponds in low lying areas, leads to escape of shrimp and, soft sediment deposition up to 5 cm on the pond bottom. Analysis of water and soil samples before and after the flood from 70 shrimp culture ponds revealed a drastic reduction in salinity, minerals composition, and ionic ratios in water, an increase in pond water turbidity and nutrients, created stress to the shrimp in the culture ponds.

Effect of intensive spells of rainfall on water quality parameters and shrimp growth parameters

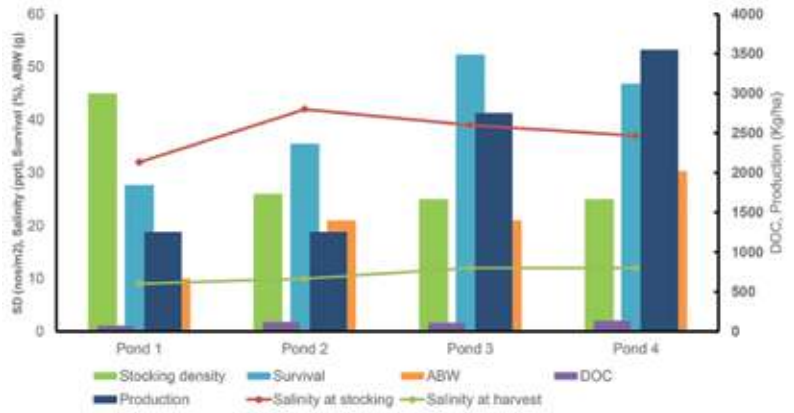
The effect of intensive rainfall spells from southwest monsoon during 2020 was monitored on the changes in water quality before and during rains (BR & DR) and production performance in shrimp cultured ponds, Navsari District, Gujarat. The stocking in pond 1 (45 nos/m^2) was done 20 days after pond 2 (26 nos/m^2) and 11 days after pond 3 and 4 (25 nos/m^2). Intense rainfall of 75 to 100 mm resulted in a salinity drop of 2.5 ppt within a single day in a 1 Acre pond. First spell of cumulative weekly rain of 250 mm in July resulted in a salinity drop of 8 to 9 ppt in a high saline pond (31-37 ppt) of 1-acre area. However, for similar pond area at intermediate salinities of 19-22 ppt, second spell of intense cumulative weekly rainfall amounting to about 500 mm in August resulted in 9 to 10 ppt drop in the pond water salinity. This is due to the difference between the salinities of rain water and the pond water, wherein a high saline water would be subjected to a greater change compared to a medium at lower salinities. The drop in pH and alkalinity was by around 0.2 to 0.3 and 20- 50 ppm respectively following heavy rain fall. The changes to the mineral profile following heavy rainfall is proportional to the salinity drop. A drop in magnesium, calcium and potassium levels were observed, although levels were similar to seawater diluted to similar salinity and minerals ratios were more or less same level. Mostly farmers who stocked late due to Covid-19 lock down, have their majority of the days of culture during monsoon. It has been observed that production was less in pond 1 due to higher stocking density and in pond 2 due to maximum difference in salinity at the time of stocking and harvest.



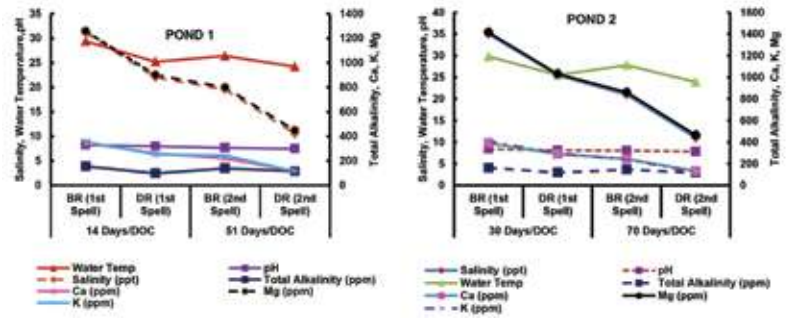
Changes in minerals concentration and ratios of source waters before and after flood

Water quality index of Muttukkadu Estuary and Adayar Creek

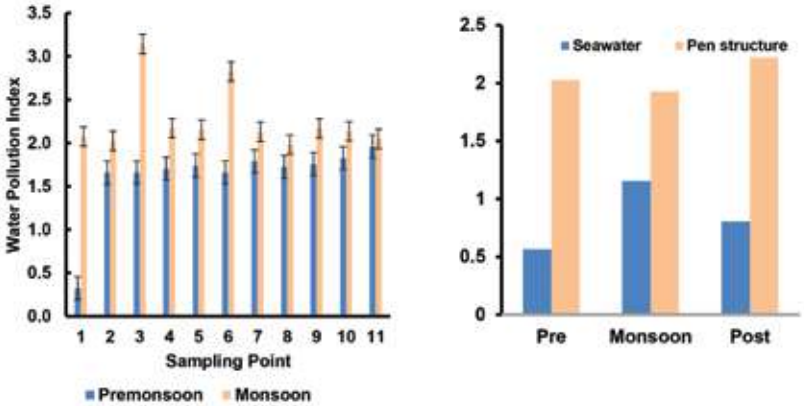
Water quality of Muttukkadu Estuary (ME) and Adyar Creek (AC) were monitored at monthly interval to assess the seasonal variation in the physico-chemical properties. Water pollution index (WPI) was calculated by the ration of observed and standard values for each parameter. WPI ranged from 0.32 to 1.96 during pre-monsoon and 1.98 to 3.14 during monsoon season in ME. The higher WPI during monsoon season in ME was due to higher concentration of nutrients such as nitrate and phospahte as a result of the runoff. WPI values significantly varied among the seasons in AE and ranged from 0.56 to 1.1 and 1.9 to 2.2 in the source water and pen culture site, respectively.



Shrimp growth parameters and production affected by intensive spells of heavy rainfall



Changes in water parameters and minerals concentration in shrimp culture ponds affected by intensive spells of heavy rainfall (BR- Before Rains; DR – During rains)



Seasonal variation in Water Pollution Index (WPI) of Muttukkadu Estuary and Adyar creek

Diurnal temperature controlled shrimp housing system

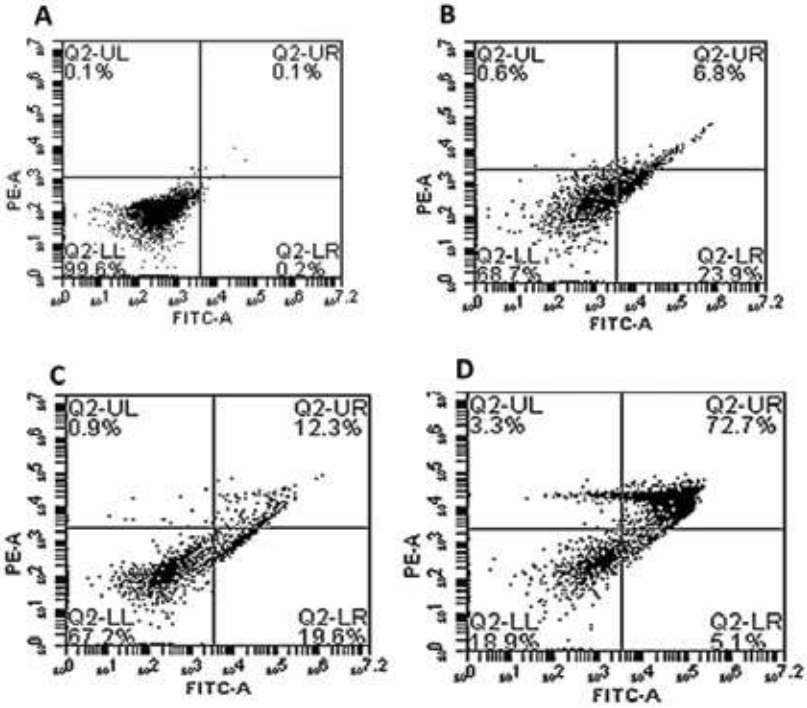
Diurnal temperature controlled shrimp housing system was fabricated for studying the influence of variations in rearing water temperature on disease occurrence in shrimp. The system consisted of a chiller and heater that are connected to the rearing units by means of corrosion resistant steel coils for temperature exchange to the rearing water without direct mixing. The temperature in the rearing tank is monitored through a control panel connected with temperature sensors in each tank. The control panel signals solenoid valves placed in respective tank units for opening or closing hot/cold water as per the set value for each unit. The system enables conducting experiments by programming for maintaining the desired temperature of rearing water in the range of 20-45°C. The unit maintains required temperature assigned in the control panel for conducting experiment with controlled temperature regime. The unit has recirculatory system to maintain water quality in the optimum range.

Genetics & Biotechnology

The genetics and biotechnology division of CIBA utilizes the state-of-art genomic analyses and innovative technologies to discover candidate genes and understand the pathways in physiological process including growth, reproduction and disease resistance in penaeid shrimps. Approaches using bioinformatics and transcriptome analysis are employed to identify genes, microsatellites and single nucleotide polymorphisms that are helpful in the selective breeding programs.

Flow cytometry based apoptotic progression analysis in *Penaeus vannamei* in response to white spot syndrome virus infection

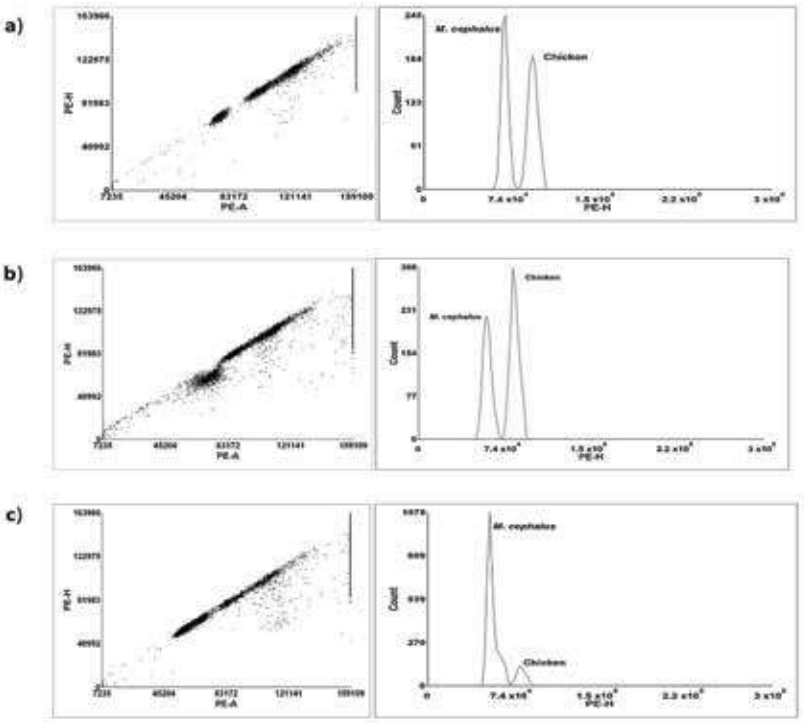
Apoptosis or programmed cell death occurs in an infected host cell as a defence mechanism to counter the viral propagation. In the present study, flow cytometry was used to analyse the apoptotic progression in the haemocytes of WSSV-infected shrimp, *P. vannamei*. Further, the expression of apoptosis-related genes was determined by qPCR to understand the relationship between the apoptosis and WSSV infection in shrimp. The percentage of early and late apoptotic cells in three groups of control shrimp and WSSV infected shrimp at different time points were analyzed. The challenged shrimp showed early apoptosis significant cell percentage difference as compared to control samples only at 18 hpi, whereas in the late apoptotic stage, significant differences were observed at all the three time-points post WSSV infection. The percentage of early apoptotic cells decreased with increase in time interval post WSSV infection and the percentage of late apoptotic cells was observed to increase by 64% at 56 hpi . The average percentage of early apoptotic cells in WSSV -infected shrimp were 25.2±1.35% at 1.5 hpi which significantly decreased to 19.3±0.64% at 18 hpi and further decreased to 6.0**±0.85**% at 56 hpi. Whereas, there was significant increase in the average percentage of late apoptotic cells at all time points 5.06% (1.5 hpi), 12.16% (18 hpi) and 69.63% (56 hpi). Quantitative real-time PCR (qPCR) was used for the expression analysis of four apoptosis-related genes such as Death-associated protein 1 (DAP-1), caspase-5, translationally controlled tumor protein (TCTP), and cathepsin D. Flow cytometric analysis of apoptotic cells in WSSV challenged *P. vannamei* shrimp is shown in figure.



Flow cytometry analysis of apoptotic haemocytes in *P. vannamei*
(a) control shrimp (b) WSSV infected shrimp at 1.5 hpi (c) WSSV infected shrimp at 18 hpi (d) WSSV infected shrimp at 56 hpi.

Genome Estimation of *Mugil cephalus*

The flow cytometry readings were acquired on BD Accuri™ C6 flowcytometer for control chicken erythrocytes and the samples. Gating of the density plots was carried out and histogram data was acquired for genome size estimation. Generation of density plot and histograms for genome size estimation of *Mugil cephalus* from gill tissue, muscle tissue and blood samples are shown in figure. The average genome size with respect to different tissues of *M. cephalus* was estimated to be 0.877 ± 0.013 pg.



Generation of density plot and histograms for genome size estimation of *Mugil cephalus* a) Gill tissue b) Muscle tissue c) Blood.

Iso-Seq based full-length transcriptome resource for *Penaeus indicus*

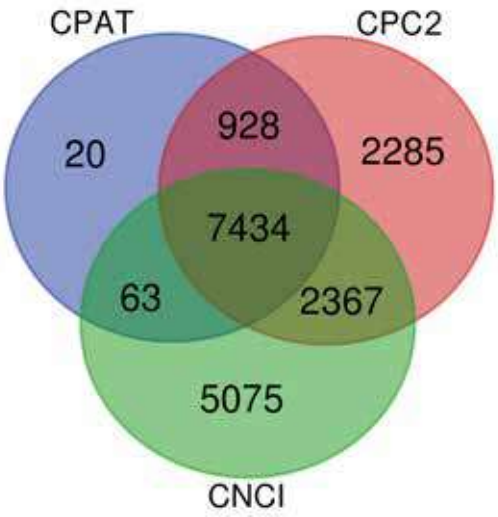
Presently, global shrimp production is dominated by *Penaeus vannamei* due to the availability of specific pathogen free (SPF) seed from genetically improved broodstock. As dependence on a single species is not an ideal scenario for sustainable shrimp production in India, the institute is promoting the development of *Penaeus indicus* as an alternative. The field-level farming demonstrations conducted by CIBA with NFDB support raised considerable interest among shrimp farmers and stakeholders. The need of the hour is exercising coordinated research efforts through functional studies and genetic improvement program to promote *P. indicus* as an additional and alternate species to farmers. In this context, access to full-length transcript sequences is a mandatory resource for researchers to derive valuable results from functional studies. Therefore, for the first time, we have generated a full-length transcriptome resource for *P. indicus* to support the efforts of developing another shrimp species for aquaculture diversification and associated genetic improvement programs.

To generate full-length transcripts, we have used the latest Pacific Biosciences (Pacbio) Isoform Sequencing (Iso-Seq) approach on Sequel II instrument using 8M single molecule real-time (SMRT) sequencing cell and circular consensus sequence (CCS) technology. This is the first report of a comprehensive transcriptome generated from different tissues and larval stage of *P. indicus* with 238.98 Gb of sequence data from gills, hepatopancreas, muscle, and pooled post larvae. In the absence of a genome for *P. indicus*, the full-length trasncriptome generated in this study would be a valuable resource for conducting functional studies involving desired economic traits and in annotation of *P. indicus* genome. The resource contains 30,479 transcripts of which 25,156 (83%) could be annotated and 9,610 (31.5%) could be mapped with enzyme codes. Of the enzyme code mapped transcripts, the hydrolases were predominant followed by transferases and oxidoreductases.

As tissue identity was also retained in the final set of transcripts, the assembled transcriptome resource would be highly valuable to study tissue-specific isoforms. For example, various isoforms of Sodium potassium ATPase subunit alpha gene in *P. indicus* contained an additional exon when compared to the corresponding gene from *P. vannamei* genome, thus indicating the isoform diversity between the two species.

Long non-coding RNA database for *Penaeus indicus*

Long non-coding RNAs (lncRNA) are transcribed from DNA but lack coding potential. Unlike the other non-coding RNAs, lncRNA are usually longer than 200 nucleotides. Recent evidence suggests involvement of lncRNA as regulators of transcription in the nucleus; and translation and post-translation modifications in cytoplasm, by influencing the gene expression. The Iso-Sequencing data generated principally to get full-length transcripts in *P. indicus*, was screened to assess the coding potential of the transcripts. Three different tools namely CPC2, CNCI and CPAT were used to screen the full-length transcripts made out of the Iso-Sequencing data. A transcript predicted to be having coding potential by any one of



The numbers of lncRNA transcripts identified by various bioinformatics tools for *P. indicus*.

the three tools is considered as a coding transcript and all others were classified as non-coding transcripts. Of the 99,458 high quality transcripts generated from Iso-Seq data, the three tools have identified 7,434 lncRNA sequences. These lncRNA sequences would be a valuable resource to understand gene expression regulation in the nucleus and the cytoplasm.

Contig-level genome assembly for *Mugil cephlus*

The *Mugil cephlus*, commonly known as flathead grey mullet is an important food fish species from brackishwater sector. The attempts made since 1970s to perfect the hatchery production technology of this species were unsuccessful and elusive. In the year 2019, the ICAR-CIBA has successfully closed the larval rearing cycle with the production of fry in captivity. As the institute is progressing towards unearthing the challenges posed by this species and moving towards commercial culture, it is imperative to simultaneously develop genomic resources in parallel. The genomic resources including the genome sequence, transcripts sequences *etc* would help the researchers to have better understanding on the number of genes and the genome features. Such information facilitates conduct of functional studies in this species leading to meaningful output aiming at improving the species. In that line, we have generated a contig-level assembly of the grey mullet genome using the long-read sequence data generated on Pacific Biosciences Sequel II platform. About 91 Gb of sequence data was used in WTDBG2.5 assembler to generate an assembly of 648 Mb. The assembly contains 1725 contigs with a contig N50 statistic of 10.05 Mb. The contig-level assembly would be polished and scaffolded in the coming year.

Contig-level assembly of *Mugil cephalus* genome.

Data used, Gb	91.62
Assembly length, Mb	648.02
Number of contigs	1725
N50, Mb	10.05
L50, number	18

Interspecific diversity study on *Etroplus* species

Etroplus is a small genus of cichlids native to Southern India and Srilanka which contains three species, namely *E. suratensis*, *E. maculatus* and *E. canarensis*. Few of the studies claim that *E. suratensis* and *E. canarensis* fall under genus *Etroplus* and *E. maculatus* belongs to *Pseudetroplus* genus. In this context, understanding their interspecific diversity considered to be important. The genetic divergence among them was estimated using a mitochondrial gene ATPase 6/8. 59 *E suratensis* (collected from Pulicat, Vembanad and Mangalore), 47 *E. maculatus* (Collected from Pulicat, Vembanad and Mangalore) and 31 *E. canarensis* (Mangalore) fish samples were utilised. ATPase 6/8 gene was PCR amplified from the collected fish samples and sequenced. 790 bp of similar region and similar length of ATPase 6/8 gene were subjected to diversity studies using Arleqeuin 35.2.2. The pair-wise F_{ST} indicated that the three species were completely divergent.

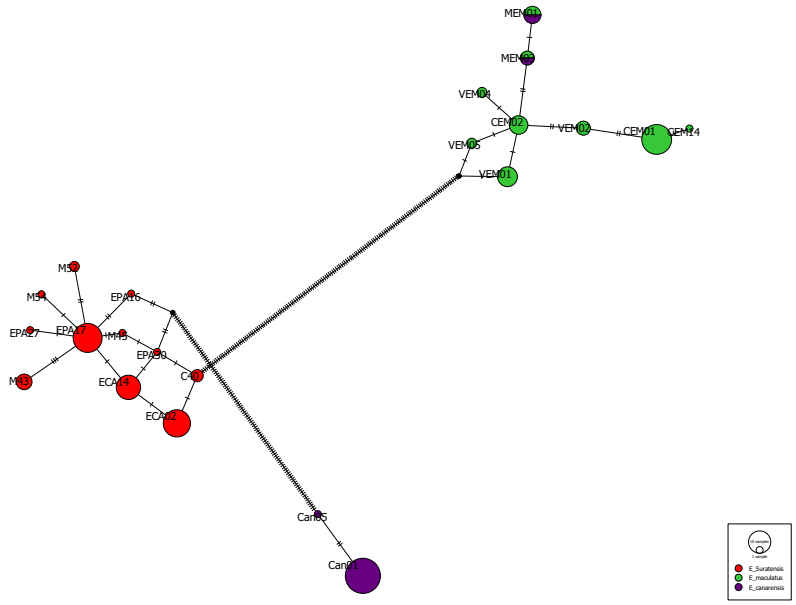
The median joining Haplotype network was generated between the three species. Each species formed a distinct clade. Each clade was distinctly separated by several mutational events. However, It was found that *E. maculatus* and *E. canarensis* populations shared few haplotypes. The network tree further explains that both *E. canarensis* and *E. maculatus* have *E. suratensis* as their common ancestor.

Karyotyping of *Monodactylus argenteus*

Silver moony, *Monodactylus argenteus* (Linnaeus, 1758), a

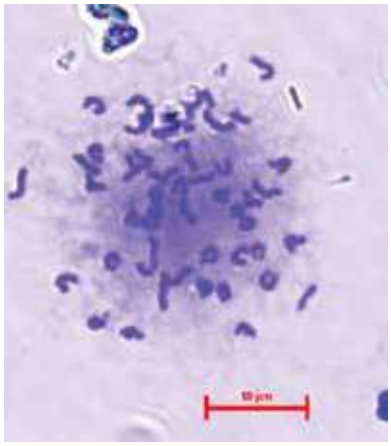
The pair-wise F_{ST} indicated that the three species of *Etroplus*

F_{ST}	*E. suratensis*	*E. maculatus*
E. maculatus	0.193	####
E.canarensis	0.348	0.355



Median joining network indicated three distinct clades for three species of Genus *Etroplus*.

brackishwater fish species has high demand in the ornamental fish industry. The genus *Monodactylus* includes four species of which *M. argenteus* is the most common species found in the brackish-waters of India. Karyotyping studies impart knowledge on the chromosome pattern of the species which helps to identify the gross abnormalities at chromosome level. In this study, the fish was injected with Colchicine to arrest the cells at metaphase stage and the gill tissues were collected. The cells were treated with hypotonic solution to swell the cells and were fixed with carnoy's fixative in the slides. The slide was stained with giemsa stain and viewed under microscope. The images were analysed using Ideokar1.2 software. Six chromosome spreads were identified and examined. The silver moony fish had 48 diploid chromosomes (2n=48) in their cells. Among the 24 pairs of chromosomes 21pairs were Metacentric with arm ratio ranging from 1.0 to 1.64 and the centromeric index varies from 38 to 49. Three pairs of chromosomes were Sub-Metacentric with the arm ratio of 1.85 to 2.33 and the centromeric index was ranged from 30 to 36.



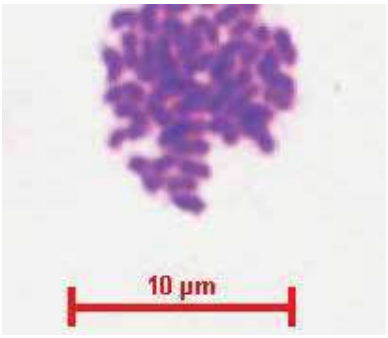
Chromosome spread of *Monodactylus argenteus* fish

Karyotyping of *Lates calcarifer*

Asian seabass (*Lates calcarifer*) is economically important brackish water aquaculture species. Understanding the chromosome pattern is useful to carry out molecular breeding, genetic selection and evolutionary studies. Further it provides information on chromosomal abnormalities, ploidy status and chromosome manipulation. The study followed standard karyotyping protocol; in brief, the 80g seabass fish was injected with colchicine, after 90 minutes, the gills tissues were collected and subjected to hypotonic treatment. The cells were then fixed using Carnoy's fixative and were observed under microscope with 100X magnification. Six metaphase

Chromosome pattern of *Monodactylus argenteus*

Number of Chromosome pairs	Arm ratio	Centromeric Index	Type
21	1 to 1.64	38 to 49	Metacentric (M)
3	1.85 to 2.33	30 to 36	Sub-Meta centric (SM)

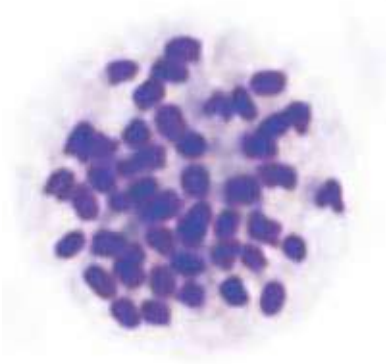


Mitotic metaphase spread of Asian seabass fish (2n=48)

chromosomal spreads were observed and concluded that the Asian seabass cells had 48 diploid chromosomes (2n=48) in their cells.

Karyotyping of *Scatophagus argus*

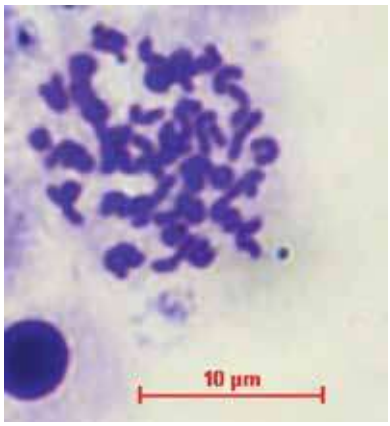
For chromosome analysis, spotted scat, *Scatophagus argus* of size 100-120g was injected with 0.5% colchicine to arrest the metaphase stage of cells. The metaphase spread of chromosome was prepared from gill tissues after treating with hypotonic solution followed by fixation in carnoy's fixative (methanol: acetic acid 3:1). The slides with chromosome spread was stained with 10% Giemsa stain and observed under a bright-field microscope at 100X magnification, and chromosome number was found to be 2n=48.



Metaphase spread of gills cells of *Scatophagus argus* stained with Giemsa stain

Karyotyping of *Lutjanus argentimaculatus*

Karyotype analysis in mangrove red snapper (*L. argentimaculatus*), a commercially important candidate brackishwater finfish species, was carried out by examining the chromosome complement at metaphase (chromosome number, size, type and morphological characteristics). For the analysis, red snappers (6-8g) were injected with 0.5% colchicine to arrest the cells at metaphase. The fish were killed one hour post-injection and different organs (gills, spleen and kidney) were dissected out for analysis. The macerated tissues were incubated in hypotonic solution (0.56% Potassium chloride solution) for an hour, fixed with Carnoy's solution and stained with Giemsa stain. The chromosome spread was observed at 100x magnification and chromosome numbers were determined. The chromosome number was found to be 48.



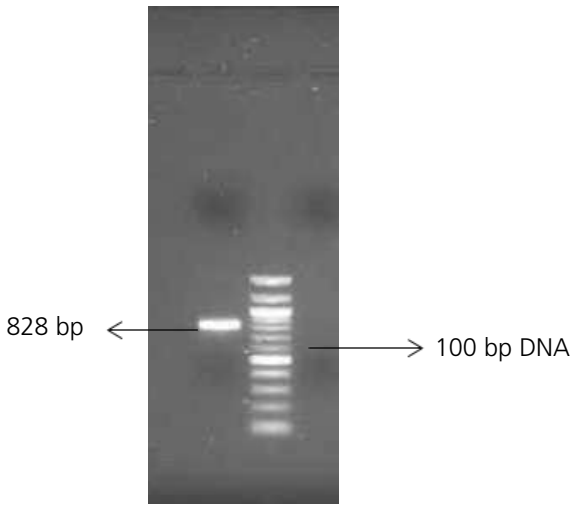
Metaphase spread of *L. argentimaculatus*

Molecular cloning of Immunoglobulin M gene of Asian seabass for immune response studies

Immunoglobulin M (IgM) is the first antibody produced in immune response and provides a crucial first line of defense for the immune system. Structurally, IgM makes up tetramers in teleost, in contrast to pentameric IgM in mammals and elasmobranch fishes. Being Asians seabass the primary aquaculture important fish species, identifying the immune responsive molecules and genes against various infectious diseases is important. Therefore, generating nucleotide information of the immune responsive molecules is considered to be essential prior to their localization and quantification studies. Protocol in brief; Asian seabass fish was challenged with VNN virus and the RNA was isolated 10 days post infection. The partial coding sequence was PCR amplified from the RNA. The PCR product was cloned using pGEMT-easy vector and sequenced. The obtained sequence was 828bp length which was blasted with NCBI database and found it had highest identity with *Siniperca chuatsi* (75.03%) and *Latris lineata* (73.46%) fishes. The obtained sequence was utilized to design the primers for qRT-PCR and In-Situ Hybridization studies.

Efficacy of probiotic species on *Vibrio harveyii* revealed by Genome scale metabolic modeling

Many strains of genus *Bacillus, Lactobacillus and, Lactococcus* are widely used as a probiotic with application in dairy, pharmaceutical industries and in clinical medicines. Constraint-based modelling is a



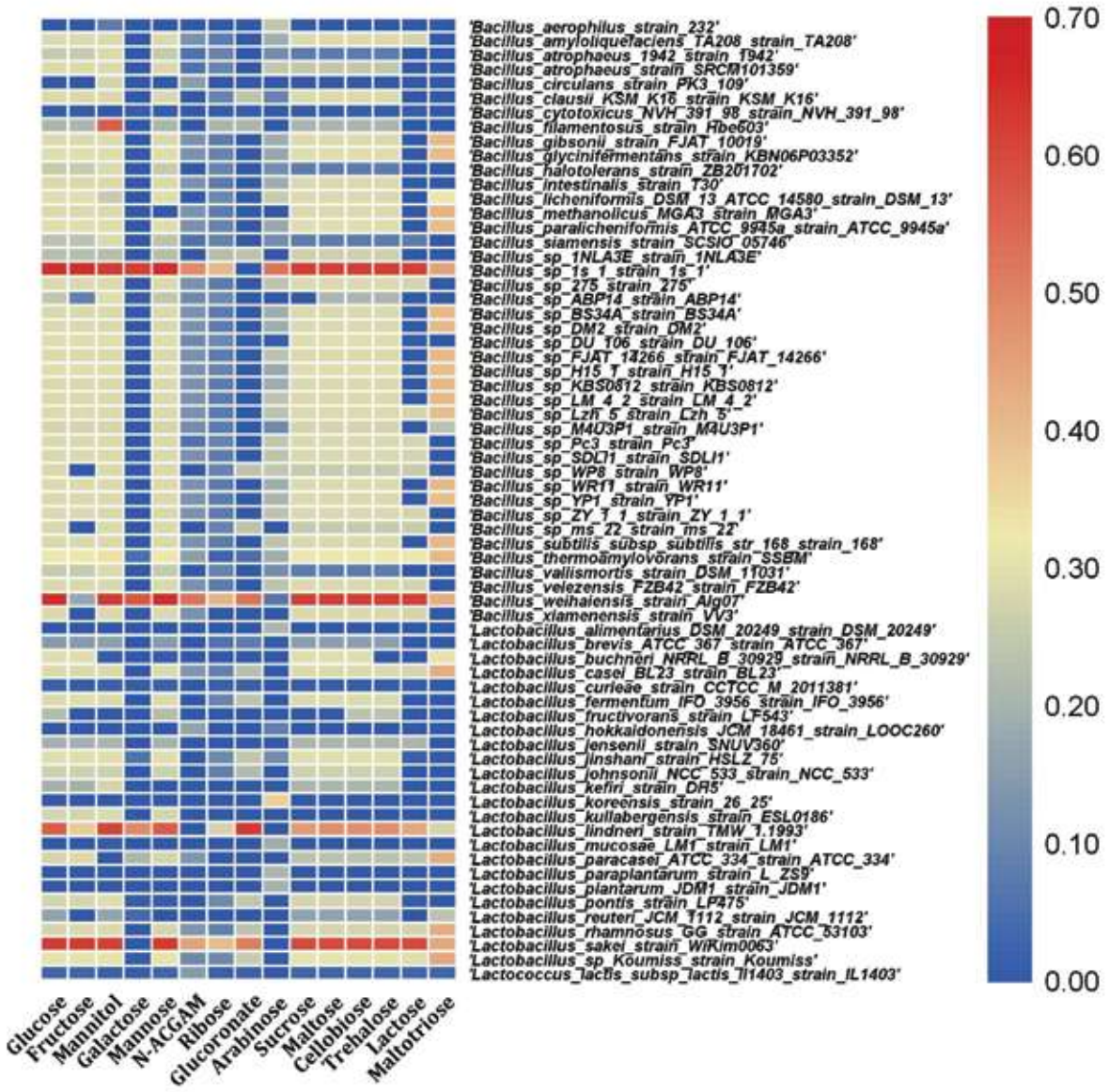
Agarose gel electrophoresis showing 828 bp PCR product of IgM

well-established approach that has been successfully used for *in silico* prediction of microbial interactions. This modeling approach was applied to predict the pairwise interactions of 193 strains from three genera namely *Lactobacilli, Bacilli and, Lactococci* with the pathogenic strain *Vibrio harveyi* QT520. All available complete genomes belonging to the selected genera were downloaded from Genbank along with the *Vibrio* strain. Draft genome-scale metabolic models were constructed using Python library CarveMe v1.2.2. CarveMe generates automated reconstruction of genome scale metabolic models using a top-down approach for single and community species. Each of the 194 protein sequences retrieved was given as an input in CarveMe to build a draft SBML model. Further, each of the 194 draft SBML models were subjected to gap filling and grown in a defined medium in anaerobic conditions with biomass components specified for gram-negative and gram-positive bacteria to render the draft model functional. Each of the gap filled genome scale metabolic models generated were merged with *V. harveyi* QT520 strain to generate 193 pairwise community models. These SBML models were imported into Matlab version R2018b. The simulations were performed with COBRA toolbox using glpk as linear programming solver. Each of the individual, paired and triplet models were subjected to FBA, a constraint-based approach to predict the flow of metabolites through a metabolic network reconstruction. Simulations were performed by maximizing the objective function i.e., the biomass reaction, while constraining the uptake rates of amino acids and essential nutrients/vitamin to -1 mmol/gDw/hr. The models were constrained with a substrate uptake of -10 mmol/gDw/hr for monosaccharides (Glucose, Fructose, Mannitol, Galactose, Mannose, N-ACGAM, Ribose, Glucoronate, Arabinose) and -5 mmol/gDw/hr for disaccharides (Sucrose, Maltose, Cellobiose, Trehalose, Lactose, Maltotriose). All the models were simulated in an anaerobic environment by setting the lower bounds of oxygen exchange to zero. An *in silico* growth rate of at least 0.01/hr was considered as organism's ability to take up the carbon source. SMETANA v1.2.0, a mixed-integer linear programming method was used to compute the metabolites exchanged between species in a pairwise community. SMETANA identifies the metabolites exchanged under a defined medium in communities.

Forty-eight out of 193 species exhibited growth benefit accompanied with decrease in growth of *V. harveyi* QT520 in at least one of the nutrient environments out of 15 nutrient environments. In other words, these species effectively suppressed pathogen growth in at least one of the nutrient environments, covering 30 species from Bacilli and 18 species from Lactobacilli. Analysis on the 48 species showcased a nutritional situation on 4 species namely, *Bacillus thermoamylovorans* SSBM, *Bacillus weihaiensis* Alg07, *Lactobacillus jinshani* HSLZ 75, and *Lactobacillus lindneri* TMW 1.1993. A nutritional situation is a condition that highlights the metabolic gains made by these four species in the presence of *V. harveyi* QT520, which cannot be achieved by these species alone. Among the four species, the highest metabolic gain is achieved by *Lactobacillus lindneri* TMW 1.1993.

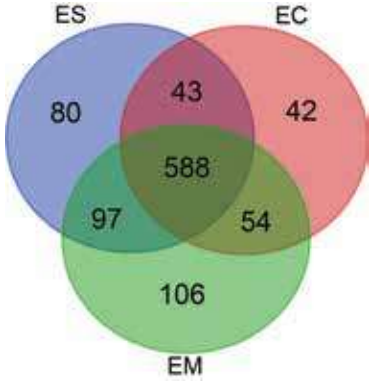
Comparative gut microbiome analysis of congeneric species belonging to genus *Etroplus*

Skin, gills, eggs, and intestinal tracts of fish harbor abundant populations of bacteria, which aids in the overall health and physiology of the host. Fish intestines in particular harbor large and diverse populations of

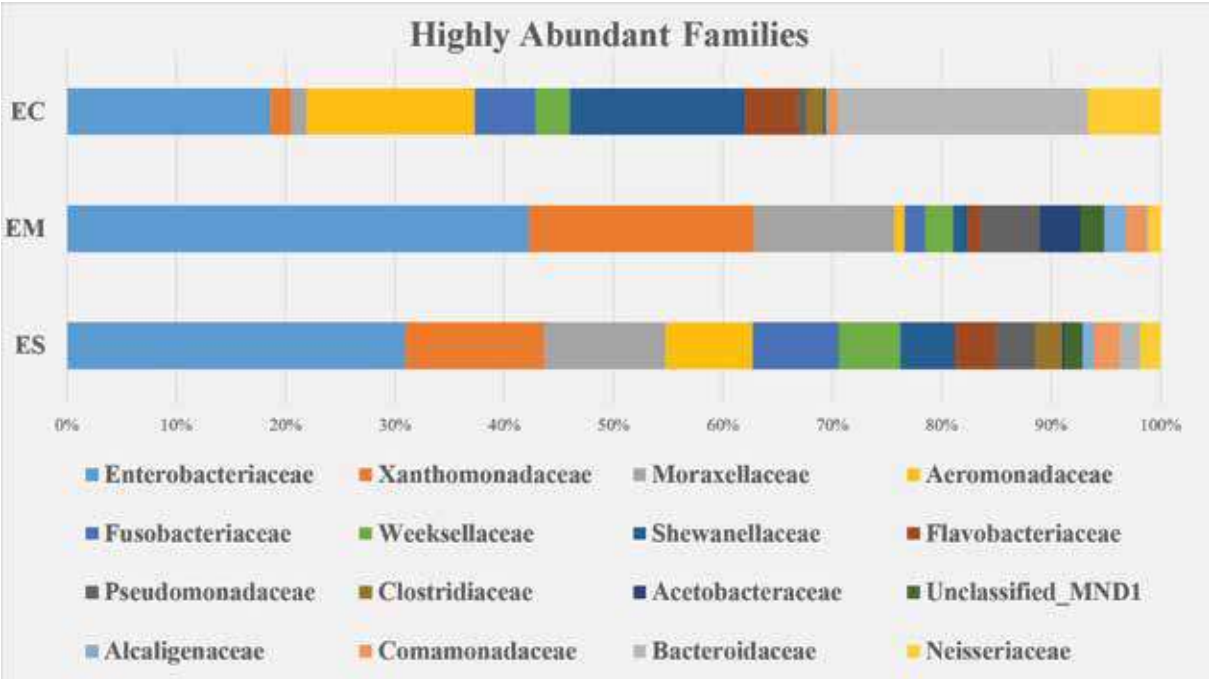


Heatmap representation of species pair with significant increase in growth compared to single species.

bacteria and this gut microflora varies among fish species, and that the dominant bacteria are typically either aerobes or facultative anaerobes. The gut microbiome of all the species belonging to genus *Etroplus* namely, *Etroplus suratensis* (ES), *Etroplus maculatus* (EM) and *Etroplus canarensis* (EC) were studied using 16S rRNA high-throughput sequencing. The fishes were collected from Bodanthila, near Netravathi River, Karnataka, the locality where all the three species coexists. To



Flower diagram of the unique and shared operational taxonomic units (OTUs) number shared in the gut of *E. suratensis* (ES), *E. maculatus* (EM) and *E. canarensis* (EC) individuals from the same locality



Abundant bacterial families found in the gut of *E. suratensis* (ES), *E. maculatus* (EM) and *E. canarensis* (EC) individuals from the same locality

profile bacterial communities, the V4 hyper-variable region (~250 base pairs) of bacterial 16S rRNA gene was amplified using the primer pair V4f and V4r attached with Illumina barcoded adapters and sample-specific indices. A total of 1010 OTUs were identified across the gut samples of the three congeneric fish species investigated. The gut of EM had the highest (106) and EC had the lowest (42) number of unique Operational Taxonomic Units (OTUs), whereas ES had 80 unique OTUs, *i.e.* not extant in any of the other two fish species. All fish species gut had 588 OTUs in common, which shows that the fish which experience similar environmental conditions and nutritionally similar diets would have more convergent gut microbiota. The graph showing abundance of 20 dominant bacterial families are given in figure. The guts of ES and EM were dominated by *Enterobacteriaceae* followed by *Xanthomonadaceae*, whereas that of EC was dominated by *Bacteriodaceae* followed by *Enterobacteriaceae*. The present study provides evidence that congeneric species occurring in same locality have a convergent gut microbiota profile, which is formed based on the similar environmental conditions under which they grow.

Social Science & Development

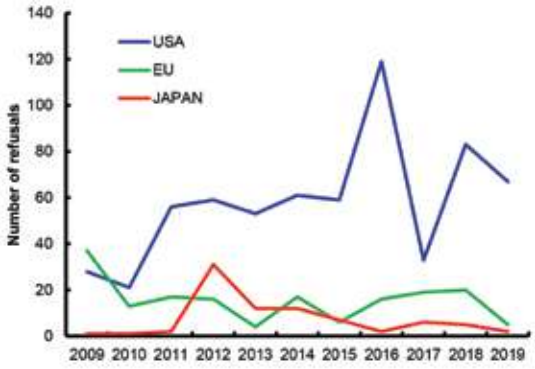
One of the major themes of research and development of CIBA is to assess the social and economic dimensions of the brackishwater aquaculture in the context of changing world. While shrimp farming remains as the major economic engine of Indian brackishwater aquaculture, farming of other brackishwater species has the potential to bring forward the marginalized coastal communites with limited livelihood options.

Economics, Trade, and Impact

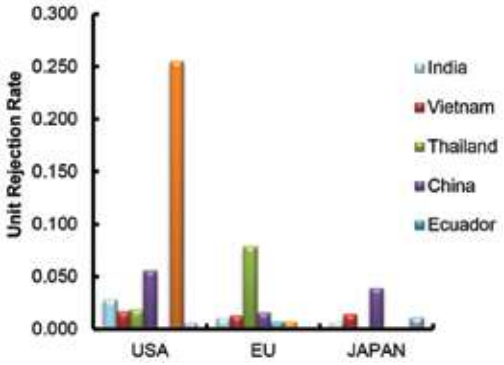
Export performance of Indian shrimp

India exported 0.65 million tonnes valued USD 4.89 billion, and the compound growth rate of Indian shrimp exports was 15.81% from 2010-11 to 2019-20. Revealed comparative advantage (RCA), and Revealed Symmetric Comparative Advantage (RSCA) estimated was 12.2 and 0.85 during 2019-20, which showed that comparative advantage of our exports to the world had increased over the years. The introduction of *P.vannamei* has boosted the Indian exports and brought a sea change in the Indian shrimp production and processing industry. The production of *vannamei* rose from 2009-10 to 2019-20 (711674 mt in 2019-20 compared to 1731 tonnes in 2009-2010) with high productivity of 7 mt/ha It was marked as one of the major reason for the performance of the Indian export industry.

Number of Indian shrimp export rejections



Unit Rejection Rate (URR) of shrimp imports

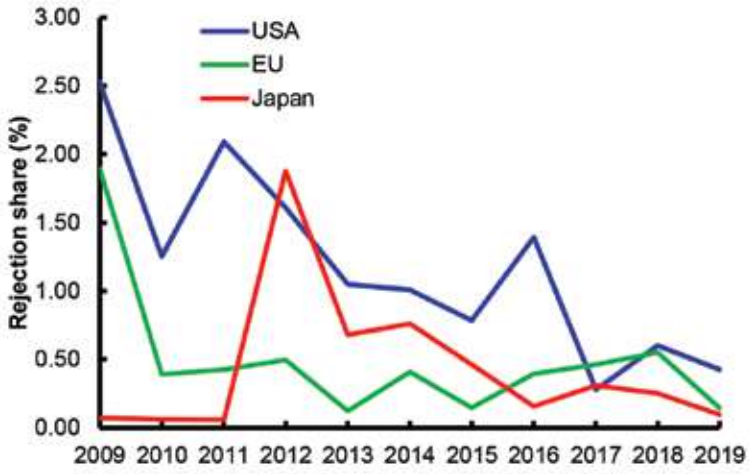


Export performance of Indian shrimp from 2010-11 to 2019-20

Quantity (Million tonnes)		Value (US $ billion)		Instability index (%) for values	Compound annual growth rate (%)	RCA		RGCA	
2010-11	2019-20	2010-11	2019-20	2010-11 to 2019-20	2010-11 to 2019-20	2010-11	2019-20	2010-11	2019-20
0.15 (1.22)	0.65 (3.35)	1.26 (10.37)	4.89 (21.44)	11.40	15.81	6.05	12.20	0.72	0.85

Values in parentheses indicate the percentage share of shrimp in agricultural exports
Data Source: www.mpeda.gov.in

Rejection of Indian shrimp exports



Unit Rejection Rate (URR) of shrimp export rejection by the US, EU, and Japan

Indian shrimp imports rejected by the USA recorded high variability with two peaks in 2004 and 2016, whereas the EU's rejections maintained at lower rates throughout the period (2012-17). Exports were highly compliant with Japanese trade regulations except for the period 2012 to 2013. However, the total number of rejections in the USA (67) was higher compared to the EU (5) and Japan (2) except during 2019.

The number of rejections per USD millions of exports (URR) over the period was calculated, and the overall reduction in URR was observed in the last decade among the major shrimp-importing countries except for Bangladesh. URR of Indian shrimp exports has also shown significant decline reaching 0.028 in 2019, indicating the improved acceptance of shrimp consignments at the USA. On the contrary, URR of Indian shrimp to the EU was variable between 0.01 and 0.04. Among the other exporting countries, URR of Thailand was comparatively higher during 2019. Interestingly, URR of Indian shrimp exports to Japan remained low between 0.01 in 2006 and 0.006 in 2019 except in 2012 (0.12). Historically, the Indian shrimp consignment rejections have been low in the EU, and Japan borders; however, a declining trend was observed for the USA over the years

Rejection share in shrimp exports: In the USA, the rejection share was 3.5 in 2007, and it is consistently reduced to 0.43 in 2019, which showed positive compliance of Indian shrimp exports. The share was very high during 2004 (6.1%). In the EU, the rejection share was almost 1% in 2007 and significantly reduced to 0.14 in 2019. In Japan, the share was very high in 2012 (2%), and afterwards, the share has been decreased. This improvement in the quality of farmed shrimp can be attributed to the concerted efforts taken by various governmental organisations, including MPEDA, EIC, ICAR, and other state departments.

Markov chain analysis of Indian shrimp export performance: Markov chain approach was used to get insight into structural change, and change in Indian shrimp exports. Transitional probability matrix values during 2014-19 indicated that the USA retained 57% of its share while losing 38% to China, and 4% to Japan; during the same period gained 59% of Vietnam, 52% of China, and 27% of EU share in the Indian shrimp market. The EU, China, Vietnam, and Japan retained their share of 56%, 37%, 37%, and 32%, respectively. China lost its share of 38% to the USA, and Vietnam lost 11% to China

Transition Probability Matrix Analysis revealed that the USA emerged as more stable importer of Indian shrimp products in 2014-19, reflected in higher retention probability. The study indicated that the EU and Japan lost their trade stability in importing shrimp products from India. China, emerging shrimp importer during the last couple of years from India would gain major share from other importing nations to meet the huge demand. In order to gain the trade, therefore, more importance has to be given on exporting a highly diversified product by increasing the quality, productivity, and efficiency of the production and export of high-quality shrimp products at a higher price.

Economic loss due to shrimp diseases in India by new PDO (Probability of Disease Occurrence) methodology

Economic loss due to *Enterocytozoon hepatopenaei* (EHP), White Spot Syndrome Virus (WSSV) infections, and other diseases occurring in *Penaeus vannamei* farming in India was estimated through a survey of shrimp farms in major shrimp farming states of India during 2018–2019**.** During April 2018 to Feb 2019, a total of 909 shrimp farmers from three states in the

east coast (Tamil Nadu, Andhra Pradesh, West Bengal) and two on the west coast (Maharashatra and Gujarat) were interviewed. Using a multistage stratified random sampling at the district level with simple random sampling without replacement at the village level, the sample for the study comprised area of 7,259 hectares with 3,841 ponds located in 23 districts. The probability of disease occurrence (PDO) index was computed using the proportion of disease occurrence at the farm, state, and national levels.

Loss of production (mt/ha/crop) was highest due to WSSV (2.58 ± 0.32), followed by EHP (1.80 ± 0.24), mixed infections of EHP, and WSSV (1.89 ± 0.53), vibriosis (0.97 ± 0.42), running mortality syndrome (1.1 ± 0.39), and other diseases (1.72 ± 0.36). However, such infections in major producing states like, Andhra Pradesh only could affect the production significantly.

EHP was highest in Andhra Pradesh (4.69±0.22) followed by Tamil Nadu (2.70±0.21), and Gujarat (1.65±0.29), the three major shrimp producing regions of the country with an average of 1.80±0.24 mt/ha/crop. Similarly, loss of productivity (mt/ha/crop) due to WSSV was highest in the farms of Andhra Pradesh (4.50±0.21) followed by Gujarat (2.80±0.40), and Tamil Nadu (2.76±0.32) with an average of 2.58±0.32 mt/ha/crop. Further, productivity loss (mt/ha/crop) due to combined infections due to EHP, and WSSV was highest for Andhra Pradesh (4.00±0.38) followed by Tamil Nadu (3.43±0.46), and Gujarat (2.00±0.76) with an average of 1.89±0.53 in the surveyed farms. Although WSSV caused the highest loss of production (mt/ha/crop), EHP with a 17% probability of occurrence, accounted for a production loss of 0.77 M tons, with a corresponding revenue loss of ₹ 3977 crores (US$ 567.62 M).

Although the probability of occurrence of WSSV was estimated (25%) to be higher than that of EHP, the estimated production loss due to WSSV was lower (0.33 million mt), with a corresponding revenue loss of ₹ 1670 crores (US$ 238.33 million).

National loss of revenue due to EHP was higher primarily because, in Andhra Pradesh, primary shrimp farming state had the PDO of 22% for EHP against 8% for WSSV. The total employment loss due to diseases was estimated to be 1.65 M worker-days' worth Rs.49.5 crores. The study revealed that the country's overall probability of infectious disease occurrence was at 49%, leading to an annual loss of 0.21million metric ton shrimp worth Rs.7161 crores.

Economic loss to shrimp farmers due to production risks

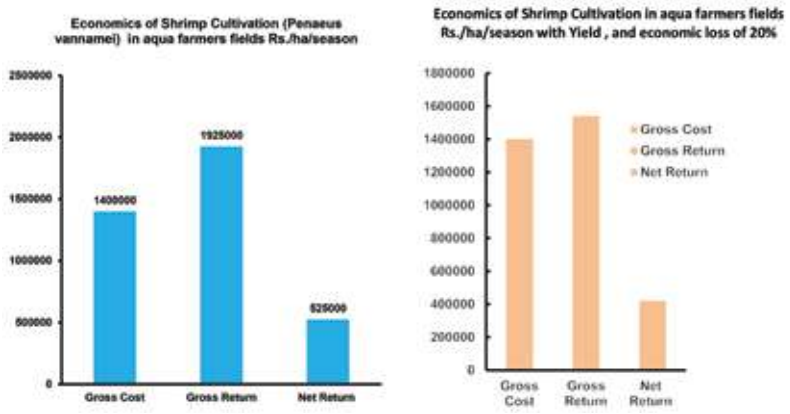
Estimating economic loss in shrimp farming was done based on field survey during 2020, based on purposive sampling technique using pre-tested interview schedule in Tiruvallur district of Tamil Nadu. The sample size was 12, and these aqua farmers were primarily undertaking *Penaeus vannamei* farming in leased ponds. These farmers have not undertaken any shrimp farming during 2020 due to COVID-19 Pandemic. Hence the study was conducted based on three years input-output data and the average market price of 2017-18 to 2019-20. The recall bias was minimised with appropriate survey management tools and cross-verification based on group discussion techniques. In those farms, which were not having any significant production, and economic loss, the realised Gross Cost was Rs.14 lakhs/ha, and the Gross Return was Rs.19.25 lakhs/ha, and the consequent Net Return was Rs.5.25 lakh/ha /season, and the same was Rs.10.50 lakh/ha for two seasons. The average yield was 7000 kg/ha, and the average market price of shrimp was Rs 275 per kg. The Benefit-Cost Ratio was 1.38.

In 2018, in 25 per cent of the sample farms, yield, and economic loss was to the extent of 20 per cent due to *Enterocytozoon*

Estimates on annual total economic losses due to shrimp diseases in India during 2018-19

Disease	Production loss (tonnes)	Income loss Rs Crores	Employment loss Worker days	Total Economic loss Rs Crores
EHP	77369.96	3977	23.89	4000.89
WSSV	32536.71	1670	16.41	1686.41
RMS	5815.11	317	1.77	318.77
Vibriosis	5227.94	279	2.15	281.15
WSSV+EHP	8322.41	406	1.98	407.98
Others*	10441.11	506	3.35	509.35
Total	139713.22	7112	49.55	7161.55

Economics of shrimp production

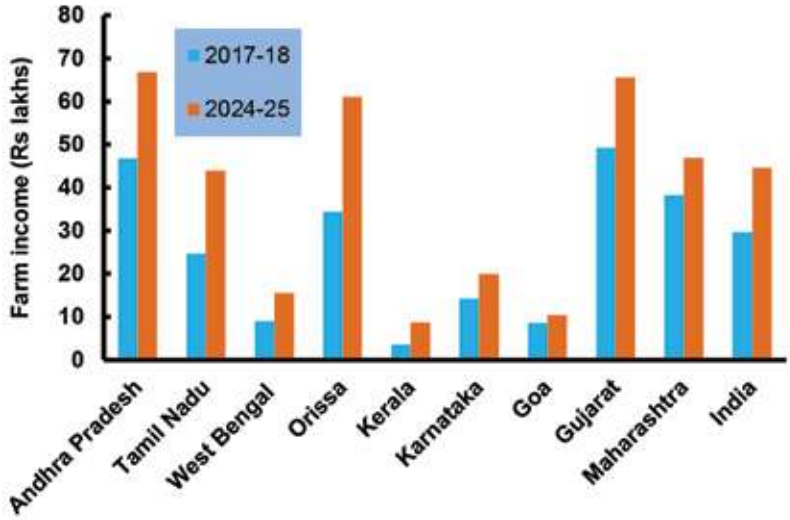


hepatopenaei (EHP). The realised economic loss was to the tune of 3.85 lakh /ha/season. However, these aqua farmers have diversified their farming with field crops, and animal husbandry, and could reduce economic loss by 22 per cent. The study is being continued. The realised Benefit-Cost Ratio was 1.10. The risk management techniques adopted by these aqua farmers include ensuring the quality, and safety of shrimp feeds, an early harvest of unaffected shrimps, sanitary measures of their shrimp farms, and creating alertness, and awareness to neighbouring shrimp farmers.

ARIMA (Auto-Regressive Integrated Moving Average) methodology to estimate the Doubling of farmer's income in brackishwater aquaculture

Shrimp area, production, and productivity data from 2001-02 to 2017-18 were used to quantify farmers' income and projected till 2024-25 using Auto-Regressive Integrated Moving Average (ARIMA) Model. Stationarity is a necessary condition in building an ARIMA model that is useful for forecasting. Several diagnostic statistics viz, Akaike Information Criterion(AIC), Schwartz's Bayesian Criterion (SBC), Normalised BIC, Mean Absolute Percentage Error (MAPE), and plots of residuals can be used to examine the goodness of fit of tentative models. The models with minimum AIC, BIC value, were selected as a best-fit model for forecasting the area's future values and production of shrimp. The country-level estimates based on ARIMA model (0,1,0) at constant prices revealed that farmer's income in real terms was Rs.29.61 lakh per farm in 2017-18, increasing to Rs.44.64 lakh per farm in India during 2024-25. In other words, the shrimp farm income grew at the compounded Rate of 5.53 per cent per annum and would increase by 1.51 times during 2017-18 to 2024-25.

Projected shrimp farm income in India



Double log regression method to estimate determining variables of disease loss

Double log regression was employed to examine the relationship between economic loss with production, stocking density, culture period, average body weight, survival, FCR, and disease incidence. The results showed that the coefficient of multiple determinations (R2) is 0.63, which indicates that 63% of the total variations in an economic loss of shrimp production are explained by the variables included in the model. The statistically significant relationship between the dependent and independent variable was indicated by p-value (<0.05). The variable production loss has a positive impact on shrimp production's economic loss in all the states. Based on the regression analysis, increased economic loss of 2.57, and 2.27% was observed with a one per cent increase in production in Andhra Pradesh, and Tamil Nadu, respectively. The estimated coefficients of stocking density

for the West Coast states, Maharashtra, and Gujarat, suggest one per cent increase in stocking density would decrease economic loss by 16%, and 11.5%, respectively.

The regression coefficient for the culture period suggests a 1% increase would reduce the economic loss by 23% in Gujarat. The regression coefficient of average body weight in Maharashtra's state was calculated at -23 ($p<0.1$). The coefficient of survival rate was very high for Maharashtra farms, suggesting one per cent increase would translate into a 52% decrease in economic loss. FCR has significant negative relationship on economic loss in the state of Gujarat. Regression coefficient analysis for diseases showed that 1% loss due to EHP and WSSV could lead to a 121% increase in economic loss in, Andhra Pradesh and 1% loss due to WSSV led to 117% economic loss in West Bengal.

The economic impact assessment of diseases in shrimp farming is vital for appropriate investment in disease control programs. Among the infectious diseases, EHP, and WSSV were the major diseases in Indian shrimp farming, causing substantial economic losses, and the consequent loss of employment. Revenue loss by EHP alone was more than two times that of WSSV contributing more than half of the national economic loss due to diseases. While disease surveillance should be a continuous program, better management practices would help reduce the loss of production and minimise economic losses. Reduction in economic loss could be achieved through a region-specific increase in stocking density, and culture period, and targeting for higher average body weight at harvest.

Association of farm variables on economic loss as estimates of coefficients in a double log regression model

Explanatory variables	Tamil Nadu	Andhra Pradesh	West Bengal	Maharashtra	Gujarat
Intercept	32.099*** (23.082)	130.06*** (21.393)	130.06	130.06	130.06
Production loss (t ha^{-1})	2.274*** (0.598)	2.574*** (0.502)	1*** (0.294)	1 (4.209)	-0.944 (0.577)
Stocking den sity (no. m^{-2})	-2.884* (1.696)	0.515 (0.523)	0 (1.184)	-16.431** (5.550)	-11.495*** (1.869)
Culture period (days)	1.992 (1.517)	0.115 (0.844)	0 (8.159)	-20.784*** (5.203)	0.907 (3.589)
Average body weight (g)	-4.159 (1.136)	-0.23 (0.677)	0 (9.491)	0	-23.233*** (2.386)
Survival rate (%)	-8.738*** (2.683)	0.516 (0.799)	0 (12.270)	-52.333*** (15.166)	13.095 (9.046)
FCR	-3.093 (1.311)	0.187 (0.319)	0 (4.484)	0	-1.108** (0.500)
EHP, WFS #	3.181*** (2.698)	121.684*** (21.880)			0.445*** (2.152)
WSSV#	1.15 (2.725)	121.835*** (21.871)	117.266** (47.108)		1.464 (2.110)
WSSV+EHP#	2.727 (2.802)	121.247*** (21.905)			2.693 (2.354)
RMS#	0	121.834*** (21.918)			
Vibriosis#		122.001*** (21.882)	117.266** (48.069)		2.684 (3.302)
Other diseases#		121.53*** (21.891)			0
Summary statistics	Number of observations = 423; F(44, 378) = 14.57; Prob > F = 0.0000; R-squared = 0.6291; Adj R-squared = 0.5860; Root MSE = 2.5427				

* is a level error significance of 10%, ** is a level error significance of 5% *** is a level error significance of 1%, Values within parentheses indicate standard error.

Prioritising the research, especially the application of artificial intelligence in disease forecasting, and implementation of required policy interventions are warranted for the sector's economic viability.

Studies on the impact of COVID-19 Pandemic in the Indian shrimp sector

Impact of Covid-19 in shrimp exports: Strengthening its position as a leading supplier of quality frozen shrimp, and frozen fish in international markets, India exported 12, 89,651 tonnes of seafood valued at Rs 45,663 crore during 2019-20. But the shrimp industry was severely affected by the recent novel coronavirus outbreak. It started at Wuhan town of China and affected 81.9 million people over 178 countries, and more than 1.79 million people have been reported dead as on 30th December 2020. The

interplay of falling demand-supply decides the eventual prices, which stayed volatile in 2020.

The losses incurred by the shrimp industry could be much higher than originally estimated. Price elasticity of demand was used for shrimp in different scenarios to project the change in quantity.

It is estimated that the coronavirus outbreak reduces the shrimp trade by 10-15%. In addition to local production of 1 million ton, China imported 0.65 million tons of seafood in 2019 to meet its domestic consumption. Major countries exporting shrimp to China in 2019 were Ecuador (322,636 tons, 55%), and India (159,785 tons, 22%). The second scenario assumes 30% drops in price, the shrimp industry of India, and Ecuador could suffer losses of up to the US $242 million, and the US $ 526 million in 2020 alone. Major challenges to the shrimp producing countries, including India in the next six months, would be finding alternate markets, targeting the harvest size, timing of stocking, and harvesting and improving domestic consumption.

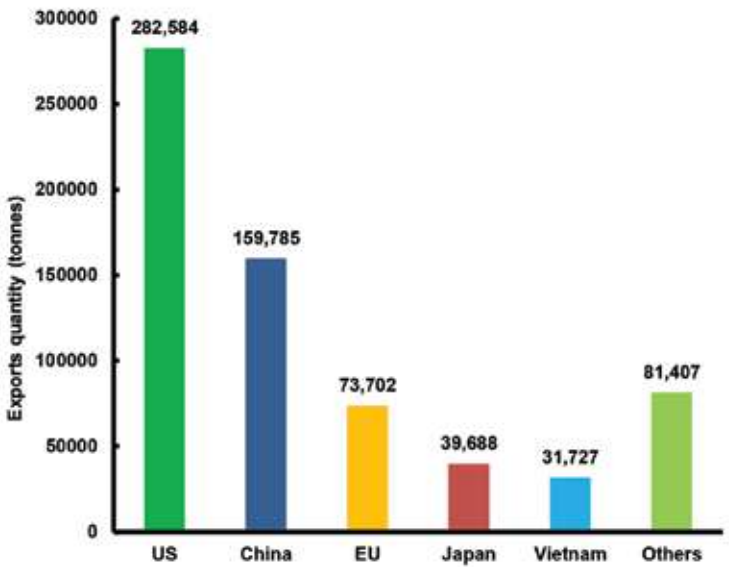
Demand projection with different scenarios

Reduction in price (%)	Change in quantity, and value exported to China			
	India		Ecuador	
	Quantity (tons)	Value (US $ Million)	Quantity (tons)	Value (US $ Million)
10	-5752	-81	-12529	-175
30	-17256	-242	-37589	- 526
50	-28761	-403	-62648	-877

Socio-economic aspects of COVID-19 impact on aquaculture; A digital questionnaire was prepared in the English language, having both objective, and open-ended type question; the questionnaire comprised two parts. Part-1 had questions on contact details of respondents and their stakeholder type. Part-II had three different sets of questions respectively related to (i) farmers, and extension personnel (input dealers, technicians, and consultants); (ii) seed, and feed producers; (iii) shrimp processors, and exporters. The questionnaire was posted across the digital platforms (CIBA Shrimpapp, ICAR-CIBA website, Facebook, WhatsApp groups, and LinkedIn networks in shrimp aquaculture in India) on 12th April 2020. In a fortnight, 504 stakeholders representing farmers (46.08%), input dealers, technicians, and consultants (40.38%), seed, and feed producers (9.48%), and processors (4.06%) across the country responded to the survey and recorded their opinion. The data collected were analysed with descriptive statistics, Garrett ranking, and Rank Based Quotient to present the results scientifically.

The overall impact and economic loss due to COVID 19 pandemic to the Indian shrimp sector were estimated based on all the stakeholders' responses in the survey conducted through CIBA shrimp app. The survey results indicated that COVID-19 related disruptions adversely affected the shrimp aquaculture sector to the tune of 30-40% in economic terms as given in figure. Most of the respondents (85%) expressed that an expected decline in shrimp export performance to the major importing nations whose economies were also severely affected by COVID-19 was the major impact. This effect had a trickling down effect in reducing farming area, and production as expressed by 81% of respondents. Three-fourths of the respondents predicted that the market price for

Indian shrimp exports in 2019



Covid 19 lockdown: Approximate estimate of economic loss to the sector

Components/ subsector	Annual capacity AC.	Assumed 60% of (AC) is used	Unit cost	@ 40% loss	
				Approximate loss in units	Approximate loss (Rs Crores)
Seed production (billion seeds)	70	42	Rs.0.40 /PL	16.8	672
Feed (million tonnes)	1.3	0.78	Rs 80/ Kg	0.312	249.75
Farming & Production (million tonne	0.8	0.48	Rs 350/ Kg	0.192	6720
Market & Export (million tonnes)	0.62	0.372	Rs 500/ kg	0.148	744
Employment (million No, people)	1.2	0.48	Rs 500/ day	57.6	2880
Total (in Rs Crores)					11265

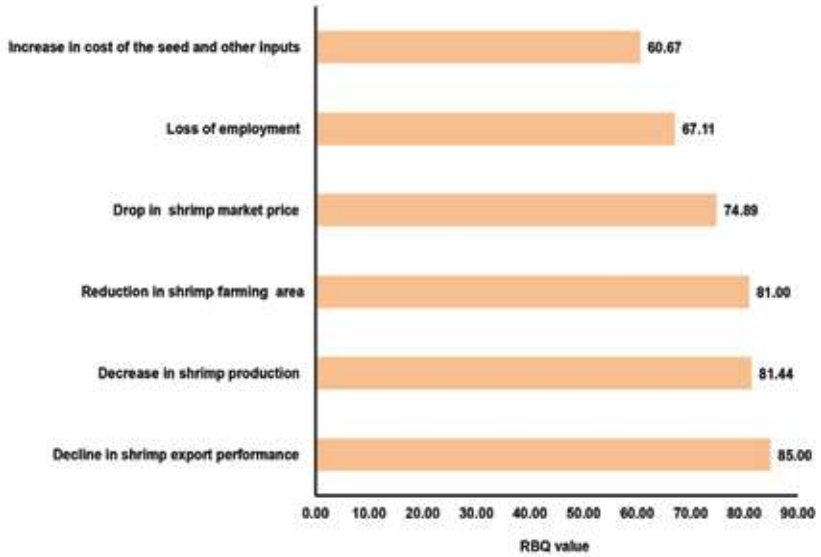
Sectoral assessment of Perceptions of Prospective impact of COVID-19, and lockdown on shrimp aquaculture sector in India

the produced shrimp in the current season was reduced by more than 35%.

The workers' loss of employment has gone up to 30-40% during the season reported by 67%. During the current lockdown period, labour from the local villages could not attend to the work due to movement restrictions, and in-house migrant workers left to their native places due to fear of infection, and lack of salary assurance from the employers. The scenario, which assumes 40% loss, India's shrimp industry could incur losses of Rs. 11265 crores.

The lockdown on account of the Coronavirus disease 2019 (COVID-19) adversely impacted the food production sector, including aquaculture, globally. Unfortunately, it was coincided with India's major shrimp farming season, which contributes 60% of the national annual shrimp production; hence, the impact was substantial. An online survey was carried out among the shrimp farming sector stakeholders to evaluate the prospective impact of COVID-19 related lockdown across the shrimp supply chain. Therefore, it is expected that farmed shrimp production and export could decline by 40% compared to the previous year. About 75% of the respondents predicted that the current season's shrimp market price would be reduced by more than 35%. The loss of employment for the workers during the season was 30-40%, as reported by 67% of the respondents. The shrimp supply chain is heavily dependent on diversely skilled labour. It offers a wide range of jobs opportunities, such as farm management,

The perceived overall impact of COVID-19 Lock Down (>30%) (N=504)



technical help at hatcheries, farms, and processing units, personnel for manufacturing, and marketing of inputs, wholesale, and retail businesses, workers to operate farm machinery, vehicles, civil works, plumbing, mechanical, and electrical equipment.

Techno-economic assessment of aquaculture technologies

Perceived efficiency of Risk Prevention, and Management Practices in Pacific White Shrimp (*Penaeus vannamei*) farming: A survey was conducted among 120 randomly chosen shrimp farmers who consulted the CIBA Shrimpapp regularly in two coastal states (Andhra Pradesh, and Tamil Nadu) to assess the farmer perceived efficiency of the proposed risk management measures in tackling the risk factors on a dichotomous scale: moderately efficient (prevent/ manage the risk factor at 50% level) or highly efficient (prevent/ manage the risk factor at 80% level), the economics of their adoption, and evaluate the mobile app module for its innovation attributes on a three-point scale viz., agree, undecided, and disagree. The data were subjected to spreadsheet-based frequency, percentage, and mean analyses to consolidate the same for effective presentation. The extent of prevention and management of the RpRm Practices was studied based on the farmers' opinion based on their adoption experiences. More than three-fourths of the respondents (76%) opined that the risk prevention and management practices proposed were highly efficient in preventing and managing the risk factors. Apart from the one-time capital expenditure on establishing permanent measures like construction of the reservoir, central drainage system, purchase of aerators, and operational expenditure of Rs 2.13 Lakhs per ha was reportedly incurred adoption of the recommended risk management practices. With the mean national productivity of 6 t / ha, the expenditure works out to be Rs 36 per kg of shrimp produced.

Techno-economic Appraisal of Asian Seabass (*Lates calcarifer*) nursery rearing in net cages: Sibling cannibalism is considered a major problem in Asian Seabass fish rearing as fry, and fingerling sizes differ greatly, and due to that its survival was relatively low. Therefore, to increase the survival, seabass should be reared in two phases, i.e. the nursery phase, and the grow-out phase. Further, juveniles from nurseries perform better in terms of growth, and survival than those stocked directly into the grow-out ponds. Nursery rearing itself is an exclusive farming activity for small-scale, and backyard farm nursery operators. An investigation was done on the techno-economic evaluation of seabass nursery systems in low saline, and brackishwater in terms of its technical efficiency, and economic viability.

The technical performance of nursery rearing in brackish and low saline waters is presented in the table. The mean survival rates realised in brackish, and low saline waters were 42.50% and 63.50%. The mean DWGs recorded were 0.08 g, and 0.15g respectively in brackish, and low saline waters. The survival was relatively high in low saline waters, vis-à-vis brackishwater systems. Environmental and associated hydrodynamic parameters might have a say in this phenomenon. Rearing of fry and fingerlings close to physiological salinity would improve performance compared to those reared at higher salinity, subject to higher energetic cost via osmotic load. Average PWG and SGR were 3667%, 5900%, 6.34%, and 10.75% respectively in brackish and low saline systems. The mean duration of the nursery was 57 days in both the systems. The mean FCR realised were 1.8, and 2.7 respectively in brackish, and low saline waters. The average production achieved per crop in brackishwater was around 4300 fingerlings (average 5 g) whereas in low saline waters, an average production of 6300 fingerlings at an (average 9 g) was realised. The technical efficiency analysis was estimated using the Cobb–Douglas functional revealed that the mean technical efficiency of the seabass nursery rearing systems were 92.45%, and 99.83% respectively for brackish water, and low saline water systems.

The production cost per fingerling was Rs 16 and Rs 13 respectively at the brackish, and low saline nursery systems. The net income realised was Rs 61,400, and Rs 1, 40,500 respectively in the brackish, and low saline nursery systems. A mean monthly income per person spending 2 hours per day was worked out as Rs 10, 233, and Rs 23,333 respectively in brackish, and low saline systems. The BCR was worked out to be 1.9, and 2.76 respectively, and the IRR was worked out to be 130%, and 300% respectively. Higher net present value (NPV), Internal Rate of Return (IRR), and a lower payback period were better indicators of the systems' economic viability. The technical and economic indicators have

shown that seabass's nursery rearing was technically efficient and economically viable. Further, it was observed that nursery rearing in low saline waters was more efficient and remunerative. It was observed that efficient feeding regimes and other environmental parameters could have enhanced survival and growth. Because of the better growth, the low saline systems' fingerlings fetched better price and economically beneficial.

Development, and validation of Smart Aquaculture Model (SAM)-Application of ICT, and data analytics for sustainable shrimp aquaculture:

An Android-based Mobile Application in the English language has been developed to record and analyse real-time data at shrimp farms. To start with the user has to login to the application. After that, he/she has to give farmer specific, farm-specific information in the application and process this information; the application would give a specification for stocking density to be adopted. Subsequently, the user has to record pond specific data on water quality, feeding, and health parameters on day to day basis, and get a specific recommendation in the app itself. Meanwhile, the user's data can be accessed through the CIBA server to monitor the farm by the subject matter team. Based on data analytics, the farmer would get a detailed *technical advisory through the app or e-mail.* Andhra Pradesh (Bapatla Mandal, Guntur district) for its adoptability, content, reliability, and other attributes. Shrimp farmers in the **i**dentified farming clusters were trained on the mobile application and its features for implementing mobile app-based farm management. A Chatbot (chatbox) application using an open-source python library RASA has been developed on Frequently Asked Questions in shrimp farming. It takes the conversion in text format and builds a model using machine learning (AI) models. So far conversions on farm-specific information, Pond preparation has been trained in RASA model, and it works 75% accuracy. Work is in progress to enhance the accuracy, and integrate the model into the mobile application.

Techno-economic viability of Seabass Nursery rearing

Sl. No	Technical indicators	BW. Nursery (M±SD.)	Low saline Nursery (M±SD.)
1.	Initial Stocking size (g)	0.15 ± 0.01	0.15 ± 0.03
2.	Stocking density (No/m^3)	500 ± 250	500 ± 250
3.	Survival (%)	42.5 ± 12.9	63.5 ± 18.5
4.	FCR (ratio)	1.8 ± 0.05	2.7 ± 0.2
5.	Daily weight gain (DWG) in g	0.08	0.15
6.	Potential weight gain (PWG) in%	3667	5900
7.	Specific growth rate (SGR)%	6.34± 0.35	10.75±0.44
8.	Coefficient of variation (CV)	0.07	0.08
9.	Duration (days)	57 ± 10.0	50 ± 10
10.	Production in nos & average wt	3930 ± 360 (4.9-6.4g)	6300 ± 180 (8-10g)
11.	Benefit Cost Ratio : Present value(PV) of benefits/PV of costs	1.90	2.76
12.	Pay Back Period in Months	3.05	3.0
13.	IRR in%	130	300
14.	Monthly income for the group is Rs. (N – 2)	30700	70000
15.	Monthly income per person (2 hrs/day- Persons engaged N- 3)	10233	23333
16.	Mean Technical Efficiency in%	0.9245(92.45%)	0.9983(99.83%)

Aquastat online version:

Aquastat India, published by ICAR-CIBA, was updated with the world aquaculture production, and trade for 2018. India shrimp production, exports, and trade data were compiled, analysed, and updated for 2019-20. This database has been updated with information about the various technical aspects of the brackishwater aquaculture sector.

Doubling farmers' income, Economic impact of various technologies, and economic loss due to diseases, and other major output of ICAR-CIBA were included in aquastat. CIBA success stories and technology timeline was also updated for the year 2019-20. State wise details on aquaculture production and exports were included for, Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Maharashtra, Odisha, Pondicherry, Tamil Nadu, and West Bengal. "Aquastat" database is uploaded and can be accessed at www.ciba.res.in/aquastat link in which aquastat data for world, India, and states are included with the suitable search options. MYSQL, and PHP scripting language

Nursery rearing in open brackishwaters

Nursery rearing low saline waters

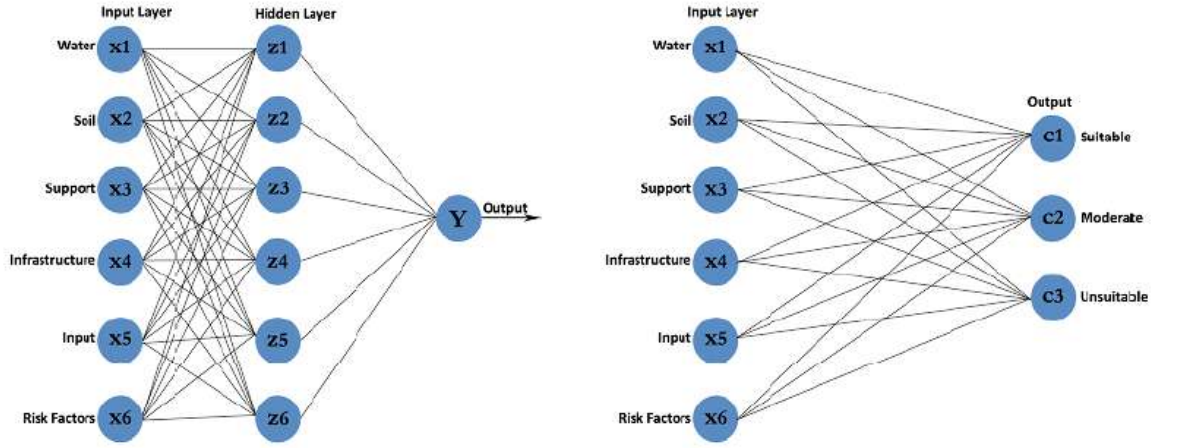
(General-purpose scripting language especially suited to web development) were used to add the database. Structured Query Language is a database reporting tool to query, and manage data in relational database management systems. Online Aquastat is updated with recent data on aquaculture production, and trade for 2019-20 and updated every year. Information based on the user's keywords in the form of country-wise, state-wise, and species wise and its combination can also be acquired. Information can be displayed on a screen in the table, and graphical format. The result can be exported to MS Word and MS Excel.

Phone in-Programme (PiP) – a bridge between Technical Know-How & Do-How

Giving support to farmers during COPVID-19 Pandemic, CIBA responded to fish farmers' needs by using the digital advisory application for providing information to fish farmers. At CIBA Headquarters in Chennai, 11 "Phone-in-Programmes (PiP)" a novel connectivity platform through mobile phones was organised. A total of 921 fish farmers/fisherfolk/technicians brackishwater aquaculture farmers interacted with subject matter specialists online. Various subject areas of "Sea bass, milkfish, Pearl spot Culture, and its Farm Management Practices", shrimp culture, crab fattening, feeds and feed management, soil and water management were covered. Disease aspects with special reference to preventing White faeces disease, seaweed in fish culture, training, subsidy, and marketing aspects were discussed. About 818 queries were answered in their vernacular language. Reaching out to farmers is important during this pandemic period. The ICT aided tools like PiP facilitated the bi-directional communication of technical information to the farmers and field issues to the scientists.

Artificial Neural network-based learning model for aquaculture development

Neural Network algorithms have been applied to optimise the aquaculture sites based on 24 input variables comprising water, soil, support, infrastructure, input, and risk factors. An Artificial Neural network can classify, predict, and pattern recognition through a learning process. The models were constructed using two supervised, and one unsupervised Neural Network algorithms viz., Back Propagation Network, and Radial Basis Function; and Linear Vector Quantization respectively. The models classify each aquaculture site into 3 classes viz., suitable, moderate, and unsuitable. From the results of the three models, it has been found that Radial Basis Function model not only gives accurate results (86%), but also the time that is taken (0.02sec) for training the dataset is less when compared with the other two models.



Structure of supervised, and one unsupervised Neural Network algorithms

Algorithm	Accuracy (%)	Time (sec)
Back Propagation Network	80	5.3
Radial Basis Function	86	0.02
Linear Vector Quantization	73	0.05

Livelihood support models

To enhance farmers income, ICAR –CIBA introduced a group based technological interventions in Keelarkollai village of Chengalpattu district of Tamil Nadu in a sustainable way. A key component of this is introducing livelihood models of consumable fishes Asian Seabass, Monos, Pearl spot, Milkfish, ornamental fish, and crab culture. Fishes and crabs were cultured in a 120 m^2, pen system in the open brackish water. Juvenile mud crab around (100-150g) 230 nos were stocked and feeding was carried out by trash fish at the rate of 10% body weight for 90-128 days to promote both fish's culture crab through diversification. A total of 108 numbers (500-700g) of mud crab, 28 kg of pearl spot, 29 kg milkfish, 78 monos, and 22 kg sea bass were harvested. Crabs with an average weight of 800g were collected from the open waters, sold live to the exporters, and the domestic market gave Rs 62000 from crabs and Rs 26,090 in fish. This enterprise's profit helped them repay the loan, and the balance amount was shared among them. The time spent by the group was one hour in the morning, and one hour in the evening so that they spent nearly one week for the entire culture period. This model was found to be replicable, and appropriate for the coastal fishers as the species was harvested from April to December all through the year to meet their livelihood, and it bears a positive relationship with beneficiaries

Ornamental fish culture, a boon for Irula Tribal women.

The ICAR-CIBA aimed to uplift the Irula tribal women's standard of living by extending, technical support in Pearl spot larval rearing technology to around 22 women in Karathittu village of Chengalpattu district, Tamil Nadu. This initiative was part of CIBA's TSP project and provided skill development by equipping them to set up a Pearl spot nursery rearing unit in their backyard. The training included guidance on site selection, suitable fish species identification, feeds, feed management, sampling, farming procedures, harvesting, fish trade, budgeting, and hands-on training. The tribal women involved in Pearl spot rearing were casual labourers in daily wages engaged in diversified works. This programme was to up-scale the rural tribal women's practical knowledge, skill, and attitude to improve their lives without distressing their daily works. Simultaneously, the time spent by them for Pearl spot culture was meagre, and the work spot was nearer to their residence. Apart from their daily wage, they earned Rs 1500-1750/month/person for about six months. in the pandemic period.

Mobile advisory in fisheries in COVID-19 Pandemic

The broad project objective is to empower fish farmers by providing the right information at the right time through a mobile-based agro-

advisory system. COVID-19 related lockdown has posed a challenge on fish farmers due to uncertainty over their job prospects. The mobile advisory was extended to empower fish farmers of coastal districts by providing the right information at the right time through a mobile-based agro-advisory system. It helped the fish farmers in accessing necessary farm information to mitigate the crisis. Moreover, farm advisories in text messages created awareness about preventive measures, health, hygiene, the importance of social distancing, symptoms & treatment facilities for COVID-19. These programmes had approximately benefitted 518 ST/SC populations in the coastal villages of Tamil Nadu.

Sustainable livelihood models for income generation - Fish cum Quail: Seabass fishes and vegetable gardening and quail farming as an allied activity have paved the way for farmers for alternate livelihood models in the Nagapattinam district. Following the partial harvest of the previous year, the estimated production of 150 kg of Seabass (Rs 75000), and 300 Kg of Tilapia (Rs.30000) is expected in grow-out pond condition. Quail farming is less laborious, playing an important role in the study area as a great employment source and earning some extra income and their current jobs as agricultural/ aquacultural farm labourers. Once in 35-40 days, eight women members in the group earn ₹12000.

Knowledge, and Economic Empowerment of women, tribal, and their families in coastal villages of Tamil Nadu through the adoption of brackishwater aquaculture, and allied technologies integrated with societal development programmes

Approximately 50 to 75 coastal women, tribal, and their families, and youth beneficiaries were selected from coastal tribal villages of Kannavanthurai, and Senjiamman tribal village of Tirupalaivanam, Tiruvallur district, and Kunnakadu, Kovalam in Chengalpattu district, Tamil Nadu. The project beneficiaries were having a low standard of living. They had no permanent livelihood employment. Few were windows; having knowledge, and experience in fish farming, showing interest in taking up these opportunities; having leadership qualities, and confidence was selected. Brackishwater aquaculture technologies like milkfish farming, seabass nursery rearing (in hapas) in open waters, and pond, seabass farming (in FRP cages) in open waters, and pond, crab farming (in the pond), *Penaeus indicus* farming (in the pond), *Etroplus suratensis* (Pearlspot) farming were selected for popularisation. This fish technology intervention was integrated with other interventions like poultry, mushroom farming, kitchen gardening, and community / societal development like distribution of diesel engine, solar lights, and farm implements to the beneficiaries to create sustainable livelihoods opportunities even during the lean fishing season. Bank accounts were opened in the Indian Bank, Kovalam, Chengalpattu district, and at Bank of India, Ponneri, Tiruvallur district in Tamil Nadu. The profit earned from the sales of fish, crab, poultry, and eggs; were deposited in their bank accounts. This bank savings facilitate them to avail bank loans for their interventions at the end of the project. Thus, Sustainable Development has been created through financial linkages.

Assessment, and transfer of brackishwater aquaculture technologies among tribal population of Tamil Nadu (under CIBA-TSP)

Under the CIBA- TSP project 10 coastal tribal families were adopted at Kulathamedu ST village, Ponneri Taluk, Tiruvallur district. Awareness on precautions to be taken during COVID 19 crises, distribution of sanitation items, and provisions for the tribal beneficiaries, pond renovation, and repair work, distribution of milkfish seeds, and 2 tailoring machines, a meeting was conducted to discuss on installing terrace garden for the tribal beneficiaries households was done.

Success story of recycling fish waste to value-added products for livelihood support and doubling farmer's income

Under Scheduled Caste Sub Plan, and Swachh Bharat Mission programmes, CIBA has established the 'Fish waste Processing unit' to recycle fish waste to high value-added products in the Nambikkai Nagar, Pattinapakkam, Chennai, Tamil Nadu. Subsequently, CIBA has signed MoU to transfer PlanktonPlus and Horti^{Plus} Production Technology to Nambikkai Fish Farmers Group. From then on, their lives changed forever. They bring 200 to 300 Kg of fish waste from nearby markets daily, process it afresh, convert it into Plankton^{Plus}, and Horti^{Plus} products and supplied to shrimp/ fish farmers Kerala, Tamil Nadu, Andhra Pradesh, Gujarat, and West Bengal. CIBA helped them on production, and marketing of Plankton^{Plus}, and Horti^{Plus}. The

group has produced 16.345 tonnes of Plankton^{Plus}, and 0.82 tonnes Horti^{Plus}, and received Rs. 13.07 lakhs. Even during the COVID 19 pandemic situation, the group continued the operation and earned around Rs.2 lakhs. The group is processing the fish waste without any hindrance, and value-added products are produced and sold as an alternative livelihoods activity.

Shri.T. Kennit Raj, a representative of Nambikkai Fish Farmers Group, has expressed their happiness about the upliftment of their socio-economic status, and doubling of their incomes through this technology. They appreciated the team CIBA's genuine efforts for promoting "waste to wealth" concept as an alternative livelihood activity for the fishers in their village. After adopting the Plankton ^{Plus} technology, Ms K.Velankanni, one of the group members from Nambikkai Nagar in Pattinapakkam, decided to become an entrepreneur. Ms Velankanni started her company, "VS Fish waste Hydrolysate", on 2nd December 2019. It is an MSME enterprise with a GST number. Nambikkai Fish Farmers Group bagged this year's National Award, "Best Fisheries Self Help Group 2020" from National Fisheries Development Board (NFDB), Ministry of Fisheries, Animal Husbandry, and Dairying, Government of India.

Demonstration of mud crab culture in pen at Adyar Creek water bodies

A series of experimental trials were conducted at Adyar creek water bodies during 2018-20 for identifying the suitable brackishwater species for culture practices. This year, 33 kg crabs ranged from 110 – 270g was

Seabass sampling at Senjiamman village, Tiruvallur district, Tamil Nadu

Milkfish harvest by Irular tribal beneficiaries at Kannavanthurai village, Pulicat, Thiruvallur

Distribution of fish seeds to Irular beneficiaries during Covid 19 crisis

Awareness created on Covid 19 crisis and distribution of provisions & sanitary items to tribal beneficiaries

stocked in 100 m^2 pen structure to demonstrate mud crab culture. Crabs were fed with live fish feed @ 10% body weight daily in two times. After stocking crab, water quality parameters like pH, salinity, and mineral contents were monitored once in 15 days. pH varied from 7.35 to 8.68 and maintained the optimum level throughout the culture. Salinity, and total hardness varied from 6-29 ppt, and 886-6879 ppm as $CaCO_3$ respectively according to sea water's salinity. After 54 days, 9.6 kg of crabs (size:168-537 g) were collected as partial harvest and Rs. 6240/- were realised as profit. Seven scheduled caste farmers from Srinivasapuram, Pattainpakkam, Tamil Nadu was trained with cage, pen installation, maintenance, feeding to animals, handling crabs, and sampling.

Polyculture of Milkfish, and mud crab farming at Sadraskuppam backwater, Kancheepuram district, Tamil Nadu

Polyculture of Milkfish and mud crab farming were conducted in the open water system pen structure (size of 150 sq.m) among 5 tribal families (10 nos.) of Sadraskuppam, Kancheepuram district, Tamil Nadu. A total of 300 nos. of Milkfish (avg. wt – 12.87 g; avg total length 11.35 cm), and 300 nos. of mud crab (45 kg) range from (75 to 230 g) size was stocked in pen. Crabs were fed with live fish feed @ 10% body weight daily in two times. Fish were allowed to feed naturally available feed. After 84 DOC, due to Nivar cyclone, crabs (64 kg) were harvested with 56% survival range from (196 to 800 g) size and Rs. 41600/-, and milkfish culture is in process.

Training programme on quail farming, poultry farming, and goat rearing as a livelihood support activity for fish farmers in Nagapattinam district

ICAR-CIBA in collaboration with Krishi Vigyan Kendra, Sikkal, Nagapattinam, organised a training programme on Quail farming, Poultry farming on 7th February 2020 for fish farmers of Singanoadi village, and goat rearing on 8th February 2020 for Dhargas village

Demonstration of fish waste to value added products to fisherwomen

fish farmers of Nagapattinam district under Chennai Petroleum Corporation Limited, CSR funding. At the outset, Dr Gopala Kannan, Programme Coordinator, KVK, Sikkal addressed the participants and appreciated the effort made by ICAR-CIBA to organise the programme and fish farmers for participating in the programme. The training was beneficial as livelihood support enabled the participants to cope with the recovery shocks and stresses during natural disorders, social, and economic upheavals. Dr MuthuKumar delivered lectures on the quail farming its various breeds, housing, feed, disease management, marketing, and licensing requirements. On country chicken farming, the training module was designed so that the participants were exposed to different aspects of poultry production. Its management like hatchery management, brooding, nutrition/feed management, vaccination schedule poultry diseases, prevention, rural poultry production, and chicken meat processing. The module included

Preparation of plankton plus and horti plus from fish waste

classroom learning through lectures, group discussion, and field visit to KVK demonstration farms at Naluvethapathy village, Nagapattinam district. On 8th February 2020, the farmers were trained on Goat farming's different aspects like housing, feeding, breeding management, deworming, disease control, marketing, and economics. The importance of Azolla cultivation for livestock and poultry farmers was also explained to the farmers. All the participants actively interacted and shared their practical experiences. A total of 31 fish farmers and two research scholars actively participated and benefitted by this programme. Dr Deboral Vimala, PS&PI of the project team, coordinated the training programme.

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

TRAINING PROGRAMS ATTENDED

SCIENTIFIC STAFF

NATIONAL

S.No	Name and designation of the Person	Programme Name	Venue	Duration	Organized by
1	Dr. R. Geetha, Scientist	Training Program on Animal Disease Economics	Izatnagar	8-10th January 2020	IVRI, Izatnagar
2	Mr. T. Sathish Kumar Scientist	Training Program on "Design Thinking in Research Project Formulation and Implementation"	Online	25th -29 August 2020	ICAR – NAARM, Hyderabad
3	Dr. Raymond Jani Angel, Scientist	Training Program on "Design Thinking in Research Project Formulation and Implementation"	Online	25th -29 August 2020	ICAR – NAARM
4	Shri. Ashok Kumar Jangam, Scientist (SS)	Training Program on "Leveraging big data and analytics"	Online	28th -30th September, 2020	ASCI, Hyderabad
5	Dr. T. Senthil Murugan, Scientist	Training Program on "Science Administration and Research Management"	Online	28th September – 9th October 2020	ASCI, Hyderabad
6	Dr. Suvana Sukumaran, Scientist	Training Program on "Climate Change: Challenges and Response"	Online	5-9th October 2020	DST
7	Dr. B. Sivamani, Senior Scientist	Training Program on "Effective Health Management for Enhancing Work Efficiency of ICAR Employee"	Online	22nd October 2020	ICAR-IIHR, Bengaluru
8	Dr. Sanjoy Das, Senior Scientist	Training Program on "Market Research and Value Chain Management of Agricultural Commodities"	Online	17 - 21st November 2020	ICAR–NAARM, Hyderabad
9	Shri. Jose Antony, Scientist	Training Program on "Market Research and Value Chain Management of Agricultural Commodities"	Online	17 - 21st November 2020	ICAR–NAARM, Hyderabad

S.No	Name and designation of the Person	Programme Name	Venue	Duration	Organized by
10	Shri. K.P. Sandeep, Scientist	Training Program on "Market Research and Value Chain Management of Agricultural Commodities"	Online	17 - 21st November 2020	ICAR–NAARM, Hyderabad
11	Shri. T. Sivaramakrishnan, Scientist	Training Program on "Market Research and Value Chain Management of Agricultural Commodities"	Online	17 - 21st November 2020	ICAR–NAARM, Hyderabad

TECHNICAL STAFF

S.No	Name and designation of the Person	Programme Name	Venue	Duration	Organized by
1	Shri. S. Nagarajan- Asst. Chief Technical Officer	3 Days webinar on Cloud computing essentials skill as digital transformation	Online	30th July to 1st August 2020	Turnip Innovations, Mumbai

ADMINISTRATIVE STAFF

S.No	Name and designation of the Person	Programme Name	Venue	Duration	Organized by
1	Ms. K. Hemalatha, Stenographer	Training Program on "Effective Health Management for Enhancing Work Efficiency of ICAR Employee"	Online	22nd October 2020	ICAR-IIHR, Bengaluru
2	Mr. Paul Peter, LDC	Training Program on "Effective Health Management for Enhancing Work Efficiency of ICAR Employee"	Online	22nd October 2020	ICAR-IIHR, Bengaluru
3	Ms. Mary Desouza, Assistant	Training Program on "Effective Health Management for Enhancing Work Efficiency of ICAR Employee"	Online	22nd October 2020	ICAR-IIHR, Bengaluru
4	Mrs. V. Usha Rani Administrative Officer	Online Training program on Administrative Finance Management	Online	23-27th November 2020	ICAR – NAARM, Hyderabad

Ph.D.'s AWARDED

	Name of the Student	Thesis Title	Date
	Mr. R. Subburaj	Studies on Captive Breeding and Quality assessment of Eggs in Asian seabass *Lates calcarifer* (Bloch, 1790) through Blastomere morphology, Morphometric, Biochemical Parameters and Immune Gene Expression. **Supervisor:** Dr. A.R. Thirunavukkarasu, Principal Scientist & Head, Fish Culture Division (Retd.)	April 2, 2019
	C. Saravanakumar	Enrichment, Isolation and Characterization of Sulfur Oxidizing Bacteria with special reference to Beggiatoa species from Brackish water Ecosystems **Supervisor:** Dr. S.V. Alavandi, Principal Scientist ICAR- CIBA Chennai	July 07, 2020

Workshops, Seminars and Meetings

Shri. Radha Mohan Singh, Honourable Former Union Minister of Agriculture & Farmers Welfare and the Member of Parliament and Chairperson, Parliamentary Standing Committee on Railways visited ICAR-CIBA on 6th January 2020

Shri.Radha Mohan Singh, former Union Minister of Agriculture & Farmers Welfare and Member of Parliament and Chairperson, Parliamentary Standing Committee on Railways visited ICAR-CIBA on 6th January 2020 and interacted with the scientists. He appreciated the efforts of CIBA in providing technology support to the brackishwater aquaculture sector and working with farmers on partnership mode. Dr.K.K.Vijayan, Director, CIBA received the honourable guest and explained him the current research programmes of the institute and conveyed his gratefulness to him for visiting the institute despite his other pre-occupations.

Republic Day celebrations at ICAR-CIBA, 26th January 2020

Republic Day was celebrated at ICAR-CIBA with scientists & staff along with family members. Dr S.V. Alavandi, HoD, AAHED and Director (i/c) hoisted the flag and greeted all the scientists and staff, and urged all to strive to excel in their respective areas of work individually and collectively to take the Institute to higher levels. The Republic Day was also celebrated at our regional centres Kakdwip Research Centre of CIBA, Kakdwip, West Bengal, Navsari Gujarat Research Centre of CIBA (NGRC), Navsari, Gujarat and Muttkadu Experimental Station (MES), Muttukadu, Tamil Nadu.

ICAR-CIBA Conducted 'National Brackishwater Aquaculture Farmers Conclave (BAFAC) -2020' at Surat, Gujarat during 19-20 February, 2020

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA), in collaboration with Society of Coastal Aquaculture and Fisheries (SCAFi) and Navsari Agricultural University (NAU), Gujarat successfully conducted the Brackishwater Aquaculture Farmers Conclave -2020 (BAFAC-2020) the first of its kind in the west coast during February 19-20 2020 at Surat, Gujarat. About 900 brackishwater farmers representing all the coastal states covering both east and west coasts of India, from West Bengal to Gujarat and inland states like Haryana Punjab and Rajasthan attended the programme, where farmers from Maharashtra and Gujarat showed up in large numbers. On the opening day, farmers from outside Gujarat visited the shrimp farms, nurseries and processing plants in Surat to get a firsthand experience. Technical sessions with scientists and farmer presentations and experience sharing in national language were held on the second day, at the International Convention Centre, Surat. Shri. Anup Kumar, IAS, Secretary, Fisheries, Animal Husbandry and Agricultural Marketing, Govt. of Maharashtra inaugurated farmers conclave, and in his inaugural address he lauded the efforts of CIBA in organising the farmer's conclave in the west coast, one of the firsts with farmer-to-farmer and farmer to scientists interactions, on pan India level. Dr.Joykrushna Jena, Deputy Director General (Fisheries), ICAR, New Delhi presided over the inaugural session of the conclave, highlighted the potential of brackishwater aquaculture in the country and benefits farmers can reap in on a sustainable mode. Dr.K.K.Vijayan, Director, ICAR-CIBA and President, SCAFi & Convener, BAFAC-2020 in his welcome address expressed the significance of BAFAC-2020, its purpose and presented an overview on the development of brackishwater aquaculture sector with special reference to the shrimp farming and the way forward its sustainability.

CIBA – Annual Day cum Family Get-together on 29th February 2020

ICAR-CIBA celebrated Annual day 2020 and family get-together on February 29, 2020 at headquarters Chennai, Ms. Leena Nair, IAS, Administrative member Tamil Nadu Real Estate Appellate Tribunal and Former Chair Person, Marine Products Export Development Authority, Kochi graced the occasion as the Chief Guest. Mr. Peer Bhasha, Inspector of Police Pattinapakkam, also joined the event. About 400 CIBA-family members, including retired alumni joined the event. Ms. Nair addressed the gathering and interacted with employees of CIBA and appreciated of the efforts and achievement of CIBA. In her address, she highlighted the role of CIBA in the progress of Indian aquaculture

ICAR-CIBA Celebrated World Women's Day-2020 with Fisher Women at Kovalam village, Chennai

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) celebrated World Women's Day on 8th March 2020 at Kovalam Village in Chengalpattu district of Tamil Nadu. The theme of World Women's Day-2020 was ushering in a "Gender Equal World". About 150 women interested in aquaculture activities from nearby villages participated in the event. The fisher women were sensitized about the opportunities available in brackishwater aquaculture like ornamental fish rearing and finfish larval

rearing that women could take up either as part-time or full-time activity that would help them to earn an additional income and employment. Success stories of the above were presented to them respectively by Dr Krishna Sukumaran, Senior Scientist, CIBA, Shri. Kennit Raj, a fisherfolk of Pattinapakkam and Smt. Chitra, Irula Tribal from Karathittu village. Shri.S.Janakiraman, Trustee of Shri Venkatraman Memorial Trust, Kovalam was the chief guest and he underlined the development activities of fisherwomen in his village and requested CIBA to take up aquaculture related activities for improving the livelihood status fisher families. Dr. D. Deboral Vimala, Principal Scientist, CIBA and coordinator of the event explained about the ICAR's flagship programmes,

National training program on 'Aquaculture Nutrition and Feed Bio-Technology' organized by CIBA, Chennai, during 27th February to 7th March 2020

A ten-day, national hands-on training program on "Aquaculture Nutrition and Feed Technology" was conducted by ICAR – CIBA, during 27th February to 7th March 2020. The specialized program offered skill development in indigenous aquafeed processing, feed bio-technology and feed management for sustainable brackishwater aquaculture to 20 participants from Punjab, Haryana, Rajasthan, U.P, Gujarat, West Bengal, Odisha, Kerala and Tamil Nadu. Dr K. K. Vijayan, Director, ICAR-CIBA interacted with the trainees during the training program and stressed the need for Public Private Partnership (PPP) involving the private players and institutions such as CIBA in scaling up of the desi technologies, for sustainable development of the sector, and also to increase the profitability of farmers.

ICAR-CIBA extends support to fish farmers by producing and supplying Seebassplus feed during COVID-19 lockdown

Brackishwater aquaculture sector was badly affected by the COVID-19 lockdown disrupting the supply of seed, feed and other farm inputs to the farmers. Feed being a critical input, non-availability of feed, which needs to be sourced from feed mills located far away places from the farm site, put the fish farmers on a challenging situation. Realizing this unforeseen situation, CIBA reached out to the farmers and initiated in-house production of seabass feed during the lockdown at the pilot scale feed mill at Muttukkadu experimental station, and supplied it to small and medium farmers on actual cost basis.

ICAR-CIBA and Society for Coastal Aquaculture and Fisheries conducted Digital Conference on "Brackishwater Aquaculture Scenario in India with a focus on shrimp farming during COVID-19: Challenges and Way Forward" on 3rd June, 2020

ICAR-CIBA conducted the first digital conference on 'Brackishwater Aquaculture Scenario in India with a focus on shrimp farming during COVID-19: Challenges and Way Forward' on 3rd June, 2020. The purpose of the conference was to flag of the issues faced by the sector in the current scenario of COVID-19 and measures to be undertaken to tackle the negative impacts. About 1800 participants representing shrimp farmers, aqua professionals, researchers, inputs dealers, processors and marketers, state fisheries department officials, academicians and students registered and participated in the on-line conference

ICAR-CIBA celebrated World Environment Day on digital platform, with an invited talk by Dr.C. Suvarna, IFS, Commissioner of Fisheries, Telangana State on 'Biodiversity and Natural Resources Management'

World Environment Day was celebrated on 5th June, 2020 by ICAR-CIBA using digital platform by organizing an invited talk by Dr.C. Suvarna, IFS, Commissioner of Fisheries, Telangana State on 'Biodiversity and Natural Resources Management'. Dr. Suvarna made an elaborate presentation on the richness of Indian biodiversity and the impact of anthropogenic activity on the natural resources such as water and soil and measures to be taken to protect the biodiversity. During the event, over 100 participants including researchers, academicians and students placed queries and opinions, and were selectively discussed during the interaction session.

ICAR-CIBA Celebrated World Oceans Day, June 8, 2020

ICAR-CIBA, Chennai celebrated 'World Oceans Day' on June 8th, and on the distributed hatchery produced brackishwater ornamental fish silver moony (monos), *Monodactylus argenteus* to the ornamental traders from Kolathur, Chennai. Emphasizing the importance of world ocean day, Dr. K. K. Vijayan, Director, CIBA talked on the role of research initiatives in the conservation of species and aquatic ecosystem, including the ocean. He has pointed out that Ornamental fish trade in the country at large depends on the collection of ornamental fish varieties from the wild, and there are not good models of closing the cycle of the indigenous ornamental species, using breeding and hatchery technology, to make the fish ornamental enterprise a sustainable one.

ICAR-CIBA Celebrated International Yoga Day on 21st June 2020

Amid COVID-19 pandemic and lockdown situations at Chennai, ICAR – Central Institute of Brackishwater Aquaculture (CIBA, Chennai) celebrated sixth international day of Yoga on 21st June 2020, adhering to this year's theme "Yoga at home, Yoga with family". For the first time since it was instituted on June 21, 2015, Yoga Day has gone digital this year. The program included a practical demonstration on simplified yoga techniques at home, by Ms. Janani Subburaj, Yoga trainer from 'Chennai Government Yoga and Naturopathy Medical College', daughter of Dr. R. Subburaj, Assistant Chief Technical Officer of CIBA.

Kakdwip Research Centre of ICAR-CIBA Distributed Fish Feed to the Cyclone "Umphun" Affected Farmers of Sundarban

The extremely severe cyclone, "Umphan" caused havoc in the lives of Sundarban inhabitants on 20th May 2020. It has badly affected all types of fish culture systems in Sundaban delta of West Bengal. During the post-cyclone and COVID-19 lockdown period, farmers are unable to get inputs essential for fish farming. Therefore, their farming operations are hampered. KRC of ICAR-CIBA has taken initiative to distribute fish feed (Poly Plus) to the needy fish farmers of Sundarban.

ICAR-CIBA celebrated National Fish Farmers Day on 10th July, 2020 at its headquarters in Chennai and its Regional Centers respectively at Kakdwip, West Bengal and Navsari, Gujarat

At CIBA Headquarters in Chennai, "Phone-in-Programe (PiP)" a novel connectivity platform through mobile phones was organized wherein 68 fish farmers/fisherfolk/ technicians brackishwater aquaculture farmers interacted with subject matter specialists through on-line on the various subject of "Sea bass, milkfish, Pearl spot Culture and its Farm Management Practices", shrimp culture, crab fattening, feeds and feed management, soil & water, disease aspect with special reference to prevention of White faeces disease, seaweed in fish culture, training, subsidy, and economic aspects. About 77 queries were answered in their vernacular languages. Dr.K.K.Vijayan, Director, CIBA underlined the importance of induced breeding in fishes and shrimps which paved the way for assured seed supply and sustainable aquaculture development in the country.

Secretary Fisheries, Dr. Rajeev Ranjan, unravel Govt of India plans for fisheries and aquaculture development, inaugurating the ICAR-CIBA Digital Conference on 'New-age technologies for sustainable brackishwater aquaculture' held on 18th July 2020

On the occasion of ICAR foundation day, the Institute Technology Management and Agricultural Business Incubator Unit of ICAR-CIBA conducted a CIBA Digital Conference (CDC-2) on Saturday, 18 July 2020. National and international policy makers, scientist and the professional shared their experience and vision forward at the conference with a focus on the role of 'emerging and novel technologies in the Brackishwater aquaculture front'. Conference through its focus on the start-ups ecosystem in the brackishwater sector, discussed the opportunities on a 'think globally and act locally' mode. Inaugurating the conference, Dr. Rajeev Ranjan, IAS, Secretory of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India, impressed upon the immense potential of the Indian aquaculture sector, especially the brackishwater aquaculture sector. Dr.K.K.Vijayan, Director, ICAR-CIBA, Chennai in the opening remarks highlighted Research and development role of CIBA, and the impact of novel technologies developed by CIBA.

ICAR-CIBA sensitized the coastal villagers on COVID-19 disease and distributed safety materials

The COVID-19 pandemic has disastrous effect on all aspects of life with millions of mortalities and worldwide imposition of lockdown, closed business activities and movement restrictions across the country to prevent its spread. As a social responsibility measure, the ICAR-Central Institute of Brackishwater Aquaculture, Chennai has taken up a sensitization programme on COVID-19 among the tribal and Scheduled Caste families of Kannavanthurai, Senjiamman, Kulathumedu tribal villages of Tiruvallur and Kundrakadu, Kovalam village, Chengalpattu districts of Tamil Nadu during 6th and 7th August 2020. As part of the programme milkfish fingerlings and CIBA feeds were distributed to fish farmers to continue their livelihood activity. Moreover, precautionary materials like hand gloves, face mask, sanitizers etc., and essential groceries were distributed to about 40 SC and ST aqua families. This event was organised under the CIBA-TSP and CIBA – CPCL CSR project by Dr. B. Shanthi, Principal Scientist & Principal Investigator of the programme.

ICAR-CIBA conducted webinar on 'Pearlspot seed production and Aquaculture: Present status and future prospects with respect to Kerala', on 7th Aug. 2020

ICAR-CIBA conducted a webinar on the thematic area of "Pearlspot seed production and Aquaculture-Present status and future prospects with respect to Kerala" on 7th Aug. 2020. In the opening remarks Dr K.K. Vijayan, Director, CIBA put forth the vision for pearlspot aquaculture, integrating CIBA's scientific advancement and technologies developed in the area of hatchery seed production, formulated feeds and farming. The latest advances in pearlspot breeding, modular system of Pearlspot Seed production developed by CIBA, and specific functional feeds developed for pearlspot broodstock- EtroBrood^{Plus}, larvae- EtroLarvi^{Plus}, and Etro^{plus} growout feeds, catering to the nutrient requirement of the species was discussed. Representatives from the pearlspot farming sector, Shri Keertiram, from Alappuzha and Shri Vergheese Shiju, Ernakulam district of Kerala presented their perspective and experiences on pearlspot farming.

ICAR-CIBA celebrated 74th Independence Day of India 2020

ICAR-CIBA celebrated its 74th Independence Day on 15th August 2020 with pride and honor. Dr. K K Vijayan, Director, CIBA hoisted the tricolour national flag and delivered the independent day speech. In his address, he remembered the great sacrifices made by the great leaders and freedom fighters for getting the Independence and highlighted that it is the duty of every Indian citizen to protect the same and to strive hard for sustainable growth and prosperity of the country. He also briefed the challenges and way out with the ongoing COVID situations, and the role of each one of us to defeat the COVID pandemic and our contributions to build the brackishwater sector, institute and nation. Likewise, the officer in charge of the regional research centers in Kakdwip, West Bengal, Navsari, Gujarat and Muttukadu Experimental Station hoisted the national flag and addressed the gatherings.

Dr. Joykrushna Jena, Deputy Director General (Fisheries), ICAR, digitally inaugurated the new Main entrance gates of ICAR- CIBA headquarter on 15th August 2020, Chennai.

On the day of 74th Independence day celebrations on 15th August 2020 Dr. Joykrushna Jena, DDG (Fisheries), ICAR, inaugurated the Main gates and Compound wall of ICAR-CIBA, Chennai through digital platform in the presence of Dr.K.K.Vijayan, Director, CIBA, Chennai. In his address DDG appreciated the prominence and aesthetic look of the new gate and entrance to the institute. He accentuated on the importance of brackishwater aquaculture sector in Indian agricultural and rural economy, and appreciated CIBA's achievements and viable technologies to the benefit of aquaculture development in the country. Dr. K.K. Vijayan, Director, CIBA, thanked DDG (fisheries) and acknowledged the hard work of staff of CIBA.

ICAR-CIBA has taken over sixty-four acres of brackishwater land near Muttukadu for establishing a center of excellence in brackishwater aquaculture

ICAR-CIBA acquired about 64 acres of land near Muttukadu from Salt board, Ministry of Commerce and Industry, Government of India on 20 August, 2020. The land is located between the east coast road (ECR), and Old Mahabalipuram Road (OMR) and is just a kilometer away from the MES and about 35 km from headquarters of CIBA. This will be developed as 3rd campus at Chennai, Centre of Excellence in Brackishwater Aquaculture for South Asia (CEBAS), Kovalam CIBA. With the mandate of sustainable brackishwater development in the country, CIBA will be using the area with new facilities for brackishwater farms with shellfish and finfish, brood banks, nursery banks and other allied activities.

ICAR-CIBA celebrated the 150th birth anniversary of Mahatma Gandhi fulfilling his visions and building of Atmanirbhar Bharat

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) organized a week long programme from 25th Sep and 1st Oct 2020 to commemorate the 150th birth anniversary of father of nation Mahatma Gandhi. During this occasion events like tree plantations, competitions for the children and virtual meetings were organized fulfilling Gandhian philosophy and building of Atmanirbhar Bharat. A virtual meeting was organized on 1st Oct, 2020 where farmers adopted the indigenous technologies of CIBA shared their experiences. Shri. A. Perumal and Shri. A. Premkumar of Dr.A.P.J.Abdul Kalam fish producers self-help group of Vennangupattu, Chengalpattu district narrated their success story of CIBA's cage aquaculture technology and Shri.Kennith Raj and his wife Smt. Veilankanni shared their successful adoption of Plankton^{Plus} and Horti^{Plus} products developed on 'waste-to-wealth' concept.

Mahila Kisan Divas 2020 was organized by ICAR-CIBA at Keelarkollai coastal village in Chengalpattu district of Tamil Nadu

ICAR-CIBA celebrated Mahila Kisan Divas with coastal fisher families and Tribal families at Keelarkollai coastal village, Chengalpattu district of Tamil Nadu on 15.10.2020. The day coincides with the International Day of Rural Women to recognise the role of Women in Agriculture and Rural Development. About 50 participants from coastal fisher families, mostly fisher women attended the program. Success stories of CIBA's livelihood technology interventions undertaken as part of the "Mera Gaon Mera Gaurav" programme and Tribal Sub Plan on nursery rearing of Asian Seabass (*Lates calcarifer)*, Pearl spot (*Etroplus suratensis*) farming, ornamental fish culture and crab farming were shared during the session. Dr. K. K. Vijayan, Director ICAR-CIBA conveyed his Mahila Kisan Divas message to the participating women and emphasized that CIBA has been working with the coastal womenfolk and fine-tuned CIBA's technologies like nursery rearing of fishes, ornamental fish farming, mud crab fattening exclusively for the women farmers. Dr.D.Deboral Vimala and Dr.P.Mahalakhsmi, Principal Scientists, Social Sciences Division of CIBA coordinated the event.

ICAR-CIBA Muttukkadu Experimental Station (MES) bridged the mini-island area inside the lagoon for expanding its research infrastructure

The Field Experimental Station of ICAR-Central Institute of Brackishwater Aquaculture at Muttukkadu (MES), outskirts of Chennai spreads out in 121 acres, including 90.45 acres of water spread. The locked mini-island (2 acres) on the western side of CIBA finfish hatchery has been connected to the main land using a new eco-friendly wooden bridge over the backwater lagoon. This land was inaugurated for use for the CIBA's R&D activities on 2nd **November 2020, by Dr. KK Vijayan, Director CIBA during which a** biofloc based pearlspot fish nursery rearing unit was also initiated with the release of fish fingerlings.

Govt. of Kerala partners with ICAR-CIBA to set up a multi-species fish hatchery

As a step towards boosting the brackishwater fish production in Kerala, the Fisheries Department, Agency for Development of Aquaculture (ADAK), Govt. of Kerala signed a MOU with ICAR-CIBA to set up a multi-species fish hatchery for Asian Seabass, Pearlspot and Milkfish at Odayam in Thiruvananthapuram district, following the initiatives taken by the Hon'Ble Fisheries Minister, Kerala Smt. J Mercykutty Amma. According to the MoU, the CIBA will provide scientific and technical support to the government for developing captive breeding and seed production of above said fish species.

'ICAR-CIBA conducted a National webinar on the most sought after Biofloc farming technology (BFT) to unravel the Theory & Practice and release of "CIBAFLOC+" a ready to use starter inoculum of bacterial consortium'

ICAR-CIBA conducted a national webinar on "Biofloc based aquaculture: a way forward," which was inaugurated by Dr. Joykrushna Jena, DDG (Fisheries), ICAR. As a part of the virtual event, 'CIBAFLOC', a ready- made inoculum developed by ICAR-CIBA for the development and maintenance of biofloc, was released and the technology was transferred to the industrial partner M/s Salem Microbes Pvt Ltd on a virtual mode by DDG,(Fy). In the technical session, world-renowned biofloc man from Israel, Prof. Yoram Avnimelech, (Emeritus), who took the technology to many countries worldwide, enlightened the audience about the significance of the technology the recent developments around the world.

ICAR-CIBA celebrated World Fisheries Day with 'fish farmers' mentored by CIBA in livelihood support activities in Brackishwater Aquaculture

ICAR-CIBA celebrated the World Fisheries Day-2020 on 21.11.2020 at its Muttukadu Experimental Station, Chennai with the fish farmers and farm women who are mentored by CIBA in taking up aquaculture based livelihood activities. On this occasion 30 fisher folks from the coastal villages of Chengalpattu district, Tamil Nadu, participated and shared their success stories. Dr.K.K.Vijayan, Director, CIBA complimented the fish farmers for successfully involving in their aquaculture activities and generating income after CIBA's interventions.

ICAR-CIBA created awareness on climate change issues in aquaculture and distributed soil and water health cards to aqua farmers at Gudur, Andhra Pradesh

On the occasion of the celebration of World Soil Day under National Innovations in Climate Resilient Agriculture (NICRA) project, ICAR-CIBA, as part of 'Brackishwater Aquaculture Farmers Meet', distributed soil and water health cards to about 71 farmers of Chillakur Mandal, Nellore District, Andhra Pradesh, at Gudur on 18th December 2020. The event was felicitated by Smt. R.R.Anupama, Associate Professor & Head, Department of Aquatic Environment Management, Fisheries College, Muthukur, and Sri S.K. Chand Basha, Assistant Director of Fisheries, Gudur Division, Andhra Pradesh.

Kisan Diwas and Swachhata Pakhwada celebrations at KRC Kakdwip of ICAR-CIBA

Kakdwip Research Centre (KRC) of ICAR-CIBA celebrated the Kisan Diwas on 23rd December 2020 in the midst of the Swachhta Pakhwada being observed during 16-30 December 2020 with the tribal farmers at Mundapara village in Sundarbans, West Bengal. Sixty aqua farmers, youth and tribal women participated in the programme and women group shared their past experiences with integrated poultry and pig-cum-fish farming and expressed their desire to scale up the technology with the technical support provided by KRC, ICAR-CIBA. KRC farm reared juveniles of mullets, CIBA-Poly*Plus* feed and plankton booster Plankton^{Plus} were also distributed to the tribal farmers.

Awards & Recognition

Dr A Panigrahi bagged the best oral presentation award in **3rd International Symposium on Genomics in Aquaculture - 2020 (ISGA-III)** held from **21 - 23 January 2020, ICAR-CIFA, Bhubaneswar, India**

ICAR-CIBA, Chennai adopted Farmer wins national recognition

The ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) has received national recognition with a farmer who adopted the technologies of the institute bagging the prestigious Jagjivan Ram Innovative Farmer award of the Indian Council of Agricultural Research (ICAR). Shri.T Purushothaman, a leading shrimp farmer from Kerala won the award which is in recognition of his outstanding contributions for the development of diversified aquaculture practices utilizing the technological advancements. An experienced aqua-farmer who specially focuses on farming indigenous species by strictly following scientific principles, Shri Purushothaman adopted various technologies of the CIBA, which helped him develop innovative practices such as zero water exchange system of indigenous shrimp farming and multi-trophic species diversification. The award includes a cash cheque of Rs 50,000 and citation.

ICAR-CIBA-Agribusiness incubation center promoted two clienteles bags national fisheries awards

As part of World Fisheries Day celebration, National Fisheries Development Board (NFDB) and Department of Fisheries (DoF), Govt., of India organized a meeting to present awards to the best stakeholders in the fisheries sector. The awards were presented to Shri. T. Kennit Raj, leader of Nambikkai Fish Farmers Group, Tamil Nadu for "*Best Fisheries Self Help Group*" and Shri. Vijay, Sai Aqua Feeds, Andhra Pradesh for "*Best Fisheries Enterprise Award,* 2020", who had adopted the technology of ICAR-CIBA supported by CIBA's-Agribusiness incubation centre (ABI). Shri. Pratap Chandra Sarangi, Hon'ble Minister of State for Fisheries, Animal Husbandry and Dairying presented the awards in the presence of Dr. Rajeev Ranjan, IAS, Secretary (Fisheries), Ministry of Fisheries, Animal Husbandry and Dairying, Government of India and Dr. Suvarna C., Chief Executive, NFDB.

Linkages & Colloborations

THE INSTITUTE MAINTAINED LINKAGES WITH THE FOLLOWING NATIONAL AND INTERNATIONAL ORGANIZATIONS

NATIONAL ICAR INSTITUTES

CMFRI	**ICAR - Central Marine Fisheries Research Institute, Kochi, Kerala** **Photo gallery**
	ICAR - Central Inland Fisheries Research Institute, Barrackpore, West Bengal **Photo gallery**
	ICAR - Central Institute of Fisheries Technology, Kochi, Kerala **Photo gallery**
	ICAR – Central Institute of Fisheries Education, Mumbai, Maharashtra **Photo gallery**
NBFGR	**ICAR – National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh** **Photo gallery** **Ganga Aquarium**
CIFA	**ICAR - Central Institute of Freshwater Aquaculture, Bhubaneshwar, Odisha** **Photo gallery**
	ICAR – Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand **Photo gallery**
CIARI	**Central Island Agricultural Research Institute Port Blair**
	Central Research Institute for Dry land Agriculture, Hyderbad
	Directorate of Seed Research, MaU
Directorate of Research on Women in Agriculture	**Directorate of Research on Women in Agriculture**
naarm	**National Academy of Agricultural Research Managmentt, Hyderbad**

OTHER INSTITUTES/SAUS/STATE AGRICULTURAL DEPARTMENTS
Agricultural and Processed Food Products Export Development Authority, New Delhi
Centre for Advanced studies in Marine Biology, Annamalai University, Parangi Pettai
Coastal Aquaculture Authority, Chennai
College of Fisheries, University of Agricultural science, Mangalore
College of Fisheries, Sri Venkateswara Veterinary University, Muthukur
Department of Horticulture, Government of Tamil Nadu, Chennai
Department of Animal Husbandary, Govt of Tamil Nadu, Chennai
Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, New Delhi
Department of Biotechnology, New Delhi
Fisheries College and Research Insttitute, Tamil Nadu Veterinary and Animal Science 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 Product Development Authority , Cochin
Navsari Agricultural University, Navsari, Gujarat
National Fishereis Development Board, Hyderabad
National Institute of Ocean Technology, Chennai
Sundarban Development Board, Govt of West Bengal
Tamil Nadu Agricultural University, Coimbatore
Tamil Nadu Veterinary and Animal Science University, Chennai
Tamil Nadu Agricultural University, Coimbatore
Tamil Nadu Dr J. Jayalalithaa Fisheries University, Nagapattinam
University of Madras, Chennai
West Bengal University of Animal And Fisheries Science, Kolkata

STATE FISHERE DEPARTMENTS/BFDAS
The institute has well established linkage with state Fishereis and Dept./BFDAs mainly for transfer of technologies

Consultancies, Technology Development & Transfer

Knowledge partnership for the production of indigenous Shrimp seed for sustainable farming

MoU was signed with Mr.Suresh Nayak, A. R. Hatchery Pvt Ltd., Panichimedu, Marakkanam, Tamil Nadu, for the Knowledge partnership for the production of indigenous penaeid shrimps (viz. Indian white shrimp, Kuruma shrimp) seed production, on 18th January 2020. This model is useful in leveraging diverse expertise between government research institute and industry to address the current issues in brackishwater shrimp aquaculture. Mr Suresh Naik, MOU partner expressed appreciation in the initiatives of CIBA in forging partnership with private players, and expressed confidence in bringing positives through the MOU, which would bring benefits to the shrimp farming sector.

ICAR-CIBA and Nature Environment and Wildlife Society (NEWS), Kolkata signed MoU for the Knowledge partnership for brackishwater aquaculture technology demonstration and training in the Sundarban, January 31, 2020

ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai, represented by its Director, ICAR-CIBA and Nature Environment and Wildlife Society (NEWS), an NGO based in Kolkata, represented by its Director, Mr. Milon Sinha signed for the knowledge partnership for brackishwater aquaculture technology demonstration and training at KRC of ICAR-CIBA, Kakdwip on 31st January, 2020. This MoU was made mainly to cover three objectives: 1. Transfer of CIBA developed technologies for livelihood improvement of Sundarban farmers, 2. Capacity building of stakeholders through training and 3. Consultancy service on evaluation of various project implemented by the NEWS

Water Fin Pvt Ltd, Andhra Pradesh signs MOU for acquiring Seabass seed production technology, 4th February, 2020

Water Fin Pvt Ltd, Andhra Pradesh signed a Memorandum of Understanding (MoU) with ICAR-CIBA on February 4, 2020 for the transfer of seabass (*Lates calcarifer*) seed production technology. Technology support under this MoU covers development of land based seabass broodstock, technical demonstration of maturation and spawning, fertilized egg transportation and incubation and technical assistance for rearing of Asian Seabass larvae into fry size. On this occasion, Dr K K Vijayan, Director, CIBA has emphasised the importance of species diversification and farming of finfish species such as seabass, in the development of brackishwater aquaculture in the country. Mr. B. Ravi Prakash, Executive Director, Water Fin Pvt Ltd spoke on the occasion and added, though their primary business is in logistics they find lot of opportunities for seabass aquaculture as a business in India in which production and supply of seed will have more business prospects. Therefore, this long-waited alliance with CIBA comes at the right time, and Water Fin Ltd is happy to associate with ICAR-CIBA.

Technical support and partnership farming for adoption of modular System of Pearlspot seed production, Nursery Rearing and growout farming Models

MoU was signed with Sri. George Alexander, Vattakattussery, Alapuzha, Kerala for technical support and partnership farming for adoption of modular System of Pearlspot seed production, nursery Rearing and growout farming Models on 24th August 2020. CIBA will provide scientific support and technical collaboration to the client to develop modular system of pearlspot seed production, nursery rearing and grow out farming models.

Fisheries graduates from Karnataka joins hands with ICAR-CIBA for hatchery technology of Asian seabass under Startup India Initiative

Start-up India is a flagship initiative of the Government of India, intended to build a strong eco-system for nurturing innovations and transform them into technology useful to society.

Under this programme, a MoU was signed on September 10, 2020, between CIBA and Canares Aquaculture, where three young fisheries sciences graduates to take up Asian seabass hatchery technology as a first of its kind in the country. The event coincided with the launching of Pradhan Mantri Matsya Sampada Yojana (PMMSY) by the Prime Minister, Narendra Modi. CIBA appreciated the enthusiasm and courage of youth turning into entrepreneurs and also creating livelihood opportunities for the rural populations in the coastal region of Karnataka. Institute has initiated the promotion of Startup enterprises in brackishwater aquaculture since 2016, since then many young professionals have been incubated under this program at CIBA with the technological interventions in various areas of brackishwater aquaculture.

Joint development of AI based IoT devices for monitoring water and sediment quality in shrimp aquaculture

MoU signed for joint development of AI Based IoT devices for monitoring water and sediment quality in shrimp aquaculture with Dr. Mrutyunjaya Sahu, CEO, Bariflo Labs private ltd, Bolangir, Odisha on September 10, 2020. CIBA will provide scientific support to Bariflo Labs for refinement of their devices as suitable for brackishwater aquaculture.

Technology Transfer of 'Phage Therapy' for the control of bacterial disease in shrimp hatchery rearing systems

ICAR-CIBA signed a Memorandum of Understanding (MoU) with M/s Salem Microbes Private Limited, Salem, Tamil Nadu on September 18, 2020 for production and marketing of a phage based product developed by the Aquatic Animal Health and Environment Division (AAHED) of CIBA, Chennai. The phage product is effective for the biocontrol of bacterial diseases in shrimp hatchery settings. 'Bacteriophages' also called 'phages' in short, are viruses that infect and kill only specific disease causing bacteria, and are an alternative to antibiotics as therapeutic agents in controlling bacterial infections.

CIBAFLOC technology transfer to M/s Salem Microbes, Salem

CIBAFLOC technology was transferred to M/s Salem Microbes, Salem and partnered with the firm for development of eco-friendly and innovative penaeid shrimp production technology. This agreement was signed on October 3, 2020. CIBA joined hands for collaborative research for future state of art biofloc technology thus establishing Advanced BFT based Technology under the ambit of Eco-based, Sustainable, Innovative Production Technology (ESIPT).

Consultancy services for *Mystus gulio* breeding and seed production technology

MoU signed with Department of fisheries, Government of Andhra Pradesh, Machalipattinam, Krishna Dist, Andhra Pradesh for providing consultancy services for *Mystus gulio* breeding and seed production technology on November 2, 2020. It is agreed to that CIBA will provide technical advice for establishment and operation of Aquaculture quality testing laboratories in Andhra Pradesh and to undertake training to the technical man power engaged in Dr. YSR Aqua Testing labs for capacity building.

Consultancy services and partnership for establishment of Eco-friendly biofloc based Nursery/Grow out systems

MoU was signed with Prasidhi Exports Private Limited, SPSR Nellore District, Andhra Pradesh on 23 November, 2020 for consultancy services and partnership for establishment of Eco-friendly biofloc based Nursery/Grow out systems. According to MoU, CIBA will provide consultancy services and to be partnered with the firm for establishment of Eco-friendly biofloc based Nursery/Grow out systems.

ICAR-CIBA signed a Memorandum of Understanding (MoU) with M/s SS Traders, Guntur, Andhra Pradesh for marketing of CIBA-Plankton Plus

ICAR-CIBA signed a Memorandum of Understanding (MoU) with M/s SS Traders, Guntur, Andhra Pradesh on December 14, 2020 for marketing of CIBA-Plankton *Plus* developed by the Nutrition unit of CIBA, Chennai. CIBA-Plankton *Plus* is a value added product developed from fish waste/trimmings using a unique technology. In aquaculture ponds especially in shrimp ponds a healthy and consistent plankton bloom is required to get better survival and growth. M/s SS Traders is an established firm and involved in marketing of many aquaculture inputs like feed, healthcare products etc for the last three decades as well as managing about 100 acres of shrimp farming in Guntur district. The partner of the company Mr Subburaj said that the company was looking for a product for consistent plankton bloom in nurseries and shrimp grow out ponds.

Secretary Fisheries, Dr. Rajeev Ranjan, unravel Govt of India plans for fisheries and aquaculture development, inaugurating the ICAR-CIBA Digital Conference on 'New-age technologies for sustainable brackishwater aquaculture' held on 18th July 2020

On the occasion of ICAR foundation day, the Institute Technology Management and Agricultural Business Incubator Unit of ICAR-CIBA conducted a CIBA Digital Conference (CDC-2) on Saturday, 18 July 2020. National and international policy makers, scientist and the professional shared their experience and vision forward at the conference with a focus on the role of 'emerging and novel technologies in the Brackishwater aquaculture front'. Inaugurating the conference, Dr. Rajeev Ranjan, IAS, Secretary of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India, impressed upon the immense potential of the Indian aquaculture sector, especially the brackishwater aquaculture sector.

Techno-commercial assessment and preparation of standard terms of ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai technologies

A meeting was held on Wednesday, the 2nd of September 2020 via Zoom to assess the technical & commercial feasibility, handholding requirement as well as preferred modes of commercialization and to develop standard terms for ICAR-CIBA.

CEO, AgIn briefed about the purpose of the meeting and welcomed all the participants of the meeting. BM, AgIn explained the process of technology commercialization and expected outcomes of the meetings. The innovator(s) briefed the committee about their Technologies.

The committee opined that the two of the three proposed technologies to be commercialized through technology transfer mode and are technically validated and commercially feasible. The committee also valuated the technology and finalized the license fee for the same.

BUSINESS MEET PHOTOS

with FIB-SOL Technologies

Video call meet with Gram Tarang Technologies Private Limited, Bengaluru

Video call meet with Sh.Ravi Prakash, Waterfin Pvt.Ltd., Hyderabad

PATENTS GRANTED

S. No.	Date of filing	App. No.	Title of the Invention	Inventors	Application Status
1.	15.05.2013	2152/ CHE/2013	A process for imaging bacteria using immobilizing matrix from bagasse	Dr. K.K. Krishnani, Dr.I.S.Azad, Dr.B.P.Gupta, Dr.M.Shashi Shekhar, Dr.P. Ravichandran	Patent No.338643 Granted 17/06/2020
2.	12.01.2016	201641001060	Modular system and method for getting repeated spawning and higher fry production in pearlspot fish	Dr. K.K. Vijayan Dr. K.P. Kumaraguru vasagam Dr. K. Ambasankar Dr. Krishna Sukumaran Dr. J. Syamadayal Dr. M. Kailasam Mr. S. Balachandran	Patent No.344940 Granted 25/08/2020

PATENTS FILED

S. No.	Date of filing	App. No.	Title of the Invention	Inventors	Application Status
1.	29.01.2020	202041003962	'Hormone pellet implant formulation and methodology for inducing maturation and spawning in milkfish (*Chanos chanos*)'	Aritra Bera, M.Kailasam, Babita Mandal, Ambasankar, M.Makesh, Krishna Sukumaran, P.Kumararaja, Arun Padiyar, K. K. Vijayan	Patent Application No. 202041003962 dated January 29, 2020.

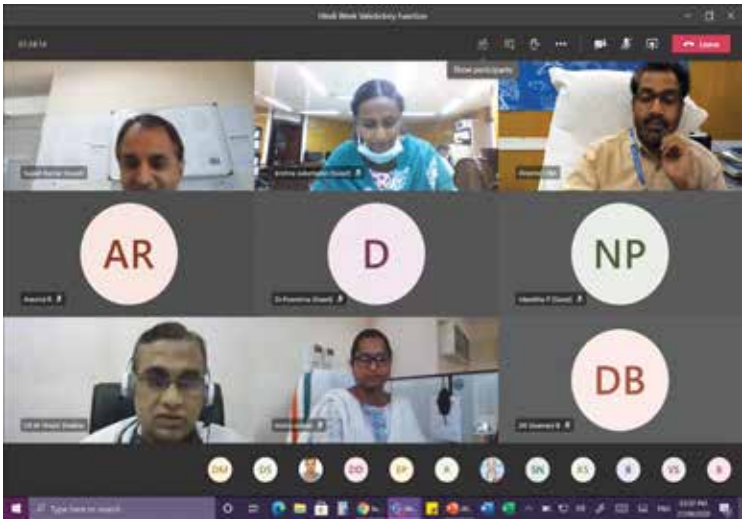
Official Language Implementation Program

HINDI WEEK CELEBRATIONS IN ICAR-CIBA

ICAR-CIBA celebrated Hindi Week during 14th – 21st September 2020 to promote use of Hindi as official language. During the week, Hindi noting and drafting, poem, Singing, etc. competitions were organized which were attended by scientists, staff and research scholars of CIBA. The competitions were conducted using online mode. The valedictory function was organized on 21st September, 2020. On this occasion, Dr. M.S.Shekhar, Officer – incharge Hindi cell in his opening remarks briefed the importance of Hindi diwas and encouraged the CIBA staff and Scientists to use Hindi as mode of communication for official work. Dr. K.K. Vijayan Director CIBA, released the 6th issue of annual Hindi magazine "Jal Tarang" and distributed the award to winners of Hindi competition and under Hindi incentive scheme. In his address Dr. K.K. Vijayan Director CIBA, remarked the linguistic diversity of India and importance of Hindi in communicating across Nation. Dr. Sujeet Kumar, Scientist and member of Hindi Cell presented the work carried out by Hindi cell during the year 2018-19. and coordinated the program.

भा.कृ.अनु.प. - सीबा में हिंदी सप्ताह का आयोजन

सीबा ने हिंदी के आधिकारिक भाषा के रूप में उपयोग को बढ़ावा देने के लिए 14 - 21 सितंबर 2020 के दौरान हिंदी सप्ताह मनाया। सप्ताह के दौरान, ऑनलाइन मोड के माध्यम से हिंदी नोटिंग, कविता, गायन, इत्यादि प्रतियोगिताओं का आयोजन किया गया, जिसमे सीबा के वैज्ञानिक, कर्मचारी और शोध छात्र उपस्थित थे। 21 सितंबर, 2020 को समापन समरोह का आयोजन किया गया । इस अवसर पर, डॉ एम.एस.शेखर, अधिकारी - हिंदी सेल ने अपनी प्रारंभिक टिप्पणियों में हिंदी दिवस के महत्व को बताया और सीबा कर्मचारियों और वैज्ञानिकों को आधिकारिक कार्यों के लिए हिंदी का उपयोग करने के लिए प्रोत्साहित किया। सीबा निदेशक , डॉ. के.के. विजयन ने वार्षिक हिंदी पत्रिका "जल तरंग" का 6 वां अंक जारी किया और हिंदी प्रतियोगिता के विजेता और हिंदी प्रोत्साहन योजना के तहत पुरस्कार वितरित किया। अपने अध्यक्षीय भाषण में, उन्होंने भारत की भाषाई विविधता और विशेष रूप से हिंदी के महत्व पर टिप्पणी की। डॉ। सुजीत कुमार ने वर्ष 2019-20 के दौरान हिंदी सेल द्वारा किए गए कार्यों को प्रस्तुत किया और कार्यक्रम का समन्वय किया।



Research & Administrative Meetings

RESEARCH ADVISORY COMMITTEE (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F.No.18-3/2016-ASR-I dated 06.02.2020) for a period of three years with effect from 01.01.2020 to 31.12.2022:

Chairman	Prof. (Dr.) B. Madhusoodhana Kurup
Members	Dr. M. Vijayakumar
	Dr. Lalit C. Garg
	Dr. Asim K. Pal
	Dr. Santhana Krishnan
	Dr. Pravin Putra
	Dr. K.K. Vijayan
Member Secretary	Dr. Subhendu Kumar Otta

The 25th meeting of the Research Advisory Committee (RAC) of CIBA was held during 18-19th May 2020 at CIBA Headquarters, Chennai through digital platform

INSTITUTE RESEARCH COUNCIL (IRC)

The Institute Research Council (IRC) of CIBA has been constituted as follows:

Chairman	**Dr. K.K.Vijayan, Director**
Members	Dr. Pravin Putra, ADG (M.Fy.)
	Dr. S.V. Alavandi, Principal Scientist
	Dr. C. P. Balasubramanian, Principal Scientist
	Dr. M. Kailasam, Principal Scientist
	Dr. M. S. Shekhar, Principal Scientist
	Dr. C. V. Sairam, Principal Scientist
	Dr. M. Muralidhar, Principal Scientist
	Dr. K. Ambasankar, Principal Scientist
Principal Investigators of all the projects	
Member Secretary	Dr. Subhendu Kumar Otta, Principal Scientist

The 37th IRC Meeting was held on 22nd and 23rd May 2020 through online 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 Putra, ADG (M.Fy.), ICAR
	Dr. Sudhansu Sekhar Mishra, Principal Scientist, ICAR- CIFA, Bhubaneswar
	Dr. V.R. Suresh, Principal Scientist, ICAR-CIFRI, Barrackpore, West Bengal
	Dr. Vindhya Mohindra, Principal Scientist, ICAR-NBFGR, Lucknow
	Dr. Shekarnath Ojha, Principal Scientist, ICAR-CIFE, Mumbai
	Commissioner of Fisheries, Govt. of Tamil Nadu, Chennai
	Director of Fisheries, Govt. of Kerala, Trivandrum
	The Dean, College of Fisheries, WBUAFS, PO Panchasagar, Chakagaria, Kolkata (WB)
	FAO, IIHR, Bangalore
Member Secretary	
	Smt. V. Usharani, Administrative Officer
Co-opted Members	
	Dr. M. Kumaran, Principal Scientist & Head of Office
	Dr. S.K. Otta, Principal Scientist & OIC, PME Cell
	Dr.P. Mahalakshmi, Principal Scientist & OIC Engineering Cell
	Shri R.K. Babu, Finance & Accounts Officer
	Shri R. Kandamani, AAO (Stores)
	Shri A. Manoharan, AAO (Estt.)
	Shri S. Pari, AAO & DDO
	Shri P. Srikanth, Junior Accounts Officer
Non-Official Members	
	Shri S. Satish Kumar, Farmers' Representative
	Shri P. Rama Chandra Raju, Farmers' Representative
	The 52nd IMC meeting held on 29th July 2020

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 03.08.2019 to 02.08.2022 vide Office Order F.No.13-1/2012-Admn. Dated 14.08.2019) is as follows:

Official Side

Chairman	**Dr. K.K. Vijayan**
Member Secretary	Dr. T. Ravisankar, Principal Scientist
Members	Dr. K. Ambasankar, Principal Scientist
	Dr. M. Kailasam, Principal Scientist
	Dr. P. Mahalakshmi, Principal Scientist
	Shri R. Elankovan, Chief Technical Officer
	Shri R. K. Babu, Finance & Accounts Officer

Staff Side

Secretary	Shri N. Jagan Mohan Raj, Sr. Technical Asst.
Members	Shri S. Saminathan, Technical Officer
	Shri P. Srikanth, JAO
	Smt. E. Mary Desouza, Assistant
	Shri C. Raghu, Skilled Support Staff
	Shri R. Mathivanan, 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 02.07.2019) is as follows:

Chairman	**Dr. K.K. Vijayan**
Elected Members	
Scientific Members	Dr. K. Ambasankar, Principal Scientist
	Dr. Nila Rekha, Principal Scientist
Technical Member	Dr. Joseph Sahaya Rajan, Senior Technical Officer
Administrative Members	Mrs. Usha Rani, A.A.O
	Shri P. Srikanth, J.A.O
Staff Member	Shri. R.Mathivanan, Skilled Support Staff

WOMEN COMPLAINT COMMITTEE

Women Complaint Committee has been constituted as follows:

Chairman	**Dr. R. Saraswathy, Principal Scientist**
Members	Dr. Prasanna Kumar Patil, Principal Scientist
	Dr. P. Nila Rekha, Principal Scientist
	Shri N. Jagan Mohan Raj, Sr. Technical Asst
	Smt. E. Mary Desouza, Assistant

External Member Dr. A. Sumathi, Asst. Prof. & Head–in-Charge, Dept. of Biomedical Sciences, Sri Ramachandra Medical College, Porur, Chennai

WOMEN CELL

Women Cell has been constituted as follows:

Chairman	**Dr. D. Deboral Vimala, Principal Scientist**
Members	Dr. R. Saraswathy, Principal Scientist
	Smt. B. Amudavalli, Assistant
	Smt. K. Hemalatha, Stenographer
	Smt. K. Subhashini, PA
Member Secretary	Shri R. Kandamani, AAO

LIAISONING COMMITTEE

The composition of the Liaisoning Committee has been constituted by CIBA vide Office Order F.No.48-16/2010-Admn. dated 06.06.2016 is as follows:

Chairman	**Dr. S. Kannappan, Principal Scientist**
Members	Dr. K. Ambasankar, Principal Scientist
	Dr. R. Saraswathy, Principal Scientist
	Dr. Akshaya Panigrahi, Principal Scientist
	Dr. M. Kumaran, Principal Scientist
	Dr. P.K. Patil, Principal Scientist

Services & Assignments

SERVICES IN COMMITTEES

Dr. K.K. Vijayan, Director

1.	Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai.
2.	ICAR Regional Committee No.VIII
3.	Executive Committee member - National Centre for Sustainable Aquaculture (NaCSA)
4.	Coastal Aquaculture Authority
5.	Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur.
6.	Scientific Advisory Committee for Dr.Perumal Krishi Vigyan Kendra
7.	State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Department of Animal Husbandry & Veterinary Services, Government of Tamil Nadu, Chennai – 6.
8.	Board of Management of Tamil Nadu Fisheries University, Nagapattinam.
9.	Board of Management of Tamil Nadu Veterinary and Animal Sciences University, Chennai.
10.	Academic Council of Central Institute of Fisheries Education, Mumbai.
11.	Board of Management of Central Institute of Fisheries Education, Mumbai.
12.	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.
13.	Advisory Committee on Hilsa Conservation and Research
14.	Governing Body of State Fisheries Resource Management Society (FIRMA), Thiruvananthapuram.
15.	Advisory Board for Fisheries Sector Development, constituted by Special Chief Secretary (Planning), Planning Department, Govt. of Andhra Pradesh.
16.	Society of Coastal Aquaculture and Fisheries
17.	Society for Fisheries Technologists
18.	Marine Biological Association of India
19.	Member of Faculty in the Board of Studies of Cochin University of Science and Technology (CUSAT), Kochi.
20.	Member – Tamil Nadu State Council for Science and Technology, Chennai.

21.	Selection Committee - Tamilnadu Scientist Award (TANSA) constituted by Tamil Nadu State Council for Science and Technology.
22.	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.
23.	Selection Committee for the selection of the University Officers of the Tamil Nadu Dr J Jayalalitha Fisheries University, Nagapattinam.
24.	State-wise Coordination Committees for doubling Farmer's income by March, 2022, constituted by Secretary, DARE & Director General, ICAR, New Delhi.
25.	Kerala State Council for Science Technology and Environment, Thiruvananthapuram.
26.	Expert committee to study on Vembanad, Astamudi and Sasthamkotta lakes, constituted by Office of the Director of Fisheries, Govt. of Kerala, Thiruvananthapuram.
27.	Sub-Committee to work out modalities for engaging Consultants in Coastal Aquaculture Authority.
28.	Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) for formulation of unit cost norms, unit costs and guideliens in respect of all the components and sub-components of the PMMSY.
29.	Member – Committee for reviewing financial elements of programmes under the Deep Ocean Mission Proposal, constituted by NIOT, Chennai.
30.	Member – Fee Fixation Committee for Private colleges of Agriculture and allied subjects affiliated with TNAU, constituted by Tamil Nadu Agricultural University.
31.	Member – National Advisory Board of the International Symposium on Coastal Agriculture (ISCA) organized by Indian Society of Coastal Agricultural Research during 5-8 November 2020 at Kolkata.

SCIENTISTS

Member of the Technical and Inspection Committee constituted to assist the Project Screening Committee (PSC) headed by Joint Secretary (Fisheries), Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture and Farmers' Welfare – Dr.K.Vinaya Kumar
As an Expert Panellist participated in AQUAINDIA 2020: The Changing Face of Indian Aquaculture organized by the Society of Aquaculture Professionals to be held during 31st January and 1st Feb., 2020 at Maradu, Kochi – Dr.K.Ambasankar
Member of Inter-departmental Committee for resolving technical issues of Domestication of Tiger Shrimp Project (DTSP) of MPEDA in Andaman and Nicobar islands-Dr C P Balasubramanian
Member Secretary in the Institutional Animal Ethics Committee (IAEC) and animal house in-charge at ICAR-CIBA – Dr.R.Ananda Raja
Editorial Board Member for Aquaculture and Fisheries Studies (AFS), Research Open World publisher, San Antonio Texas, USA - Dr.Prem Kumar

Mera Gaon Mera Gaurav Programme

Under the flagship programme of the Honourable Prime Minister of India, ICAR- CIBA is implementing Mera Gaon and Mera Gaurav (MGMG) Scheme in three districts of Tamil Nadu viz., Chennai, Chengalpattu and Thiruvallur. During the period under report, Scientists in 14 teams implemented the programme in 14 villages, in a phased manner of making a visit in a month for need based activities through technological interventions on partnership mode. The teams visit the villages regularly and update them about the need-based and location specific technologies forging convergence with line departments, KVK/SHGs/NGOs etc. through field visits, training programmes, demonstrations, group meetings etc. They also create awareness among the aqua farmers and farm women and fishers on national level important programmes such as Swaachh Pakhwada, Water Conservation, World Women's Day, Constitution Day etc.

The team of Scientist had undertaken 86 visits, 26 meetings and 20 training programmes; under the patronage of the MGMG programme, In addition, 12 demonstrations were conducted, 230 mobile advisories have been extended, 5 literatures were distributed, and organized 16 campaigns. The total number of activities conducted was 165 and 1445 fish/ aqua farmers got benefitted out of it. These activities were taken up for technology dissemination from lab to land and to create awareness among farmers about the Organizations which would help them in their aqua farming activities. 12 demonstrations were conducted under the five major heads by ICAR-CIBA to promote the direct interface of scientists with the farmers viz.,

1. Waste to Wealth: Recycling of fish waste to value-added products, CIBA-Plankton^{Plus} and Horti^{Plus}
2. Re-circulatory Aquaculture System" model for pearl spot nursery rearing in tribal village.
3. Homestead backyard Pearl spot hatchery activity demonstrated among the clam collecting coastal families.
4. Comparative assessment of Nursery rearing of Asian Seabass fish under different salinity regimes as a livelihood development model for the coastal fisher families.
5. Utilization of open brackishwater water bodies for nursery rearing of Seabass (*Lates calcarifer*) as a livelihood support activity.

Cleaning of MGMG village premises, Kuvathur, Tamil Nadu, ICAR-CIBA, Chennai

Swachh Bharat Mission

In response to the noble call, Swachh Bharat Mission, various activities were conducted under Swachhta Pakhwada at ICAR-CIBA, Chennai, Muttukadu Experimental Station, Mutttukadu, Navsari Gujarat Research Center, Navsari, Gujarat and Kakdwip Research Centre of CIBA, Kakdwip, West Bengal with due gravity and purposefulness during 16-31 December 2020.

Swachhta Pledge was taken by around 150 participants including scientists, officers, staff and students of ICAR-CIBA, Chennai, Muttukadu Experimental Station, Mutttukadu, Navsari Gujarat Research Center, Navsari, Gujarat and Kakdwip Research Centre of CIBA, Kakdwip on 16th October 2020. As a part of pakhwada, tree planation was done at Kovalam Experimental Station, Tamil Nadu.

Swachhta Pledge by Scientists, staff, research scholars and students, ICAR-CIBA, Chennai

Drawing and Essay competitions among school students

Awareness programme on maintenance and importance of kitchen garden was conducted at the tribal village Mundapara, Manmathapur, Sundarban and Signod village, Navsari district, Gujarat. Utilizing homestead fallow land by converting to kitchen garden for cultivation of horticultural crops provides extra incomes, meets up domestic needs for vegetables and nutrition, and creates clean and esthetic surroundings of a house. This would also help in keeping house premise weed free and maintaining healthy organic environment. Therefore, maintenance of kitchen garden as a household activity by small and marginal farmers is encouraging and rewarding. The participating farmers were urged to maintain kitchen garden to achieve both clean environment and extra income from vegetable cultivation.

Headquarters of ICAR-CIBA, Chennai, Kakdwip Research Centre (KRC) of CIBA, Kakdwip, West Bengal and Navsari Gujarat Research Center (NGRC) of CIBA, Navsari, Gujarat have conducted cleaning and sanitization activities at office campus and farms to combat spread of COVID-19 as a part of Swachhta Pakhwada. The attendees were informed about the COVID-19, its mode of spreading and how to contain it. Moreover, Do's and Don'ts on fight against COVID-19 were narrated to the staffs and farm labours. In addition, face masks were distributed to all staffs and farm labours for all-time use at office premise. A hand sanitizer disposal machine was installed at office entrance. Sanitization of office building and common areas is being performed at weekly intervals.

Distribution of face mask and automatic sanitizer to Signod villagers, Navsari, Gujarat – NGRC of CIBA, Chennai

Kitchen Gardening at the tribal village Mundapara, Manmathapur, Sundarban

Awareness programme on maintenance and importance of kitchen garden was conducted at the tribal village Mundapara, Manmathapur, Sundarban and Signod village, Navsari district, Gujarat. Utilizing homestead fallow land by converting to kitchen garden for cultivation of horticultural crops provides extra incomes, meets up domestic needs for vegetables and nutrition, and creates clean and esthetic surroundings of a house. This would also help in keeping house premise weed free and maintaining healthy organic environment. Therefore, maintenance of kitchen garden as a household activity by small and marginal farmers is encouraging and rewarding. The participating farmers were urged to maintain kitchen garden to achieve both clean environment and extra income from vegetable cultivation.

Awareness programmes on preventive measures of Covid 19, usage of *Aarogya Setu,* advantages of wearing mask, social distance and also importance of cleanliness, hygiene and sanitation among the villagers and cleanliness drive in villages has conducted at: (1) Kuvathur, MGMG village, Kancheepuram district, Tamil Nadu: Followed by the awareness meeting, 30 villagers including CIBA staff and villagers cleaned the village premises of public pathways/roads. They distributed cleaning materials, mask, gloves and sanitizers to the villagers (2) Signod village, Navsari district, Gujarat: About 40 villagers including NGRC of CIBA staff actively participated in the programme. Automatic sanitizers were installed in the village premises and also nearby aquaculture ponds to make use of villagers and farm labourers. They also distributed cleaning materials, face mask and gloves to the villagers.

Distribution of cleaning materials to MGMG villagers, Kuvathur, Tamil Nadu, ICAR-CIBA, Chennai

Distinguished Visitors

Sl. No	Details of visitors	Date of visit
Headquarters		
1	Shri. Radha Mohan Singh, Honourable Former Union Minister of Agriculture & Farmers Welfare and the Member of Parliament and Chairperson, Parliamentary Standing Committee on Railways	06.01.2020
2	Dr.Leena Nair, IAS, Chief Guest, CIBA Annual Day	29.02.2020
3	Dr.K.Devaki, Subject Matter Specialist from Krishi Vigyan Kendra, Kancheepuram district	21.11.2020
Kakdwip Research Centre		
4	Shri. Milon Sinha, Director, Nature Environment and Wildlife Society (NEWS), Kolkata	31.01.2020
Navsari Gujarat Research Centre		
5	Shri. C. R. Patil, Honourable Member of Parliament, Chief Guest, National fish farmers' day	10.07.2020

Personnel

List of personnel of CIBA, Chennai as on 31.12.2020 (not a gradation list)

Sl.No.	NAME	DESIGNATION	
1.	Dr. K.K. Vijayan	Director	
2.	Dr. S.V. Alavandi	Principal Scientist/HOD (I/c),	
3.	Dr. K. P. Jithendran	Principal Scientist	
4.	Dr. C.V. Sairam	Principal Scientist	
5.	Dr. T. Ravisankar	Principal Scientist	
6.	Dr. M. Muralidhar	Principal Scientist	
7.	Dr. (Smt) M. Jayanthi	Principal Scientist	
8.	Dr. (Smt) B. Shanthi	Principal Scientist	
9.	Dr. C. P. Balasubramanian	Principal Scientist	
10.	Dr. M. Kailasam	Principal Scientist	
11.	Dr. (Smt) D. Deboral Vimala	Principal Scientist	
12.	Dr. M. Shashi Shekhar	Principal Scientist	
13.	Dr. (Smt) P. Nila Rekha	Principal Scientist	
14.	Dr. K. Ambasankar	Principal Scientist	
15.	Dr. J. Syama Dayal	Principal Scientist	
16.	Dr. Akshya Panigrahi	Principal Scientist	
17.	Dr. M. Kumaran	Principal Scientist	
18.	Dr. S. Kannappan	Principal Scientist	
19.	Dr. (Smt) M.Poornima	Principal Scientist	
20.	Dr. (Smt) R. Saraswathy	Principal Scientist	
21.	Dr. M.Makesh	Principal Scientist	
22.	Dr. (Smt) Sherly Tomy	Principal Scientist	
23.	Dr. Prasanna Kumar Patil	Principal Scientist	
24.	Dr. Subhendu Kumar Otta	Principal Scientist	
25.	Dr. (Smt) P. Mahalakshmi	Principal scientist	
26.	Dr. K.P. Kumaraguru vasagam	Principal Scientist	

Sl.No.	NAME	DESIGNATION	
27.	Dr. T. Senthil Murugan	Principal Scientist	Promoted on 05.04.2018
28.	Shri. Ashok Kumar Jangam	Scientist (SS)	
29.	Dr. R. Ananda Raja	Senior Scientist	
30.	Dr. (Smt) P. Ezhil Praveena	Senior Scientist	
31.	Dr. (Smt) Krishna Sukumaran	Senior Scientist	
32.	Dr. (Smt).Shyne Anand	Senior Scientist	
33.	Dr. B .Sivamani	Senior Scientist	
34.	Dr. (Smt) R. Geetha	Senior Scientist	
35.	Dr. Vinaya Kumar Katneni	Scientist	
36.	Dr. Sujeet Kumar	Scientist	
37.	Dr. P. Kumararaja	Scientist	
38.	Dr. (Smt) N. Lalitha	Scientist	
39.	Dr. (Smt) T. Bhuvaneswari	Scientist	
40.	Dr. (Smt) Vidya Rajendran	Scientist	
41.	Dr. Satheesha Avunje	Scientist	
42.	Shri. K.P. Sandeep	Scientist	
43.	Dr. Aritra Bera	Scientist	
44.	Shri. T. Sathish Kumar	Scientist	
45.	Smt. M.U. Rekha	Scientist	
46.	Dr. N.S. Sudheer	Scientist	
47.	Dr. Suvana Sukumaran	Scientist	
48.	Dr. (Smt) Neethu K.C.	Scientist	
49.	Shri. Dani Thomas	Scientist	
50.	Shri. R. Aravind	Scientist	
51.	Shri. Biju I.F.	Scientist	
52.	Ms. Misha Soman	Scientist	
53.	Smt. Mary Lini	Scientist	
54.	Dr. J. Raymond Jani Angel	Scientist	
55.	Shri. T. Sivaramakrishnan	Scientist	
56.	Dr. Vinay Tharabenahalli Nagaraju	Scientist	

Sl.No.	NAME	DESIGNATION	
TECHNICAL			
1.	Shri R. Elankovan	Chief Tech. Officer	
2.	Dr. S. Sivagnanam	Chief Tech. Officer	
3.	Shri D. Raja Babu	Chief Tech. Officer	
4.	Shri M. Shenbagakumar	Chief Tech. Officer	(retd 31.7.20)
5.	Shri R. Puthiavan	Assistant Chief Tech. Officer	
6.	Smt. K. Jacquline	Assistant Chief Tech. Officer	
7.	Shri Joseph Sahayarajan	Assistant Chief Tech. Officer	
8.	Shri S. Rajamanickam	Assistant Chief Tech. Officer	
9.	Shri S. Nagarajan	Assistant Chief Tech. Officer	
10.	Dr. A. Nagavel	Assistant Chief Tech. Officer	
11.	Shri R. Subburaj	Assistant Chief Tech. Officer	
12.	Shri N. Ramesh	Tech. Officer	Retd 30.11.20
13.	Shri S. Saminathan	Tech. Officer	
14.	Shri N. Jagan Mohan Raj	Tech. Officer	
15.	Shri D. M. Ramesh Babu	Tech. Officer	
16.	Shri G. Thiagarajan	Tech. Officer	
17.	Shri K. Paranthaman	Senior Tech. Asst.	(retd 30.6.20)
18.	Shri K. Karaian	Senior Tech. Asst.	
19.	Shri. S. Prabhu	Technical Asst.	
20.	Shri. K.V. Delli Rao	Senior Technician	
ADMINISTRATION			
1.	Shri Babu R.K	Finance & Accounts Officer	
2.	Smt. V. Usharani	Admn. Officer	Promoted on 22.07.2020
3.	Shri R. Kandamani	Asst. Admn. Officer	Trd on promotion on 06.08.2020
4.	Shri S. Pari	Asst. Admn. Officer	
5.	Shri P. Srikanth	Junior Accounts Officer	
6.	Smt. S. Nalini	P.S	
7.	Shri. K.G. Gopala Krishna Murthy	P.A.	
8.	Smt. K. Subhashini	P.A.	
9.	Shri A. Manoharan	Assistant	
10.	Smt. E. Amudhavalli	Assistant	
11.	Shri A. Sekar	Assistant	
12.	Smt. E. Mary Desouza	Assistant	

Sl.No.	NAME	DESIGNATION	
13.	Shri. Raghavendra.K	Assistant	
14.	Smt. K. Hemalatha	Stenographer, Grade – III	
15.	Smt. R. Vetrichelvi	Upper Division Clerk	
16.	Smt. M. Mathuramuthu Bala	Upper Division Clerk	
17.	Smt. B. Prasanna Devi	Upper Division Clerk	
18.	Shri. R. Kumerasen	LDC	
19.	Shri A. Paul Peter	LDC	
20.	Shri. V. Kishorkumar	LDC	
SKILLED SUPPORT STAFF			
1.	Shri K. Nithyanandam	Skilled Support Staff	
2.	Shri V. M. Dhanapal	Skilled Support Staff	
3.	Shri V. Kumar	Skilled Support Staff	
4.	Shri E. Manoharan	Skilled Support Staff	Retd 31.05.20
5.	Shri C. Saravanan	Skilled Support Staff	
6.	Shri S. Selvababu	Skilled Support Staff	
7.	Shri C. Ragu	Skilled Support Staff	
8.	Shri P.G. Samuvel	Skilled Support Staff	
9.	Shri M. Sakthivel	Skilled Support Staff	
10.	Shri R. Mathivanan	Skilled Support Staff	
11.	Shri R. Indra Kumar	Skilled Support Staff	
12.	Shri G. Dayalan	Skilled Support Staff	
13.	Shri Kanaka Prasad	Skilled Support Staff	
14.	Smt. S. Premavathy	Skilled Support Staff	Retd 31.10.20
15.	Shri. J. Murugan	Skilled Support Staff	
16.	Shri. S. Solin Igneshus	Skilled Support Staff	

Kakdwip Research Centre of CIBA

SCIENTISTS

1.	Dr. Debasis DE	Principal Scientist	
2.	Dr.T.K.Ghosal	Principal Scientist	
3.	Dr.Sanjoy Das	Principal Scientist	
4.	Dr.G.Biswas	Senior Scientist	
5.	Dr. Prem Kumar	Senior Scientist	
6.	Ms.Christina Lalramchhani	Scientist	
7.	Mrs. Babita	Scientist	
8.	Ms. Leesa Priyadarsani	Scientist	

Sl.No.	NAME	DESIGNATION	
TECHNICAL			
1	Smt. Chhanda Mazumder	Senior Tech. Asst.	
ADMINISTRATION			
1.	Shri.Sanjoy Some	LDC	
SKILLED SUPPORT STAFF			
1.	Shri N.N. Jana	Skilled Support Staff	Retd 28.2.2019
2.	Shri K.P. Naskar	Skilled Support Staff	Retd 31.08.2020
3.	Smt L.R. Bhuiya	Skilled Support Staff	
4.	Shri U.K. Santra	Skilled Support Staff	
5.	Shri P.C. Das	Skilled Support Staff	
NAVSARI-GUJARAT RESEARCH CENTRE OF CIBA, GUJARAT			
1	Shri. Pankaj Amrut Patil	Scientist	
2	Shri. Tanveer Hussain	Scientist	
3	Shri. Jose Antony	Scientist	

Infrastructure Development for the year 2020

1. Expansion of laboratory building at Hqrs, Chennai
2. Renovation & laying interlocking paver block and kerb stone work around the around Electrical room CIBA Hqrs, R.A.Puram, Chennai-28.
3. Conversion of existing Electricity Low Tension (LT) into High Tension (HT) power supply at Muttukadu Experimental Station of ICAR-CIBA, Muttukadu
4. Supply and installation of Roof top solar plants over the feed mill and conference hall at MES of CIBA, Muttukadu
5. Repair and renovation of existing damaged fencing at MES of CIBA Muttukadu.
6. Repair & renovation of Mullet Culture Pond and Effluent Treatment Pond at MES of CIBA, Muttukadu
7. Repair and renovation of ornamental fish rearing facility roof shed at MES - FCD hatchery at Muttukadu.
8. Replacement of Air conditioners with buy back at MES of CIBA, Muttukadu Experimental Station of CIBA, Muttukadu
9. Renovation and modification in larval rearing room and algal section in the Shrimp hatchery at Muttukadu Experimental Station of CIBA, Muttukadu
10. Repair/renovation of the ponds with central drainage system at MES of CIBA, Muttukadu.
11. Renovation of approach road at MES of CIBA, Muttukadu
12. Replacement of roof structures of ornamental fish breeding unit and pearl spot Breeding unit at MES of CIBA, Muttukadu.
13. Repair and renovation of milkfish experimental ponds at MES of CIBA, Muttukadu
14. Renovation and modification of old transformer building is to be used as fish waste processing unit at KRC of CIBA, Kakdwip
15. Renovation of store at KRC of CIBA, Kakdwip
16. Renovation of barbed wire fencing at KRC of CIBA, Kakdwip
17. Fencing of reservoir pond adjacent to sector A at KRC
18. Lighting arrester and earthing installation in main office building and wet laboratory at KRC of CIBA, Kakdwip
19. Renovation of 22 experimental ponds with construction of RCC inlet sluice and dyke strengthening and protection etc., at KRC of CIBA, Kakdwip, Dist- south 24 Parganas, West Bengal
20. Repairs of approach road to the B and C sector farms at KRC of CIBA, Kakdwip, Dist- south 24 Parganas, West Bengal
21. Renovation of fish hatchery, RAS shed, Hilsa RAS tank, Boundary wall, quarters, staff room and generator shed at farms at KRC of CIBA, Kakdwip
22. Re-construction of three main feeder sluices of farms at KRC of CIBA, Kakdwip, Dist South 24 Parganas, west Bengal

Expansion of Laboratory building at CIBA Hqrs

Ornamental breeding facility at MES of CIBA, Muttukadu

Library & Documentation

LIBRARY AND DOCUMENTATION

CIBA library and e-resource centre has s repository of highly valuable referral books and journals pertaining to aquaculture and allied topics catering to the needs of scientists, research scholars, scientific personnel of other research organisations, academicians, university students and other stakeholders.

a. Library holdings

CIBA library currently holds more than 3,000 books including the newly procured books during the year. In addition to the e-subscription through Consortium for e-Resources in Agriculture (CeRA), CIBA library has been subscribing print volumes of national and international journals. Regional research centers at Kakdwip, West Bengal and Navasari, Gujarat also maintain library facilities. The details of Library holdings are provided in the illustration below.

b. *Library and e-Resource Centre*

The CIBA library has been upgraded as Library and e-Resource Centre with six workstations having the facility to access e-books, online journals, Institute publications and scientists' publications for easy retrieval and use by scientists and scholars.

c. Data Repository

Under the digitalization initiative, all institute publications and individual scientist's publications have been digitized and uploaded in the ICAR-KRISHI Portal. ICAR-CIBA has uploaded all the publications and technologies developed since 1987.

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. CIBA library has listed all the full content accessible online journals along with their access links in the CIBA web portal for easy retrieval by scientists and scholars. The library sent the research papers requested by scientists of various ICAR institutes under CeRA document delivery request (DDR).

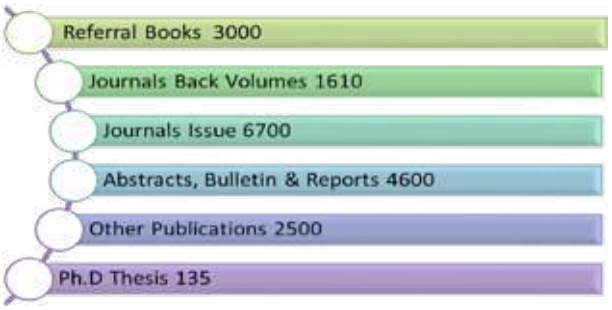
e. Exchange services

CIBA library maintains regular exchange services with national and international organisations of mutual interest in the sector. Institute's annual reports, newsletters and other research publications are being sent to various research organizations, universities and other stakeholders to update the Institute's research and development programmes. The library also receives similar services from other organizations.

f. Utilization of funds

The funds available to the tune of Rs. 6.00 lakhs were effectively utilized towards the procurement of new books, Journals, Anti-plagiarism and Grammarly software for the library users, Scientists and Staff of Headquarters, KRC and NGRC.

Library Holdings



Publications 2020

CIBA PUBLICATIONS

Annual Report 2019
CIBANews Issues 8, 9
Jaltarang Vol.6 (Hindi Magazine)

Technical Series

1. Seabass seed advisory. CIBA Technical Advisory Series-10 (English and Hindi).
2. Milkfish seed advisory. CIBA Technical Advisory Series-11 (English and Hindi).
3. Pearlspot seed advisory. CIBA Technical Advisory Series-12 (English and Hindi).
4. Long whiskers catfish seed advisory. CIBA Technical Advisory Series-13 (English and Hindi).
5. CIBA-Plankton^{Plus} - an effective plankton booster for aquaculture developed from fish waste. CIBA Technology series-20

CIBA extension series

1. Farming of Indian White shrimp, *Penaeus indicus.* ISBN 978-81-940231-5-9, Jan, 2020.
2. Brackishwater polyculture farming model with shellfish and finfish: A Gujarat perspective. ICAR-CIBA Extension Series No.73 (English and Gujarati).
3. Integrated farming system in brackishwater aquaculture ponds as a livelihood model for tribal communities of Gujarat. ICAR-CIBA Extension Series No.74 (English and Gujarati).
4. Cost effective low volume multispecies cage culture model for brackishwater finfish farming in backwater creeks: An alternative model for coastal tribal and fisher folks of Gujarat. ICAR-CIBA Extension Series No.75 (English and Gujarati).
5. Farming of Indian white shrimp, *Penaeus indicus.* ICAR-CIBA Extension Series No.76 (English and Gujarati)
6. Asian seabass nursery rearing in hapa as a livelihood security for the mangrove coastal community of maharashtra. ICAR-CIBA Extension Series No.77 (English and Marathi)
7. Cost effective low volume multispecies cage culture in mangrove based creeks as an alternative livelihood for coastal fisher folks of Maharashtra. ICAR-CIBA Extension Series No.78 (English and Marathi)
8. Nursery rearing of pearlspot in hapa as alternate livelihood income for the coastal and mangrove women self help groups of Maharashtra. ICAR-CIBA Extension Series No.79
9. Seed production technology of brackishwater catfish, *Mystus gulio:* A livelihood option for farmers of Sundarban, West Bengal. ICAR-CIBA extension series No.83.

Peer Reviewed Journals

1. Alagappan, M., Kumaran, M., 2020. A study on the information sources and influence of socio-personal attributes on information seeking behavior of aqua farmers. Int. J. Farm Sci., 10(2): 5-12.
2. Alagappan, M., Kumaran, M., 2020. Assessment of information seeking behaviour and constraints in obtaining information of public and private aquaculture extension personnel. Int. J. Farm Sci., 10(1): 104-114.
3. Antony, J., Harikrishna, V., Sudhagar, A., Reddy, A.K., Roy, L.A., 2020. Effects of salinity on growth characteristics and osmoregulation of juvenile cobia, *Rachycentron canadum* (Linnaeus 1766), reared in potassium-amended inland saline groundwater. J. World Aquac. Soc., 52(1), 155-170. (https://krishi.icar.gov.in/jspui/handle/123456789/45225)
4. Bera, A., Chadha, N.K., Dasgupta, S., Chakravarty, S., Sawant, P.B., 2020. Hypoxia-mediated inhibition of cholesterol synthesis leads to disruption of nocturnal sex steroidogenesis in the gonad of koi carp, *Cyprinus carpio*. Fish Physiol. Biochem., 46(6), 2421-2435.

5. Binesh, C.P., Jithendran, K.P., Kumar, S., Raja, A.R., Ambasankar, K., 2020. Molecular surveillance detects betanodavirus infection in farmed and wild fishes of India. J. Aquat. Biol. Fish., 8, 118-123.

6. Christina, L., Paran, B.C., Anand, P.S.S., Ghoshal, T.K., Kumar, P., Vijayan, K.K., 2020. Integrated rearing system approach in the farming of mud crab, shrimp, fish, oyster and periphyton in bracksihwater pond. Aquac. Res., 51(10), 4165-4172. (https://krishi.icar.gov.in/jspui/handle/123456789/41952)

7. Dayal, J.A., Jannathulla, R., Ambasankar, K., Muralidhar, M., 2020. *Aspergillus niger* fermented plant protein mix as a potential substitute for fishmeal in the diet of *Penaeus vannamei* (Boone, 1931). Aquac. Nutr., 26(3):853-865.doi.org/10.1111/anu.13044. (http://krishi.icar.gov.in/jspui/handle/123456789/33702)

8. De, D., Anand, P.S.S., Mukherjee, S., Kumar, P., Dayal, J.S., Raja, R.A., Bera, A., Suresh, V.R., Vijayan, K.K., 2020. Broodstock development and captive maturation of hilsa (*Tenualosa ilisha*) in a brackishwater pond-based system. J. Fish Biol., 97(3),720-733. (https://krishi.icar.gov.in/jspui/handle/123456789/41944)

9. De, D., Sandeep, K.P., Kumar, S., Raja, R.A., Mahalakshmi, P., Sivaramakrishnan, T., Ambasankar, K., Vijayan, K.K., 2020. Effect of fish waste hydrolysate on growth, survival, health of *Penaeus vannamei* and plankton diversity in culture systems. Aquaculture, 524, 735240. (https://krishi.icar.gov.in/jspui/handle/123456789/41950)

10. Durgude, A., Pathan, D., Sawant, N.S., Patil, P.A., Shelar, G., 2020. Effect of stocking densities on reproductive performance of black molly, *Poecilia sphenops* in cages. J. Entomol. Zool. Stud., (3): 2019-2023.

11. Geetha, R., Ravisankar, T., Patil, P.K., Avunje, S., Vinoth, S., Sairam, C.V., Vijayan, K.K., 2020. Trends, causes, and indices of import rejections in international shrimp trade with special reference to India: a 15-year longitudinal analysis. Aquac. Int., 28, 1341–1369. (https://krishi.icar.gov.in/jspui/handle/123456789/42915)

12. Girisha, S.K., Kusshala, K.B., Nithin, M.S., Puneeth, T.G., Kumar, B.T.N., Vinay, T.N., Suresh, T., Ajay, S.K., Venugopal, M.N., Ramesh, K.S., 2020. First report of the infectious spleen and kidney necrosis virus (ISKNV) infection in ornamental fishes in India. Transbound. Emerg. Dis., 68(2), 964-972. (https://krishi.icar.gov.in/jspui/handle/123456789/45386)

13. Hussain, T., Philipose, K.K., Jayasree, L., Kailasam, M., Biswas, G., Kumar, P., Bera, A., Subburaj, R., 2021. Cannibalism, survival and growth of Asian seabass, *Lates calcarifier* (Bloch,1790) fry in different stcoking densities. J. Exp. Zool., Indian 24(1): 147-153.

14. Jannathulla, R., Ambasankar, K., Dayal, J.S., Rajesh, B., Sravanthi, O., Kalanjiyam, M.R., 2020. A comparative study on the physico-chemical quality indices of whole, commercial and refined wheat flours: Emphasis on essential amino acid index for three major penaeid shrimp species cultured in India. Indian J. Fish., 67(2), 48-54. (https://krishi.icar.gov.in/jspui/handle/123456789/42621)

15. Jannathulla, R., Dayal, J.S., Ambasankar, K., Chitra, V., Muralidhar, M., 2020. Effect of water salinity on tissue mineralisation in *Penaeus vannamei* (Boone, 1931). Indian J. Fish., 67(1),138-145. (https://krishi.icar.gov.in/jspui/handle/123456789/45009)

16. Jannathulla, R., Yuvapushpa, R., Claret, E.A., Gopikrishna, G., Ambasankar, K., Muralidhar, M., Dayal, J.S., 2020. A study on apparent digestibility coefficients of dry matter, protein, energy and amino acids for untreated and fermented guar meal in *Penaeus indicus* (Edwards, 1837) and *Penaeus monodon* (Fabricus, 1798). Aquac. Res., 51(5), 2155-2159. (https://krishi.icar.gov.in/jspui/handle/123456789/45008).

17. Jayanthi, M., 2020. Assessment of land and water ecosystems capability to support aquaculture expansion in climate vulnerable regions using analytical hierarchy process based geospatial analysis. J. Environ. Manage., 270, 110952. (https://krishi.icar.gov.in/jspui/handle/123456789/44656)

18. Jayanthi, M., Duraisamy, M., Thirumurthy, S., Samynathan, M., Sabyasachi, K., Manimaran, K., Muralidhar, M., 2020. Ecosystem characteristics and environmental regulations based geospatial planning for sustainable aquaculture development. Sci. Rep., 31(16), 2430-2445. (https://krishi.icar.gov.in/jspui/handle/123456789/41946)

19. Jayanthi, M., Balasubramaniam, A.A.K., Suryaprakash, S., Ravisankar, T., Duraisamy, M., Manimaran, K., Bera, A., Puthiavan, R., Sivagnanam, S., 2020. Assessment of the new generation aeration systems efficiency and water current flow rate, its relation to the cost economics at varying salinities for *Penaeus vannamei* culture. Aquac. Res., 51(5), 2112-2124. (https://krishi.icar.gov.in/jspui/handle/123456789/41945)

20. Jayasankar, V., Tomy, S., Wilder, M.N., 2020. Insights on molecular mechanisms of ovarian development in decapod Crustacea: Focus on vitellogenesis-stimulating factors and pathways. Front. Endocrinol., https://doi.org/10.3389/fendo.2020.577925. (https://krishi.icar.gov.in/jspui/handle/123456789/45223)

21. Kirubasankar, R., Kumar, K.L., Raymond, J.A.J., Salim, S.S., Saravanan, K., Krishnan, P., Ravikumar, T., Roy, S.D., 2020. Impact evaluation of marine fisheries interventions among tribal fisher commune of Car Nicobar Island, India. J. Mar. Biol. Ass. India, 62(1),84-89. (https://krishi.icar.gov.in/jspui/handle/123456789/41955)

22. Kirubasankar, R., Krishnan, P., George, G., Kumar, K.L., Raymond, J.A.J., Saravanan, K., Roy, S.D., 2021. Fisheries governance in the tropical archipelago of Andaman and Nicobar–opinions and strategies for sustainable management. J. Coast. Conserv., 25(1):1-13.

23. Kripa, M. K., Lele, N., Panda, M., Das, S.K., Nivas, A.H.,, Divakaran, N., Sawant, A., Gaonkar, S.N., Pattnaik, A. K., Samal, R.N., Thangaradjou, T., Saravanakumar, A., Rodrigues, B.F., Roy, S.D., Sankar, R.K., Kumar, L., Raymond, J.A.J., Raghavan, P., Mankad, A.U., Murthy, T.V.R., 2020. Biodiversity assessment of Indian mangroves using insitu observations and remotely sensed data. Biodiversity, 21(4),198-216.

24. Kumar, J.A., Kumar, K.V., Avunje, S., Akhil, V., Ashok, S., Kumar, S., Sivamani, B., Grover, M., Rai, A., Alavandi, S., Vijayan, K.K., 2020. Phylogenetic relationship among brackishwater Vibrio species. Evol. Bioinform., 16: 1-8, https://doi.org/10.1177/ 1176934320903288.

25. Kumar, K.V., Shekhar, M.S., Kumar, J.A., Prabhudas, S.K., Krishnan, K., Nimisha, K., Balasubramanian, C. P., Baghel, D.S., Vijayan, K. K., Jena, J.K., Mohapatra, T., 2020. Novel isoform sequencing based full-length transcriptome resource for Indian white shrimp, *Penaeus indicus*. Front. Mar. Sci., https://doi.org/10.3389/fmars.2020.605098. (https://krishi.icar.gov.in/jspui/handle/123456789/45224)

26. Kumar, N., Gupta, S.K., Chandan, N.K., Bhushan, S., Singh, D.K., Kumar, P., Kumar, P., Goraksha, C.W., Singh, N.P., 2020. Mitigation potential of selenium nanoparticles and riboflavin against arsenic and elevated temperature stress in *Pangasianodon hypophthalmus*. Sci. Rep., 10, 17883. (https://krishi.icar.gov.in/jspui/handle/123456789/45384)

27. Kumar, P., Biswas G., Ghoshal, T.K., Christina, L., Behera, P., Kailasam, M., 2020. Effect of salinity acclimatisation oand administration of hormones on oocyte maturation, ovulation and spawning of goldspot mullet *Liza parsia* (Hamilton, 1822) reared in brackishwater pond. Indian J. Fish., 67(1), 56-63. (https://krishi.icar.gov.in/jspui/handle/123456789/41953)

28. Kumar, P., De, D., Biswas, G., 2020. Age at stocking is a decisive factor on growth and survival of the Indian shad, *Tenualosa ilisha* during nursery rearing in fertilized earthen ponds. Aquaculture, 533, 73611. (https://krishi.icar.gov.in/jspui/handle/123456789/45381)

29. Kumar, P., Kailasam, M., Biswas, G., Christina, L., Ghoshal, T.K., 2020. Effect of different inducing hormones, sex ratio and oocyte diameter on breeding performance of brackish water catfish, *Mystus gulio*. Aquaculture, 530, 735821.

30. Kumaran, M., Anand, P.R., Vijayakumar, S., Vimala, D.D., Jayanthi, M., Sairam, C.V., Vijayan, K.K., 2021. Socio-economics and livelihood status of coastal fishers in the Puducherry union territory of India – An exploratory study. Indian J. Fish., 68(1): 82-91.

31. Kumaran, M., Geetha, R., Antony, J., Vasagam, K.P.K., Anand, P.R., Ravisankar, T., Raymond, J.A.J., De, D., Muralidhar, M., Patil, P.K., Vijayan, K.K., 2020. Prospective impact of Corona virus disease (COVID-19) related lockdown on shrimp aquaculture sector in India – a sectoral assessment. Aquaculture, 531, 735922. (https://krishi.icar.gov.in/jspui/handle/123456789/42914)

32. Kumaran, M., Sundaram, M., Mathew, S., Anand, P.R., Ghoshal, T.K., Kumararaja, P., Raja, R.A., Anand, P.S.S., Vijayan, K.K., 2020. Is Pacifc white shrimp (*Penaeus vannamei*) farming in India sustainable? A multidimensional indicators-based assessment. Environ. Dev. Sustain., 23, 6466–6480. (https://krishi.icar.gov.in/jspui/handle/123456789/42916)

33. Mandal, B., Kailasam, M., Bera, A., Sukumaran, K., Hussain, T., Makesh, M., Thiagarajan, G., Vijayan, K.K., 2020. Gonadal recrudescence and annual reproductive hormone pattern of captive female Spotted Scats (*Scatophagus argus*). Anim. Reprod. Sci., 213, 106273. (https://krishi.icar.gov.in/jspui/handle/123456789/41954)

34. Mohanty, S., Makesh, M., Rajendran, K.V., Babu, S., Anand, D., Kumar, S., Kumar, A., Baitha, R., Sarma, K., 2020. Production and characterisation of monoclonal antibodies against immunoglobulins of *Cirrhinus mrigala* (Hamilton 1822). Indian J. Fish., 67(2), 55-61. (https://krishi.icar.gov.in/jspui/handle/123456789/41959)

35. Mojzesz, M., Rakus, K., Chadzinska, M., Nakagami, K., Biswas, G., Sakai, M., Hikima, J., 2020. Cytosolic sensors for pathogenic viral and bacterial nucleic acids in fish. Int. J. Mol. Sci., 21(19), 7289. (https://krishi.icar.gov.in/jspui/handle/123456789/45387)

36. Navaneeth, K.A., Bhuvaneswari, T., Rajan, J.J.S., Alavandi, S.V., Vijayan, K.K., Otta, S.K., 2020. Characterization of *Vibrio parahaemolyticus* isolates from shrimp farms of southeast coast of India with special reference to Acute Hepatopancreatic Necrosis Disease (AHPND) status. Aquaculture, 518, 734813. (https://krishi.icar.gov.in/jspui/handle/123456789/45379)

37. Otta, S.K., Hoque, F., 2020. Health management in coastal aquaculture system. J. Indian Soc. Coastal Agric. Res., 38(2), 38-42. (https://krishi.icar.gov.in/jspui/handle/123456789/45226)

38. Panigrahi, A., Das, R.R., Sivakumar, M.R., Saravanan, A., Saranya, C., Sudheer, N.S., Vasagam, K.K., Mahalakshmi, P., Kannappan, S., Gopikrishna, G., 2020. Bio-augmentation of heterotrophic bacteria in biofloc system improves growth, survival, and immunity of Indian white shrimp *Penaeus indicus*. Fish Shellfish Immunol., 98, 477-487. https://krishi.icar.gov.in/jspui/handle/123456789/41948

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44. Saikrithi, P., Balasubramanian, C.P., Otta, S.K., Tomy, S., 2020. Expression dynamics of solute carrier family 15 member 4 (SLC15A4) and its potential regulatory role in ovarian development of the Indian white shrimp, *Penaeus indicus*. Mol. Biol. Rep., 47, 3797–3805. (https://krishi.icar.gov.in/jspui/handle/123456789/42623)

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Popular Articles

1. Biswas, G., Bera, A., Mandal, B., Kailasam, M., Vijayan, K.K., 2020. A sustainable and profitable brackishwater finfish farming model for milkfish, *Chanos Chanos* (Success story of Mr. Amalesh Chaterjee). Special Issue: Proceedings of the Brackishwater Aquaculture. Farmers Conclave-2020 (BAFAC– 2020) Aquaculture Spectrum, 3(5), 17-19.

2. De, D., Sandeep, K.P., Mahalakshmi, P., Vijayan, K.K., 2020. Enhancing aquaculture production using recycled fish waste: Novel ICAR - CIBA technology (ICAR-CIBA Plankton Plus) scores in farm trials. Aquaculture Spectrum, 3(12), 25-30.

3. Kaushik, A. H., Hussain, T., Kailasam, M., Patil, P.K., Thiagarajan, G., 2020. Satellite nursery for seabass fish an innovative approach. May 2020. Aquaculture Spectrum, 3(5): 79-81.

4. Kumar, P., Ghoshal, T.K., Das, S., Chandda, M., 2020. Homestead modular hatchery technology of brackishwater catfish, *Mystus gulio*: A potential alternate livelihood option for small and marginal farmers of Sunderban. Aquaculture Asia, 24(3), 22-28. (https://krishi.icar.gov.in/jspui/handle/123456789/45385)

5. Kumar, P., Shekhar, M.S., Sukumaran, K., Kumar, S., Suvana, S., Vijayan, K.K., 2021. Seed production and farming of brackishwater catfish. ICAR-Kheti-Matsya visaesyank (Hindi), 58-60.

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9. Patil, P., Hussain, T., Palav, K., Kailasam, M., Sairam, C.V., Subburaj, S., Ambasankar, K., Vasudevan, N., Vijayan, K.K., 2020. Cage culture of seabass and pearlspot in mangrove-based creeks as an alternate livelihood for the mangrove coastal community of Sindhudurg, Maharashtra – A success story. Aquaculture spectrum 3(5):21-26.

10. Poornima, M., Raymond, J. A. J., Thomas, D., Alavandi, S.V., 2020. Introduction of exotic fish species in reservoir ponds in India: Risks and challenges. Aqua tech bilingual magazine (April): 83-90.

11. Ravisankar, T., Kumaran, M., Geetha, R., Sairam, C.V., 2020. Credit and insurance requirements for sustainable aquaculture development. Aquaculture Spectrum (Spl. Issue): 24-46.

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13. Sukumaran, K., Vasagam, K.P.K., Mandal, B., Biswas, G., Hussain, T., Bera, A., Kailasam, M., Vijayan, K.K., 2020. Advances made at ICAR-CIBA in seed production technology of pearlspot. Jaltarang, 6:69-72.

14. Thomas, D., Rekha, M.U., Raymond, J.A.J., Sukumaran, K., Kailasam, M., Vijayan, K.K., 2020. Silver moony (Monos) the butterflies of brackishwater habitat in aquaculture spectrum. The Indian Aquaculture Magazine, 3(10), 10.

BOOKS/BOOK CHAPTER

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2. Bera, A., Kailasam, M., Mandal, B., Ambasankar, K., Sivaramakrishnan, T., Sukumaran, K., Makesh, M., Biswas, G., Babu, D.R.,, Thiagarajan, G., Vijayan, K.K., 2020. Milkfish *Chanos chanos*. In: Kailasam, M., Kumaraguru Vasagam, K.P., Sukumaran, K., Bera, A. (Eds.), A handbook on candidate finfish species suitable for brackishwater aquaculture (ISBN: 978-81-945379-0-8). ICAR-CIBA, Chennai, 10-13.

3. Kailasam, M., Hussain, T., Bera, A., Thomas, D., Sivaramakrishnan, T., Makesh, M., Rajababu, D., Vijayan, K.K., 2020. Mangrove red snapper *Lutjhanus argentimaculatus*. In: Kailasam, M., Kumaraguru Vasagam, K.P., Sukumaran, K., Bera, A. (Eds.), A handbook on candidate finfish species suitable for brackishwater aquaculture (ISBN: 978-81-945379-0-8). ICAR-CIBA, Chennai, 21-23

4. Kailasam, M., Vasagam, K.P.K., Sukumaran, K., Bera, A., 2020. A handbook on candidate finfish species suitable for brackishwater aquaculture. ICAR-CIBA ISBN No. 978-81-945379-0-8.

5. Kumaran, M., 2021. Nursery rearing of Asian Seabass *(Lates calcarifer)* in estuarine waters for the livelihood security of coastal fishers of Puducherry – a success story. In M.Kumaran et al. (Eds.) Innovative Approaches and Success Stories of Brackishwater Aquaculture Farmers (second edition), *ICAR-Central Institute of Brackishwater Aquaculture, Chennai, ISBN No: 978-81-940231-2-8, 133-139.*

6. Kumaran, M., Vimala, D.D., Muralidhar, M., Sairam, C.V., Sukumaran, K., Anand, P.R., Vijayan, K.K., 2021. Innovative Approaches and Success Stories of Brackishwater Aquaculture Farmers (second edition), *ICAR-Central Institute of Brackishwater Aquaculture, Chennai, ISBN No: 978-81-940231-2-8, 168p.*

7. Mohanty, B.P., Ganguly, S., Mahanty, A., Mitra, T., Patra, S., Karunakaran, D., Mathew, S., Chakraborty, K., Paul, B.N., Sarma, D., Dayal, J.S., Singh, S., Ayyappan, S., 2019. Fish in human health and nutrition. In: Advances in Fish Research, Vol VII. Narendra Publishing House, New Delhi, ISBN: 978-93-87590-48-9, 189-218.

8. Patil, P.A., Hussain, T., Palav, K.V., Patil, S.M., Palav, K.V., Sanaye, S., Kailasam., M., Sairam, C.V., Subburaj, R., Mukesh, M., Kumaraja, P., Jayanthi, M., Balasubramanian, C.P., Ambasankar, K., Vijayan, K.K., 2020. Brackishwater cage culture of candidate species in diverse rearing systems for alternative livelihood and societal development in Maharashtra, Published by ICAR- *ICAR-Central Institute of Brackishwater Aquaculture, Chennai,* pp 133.

9. Poornima, M., Kathyayani, S.A., 2020. Brief synopsis on metagenomic studies on circular, rep-encoding single-stranded (CRESS) DNA viruses of diverse aquatic milieus. In:Research Trends in Life Sciences (Volume – 4), B.S. Chandel (ed.) AkiNik Publications, New Delhi (ISBN: 978-93-90322-67-1), 43-65.

10. Sukumaran, K., Thomas, D., Rekha, M.U., Raymond, J.A.J., Bera, A., Makesh, M., Ambasankar, K., Kailasam, M., Vijayan, K.K., 2020. Grey mullet *Mugil cephalus*. In: Kailasam, M., Kumaraguru Vasagam, K.P., Sukumaran, K., Bera, A. (Eds.), A handbook on candidate finfish species suitable for brackishwater aquaculture (ISBN: 978-81-945379-0-8). ICAR-CIBA, Chennai, 18-20.

11. Sukumaran, K., Vasagam, K.P.K., Thomas, D., Rekha, M.U., Mandal, B., Biswas, G., Babu, D.R., Vijayan, K.K., 2020. Pearlspot *Etroplus suratensis*. In A handbook on candidate finfish species suitable for brackishwater aquaculture. P16.

12. Tomy, S., 2021. Estrogenic regulation of reproduction in teleosts. In: Sundaray J.K., Rather M.A., Kumar S., Agarwal D. (eds), Recent updates in molecular Endocrinology and Reproductive Physiology of Fish. Springer, Singapore. https://doi.org/10.1007/978-981-15-8369-8_3

ORAL PRESENTATIONS

1. Bera, A., Kailasam, M., Babita, M., Sukumaran, K., Makesh, M., Sivaramakrishnan, T., Subburaj, R., Thiagarajan, G., Vijayan, K.K., 2020. Effect of algae based enriched rotifers feeding on the differential growth, and survival of milkfish (*Chanos chanos*) during hatchery rearing. National Conference on Recent Advances In Aquaculture (NCRAA 2020), Sir Theagaraya College, Chennai, 6-7 February, 2020. pp.46

2. Biju, I.F., Antony, J., Anand, P.S.S., Balasubramanian, C.P., Aravind, R., Rajamanickam, S., Vijayan, K.K., 2020. Reproductive performance, larval growth and salinity tolerance of penaeid shrimp *Penaeus japonicus* Form II from southeast coast of India. In Joshi, K. K. et al. Marine Ecosystems Challenges and Opportunities (MECOS 3).

3. James, N., Tomy, S., Otta, S.K., Balasubramaniam, C.P., 2020. Molecular traces of glycoprotein hormones A2 and B5 and their role in reproduction and larval development of the Indian white shrimp, *Penaeus indicus*. In: International Conference on Impact of Climate Change on Hydrological Cycle, Ecosystem, Fisheries and Food security (ClimFishCon 2020). Book of Abstracts, February 11-14, 2020, Kochi, 95-96.

4. Kumaran, M., 2020. Fisheries extension-making it vibrant and demand driven. National virtual workshop on Fisheries Extension, College of Fisheries West Bengal, 17th July, 2020.

5. Kumaran, M., 2020. Reaching the un reached shrimp farmers during COVID-19. Lead paper presented in the National Seminar on 'Fisheries Supply Chain Dynamics during COVID-19', Fisheries College, Tripura, 8th June, 2020.

6. Makesh, M., Vijayan, K.K., 2020. Vaccines for managing viral diseases of marine fish. Lead Paper presented at International conference of virology (VIROCON 2020) on Evolution of viruses and viral diseases organized by the Indian Virological Society in collaboration with Indian National Science Academy, at Indian National Science Academy, New Delhi, 18-20, February, 2020.

7. Poornima, M., 2020. Emerging diseases in shrimp farming presented on in the Brackishwater Aquaculture Farmers Meet' organized by ICAR-CIBA at Guduru, SPSR Nellore District, Andhra Pradesh on 18th December 2020.

8. Poornima, M., Priyadarshini, S.K., 2020. Wastewater-based epidemiology (WBE) approaches for detection of SARS-CoV-2 in the Covid-19 pandemic: A concise review analysis presented online orally. In: International E-conference on "Recent Trends in Drug Discovery, Diagnostics and Therapeutics: A special emphasis on COVID19" organized by the Department of Biotechnology, VIGNAN's Foundation for Science, Technology & Research in association with Kansas State University, LLB School, AP Akademie of Sciences and Al-Quds University during 2-4 July, 2020 and adjudged as Third best prize under oral presentation category.

9. Poornima, M., Subramanian, S.K., Yengkhom, O., 2020. Tilapia: versatile species introduction vs Indian perspective on Status, concerns and challenges to fisheries biodiversity. Presented in the International Conference on Emerging Trends in Biotechnology (ICETB)" organized by the School of Biosciences and Technology and Association of Biotechnology and Pharmacy at at Vellore Institute of Technology, Vellore, Tamil Nadu, India during 14-16 December, 2020, p 154.

10. Raja, A.R., Patil, P.K., Avunje, S., Jithendran, K.P., Alavandi, S.V., Vijayan, K.K., 2020. Controlling parasitic infestations in commercially important fish through oral administration of emamectin benzoate. Presented in a virtual conference "Fifth National Conference on Agricultural Scientific Tamil" organized by Agricultural Scientific Tamil Society, New Delhi and Tamil Nadu Agricultural University, Coimbatore during 9-10th October, 2020.

11. Raja, A.R., Patil, P.K., Avunje, S., Kumaran, M., Anand, P.R., Alavandi, S.V., Vijayan, K.K., 2020. First report on natural infestation of an anchor worm, *Lernaea cyprinacea* Linnaeus, 1758 in cage culture of Asian Seabass, *Lates calcarifer* fry and testing the efficacy of an anti-parasitic drug, emamectin benzoate. Presented in a virtual conference "Sixth National Conference on Agricultural Scientific Tamil" organized by Agricultural Scientific Tamil Society, New Delhi, 21-22nd December 2020.

12. Raja, A.R., Sukumaran, K., Jithendran, K.P., Vijayan, K.K., 2020. Infestation of gill copepod *Lernanthropsis mugilii* and its effect on grey mullet *Mugil cephalus*. Presented in the "Third International symposium on Marine Ecosystems Challenges and Opportunities (MECOS3)" organized by the Marine Biological Association of India (MBAI) during 7-10th January, 2020 at Kochi. p. 475-476. ISBN No. 978-93-82263-37-1.

13. Saikrithi, P., Tomy, S., Balasubramanian, C.P., Otta, S.K., 2020. Involvement of serotonin and dopamine receptors in the neuroendocrine mediation of vitellogenesis in *Penaeus indicus*. In: International Symposium MECOS3 Marine Ecosystems Challenges and Opportunities-3 (MECOS3). Book of Abstracts, MBAI CMFRI, January 7-10, 2020, Kochi, 426-427.

14. Thomas, D., Bera, A., Rekha M.U., Raymond J.A.J., Kailasam, M., Vijayan, K.K., 2020. Silver moony (*Monodactylus argenteus*) and silver fish (*Chanos chanos*) – The potential ornamental fish species in brackishwater aquariculture. National Conference on Recent Advances in Aquaculture (NCRAA 2020), Chennai, 6-7 February, 2020.

Participation in Meetings / Workshops / Seminars / Conferences / Symposia

DIRECTOR

1. International Symposium on Marine Ecosystems Challenges and Opportunities (MECOS 3), organized by Marine Biological Association of India (MBAI) organized by CMFRI, Kochi held during 7-9 January 2020
2. Aqua India – 2020, organized by Society of Aquaculture Professionals at Le Royal Meridian Kochi held during 31st January - 1 February 2020
3. International Conference on Impact of climate change on Hydrological Cycle Ecosystem, Fisheries and Food Security (ClimFishCon 2020) jointly organized by Cochin University of Science and Technology, School of Industrial Fisheries, Kochi Department of Fisheries, Kerala held during 12-13 February 2020
4. Brackishwater Aquaculture Farmers' Conclave (BAFAC – 2020) organized by CIBA at Surat held during 19-20 February 2020
5. Directors Conference through Video Conferencing organized by Director General, ICAR at New Delhi held on 19th March 2020
6. ICAR Director's Meeting organized by Director General, ICAR, New Delhi held on 10th April 2020
7. Virtual Meeting of the Director of Fisheries Institutes, organized by DDG (Fy.), ICAR at SMD (Fisheries) ICAR, New Delhi held on 13th April 2020
8. Virtual SFC Meeting of ICAR-CIBA, organized by DDG (Fy.) at SMD (Fisheries) ICAR, New Delhi on 29th May 2020
9. Expert Committee on Inland Fishery Resources (ECIFR), organized under the co-chairmanship of Joint Secretary (M.Fy.) and Joint Secretary (I.Fy.), Department of Fisheries, Ministry of Fisheries and Animal Husbandry, Govt. of India at Krishi Bhavan, New Delhi through online held on 10th June 2020
10. Virtual Meeting of the Director of Fisheries Institutes, organized by DDG (Fy.), ICAR at SMD (Fisheries) ICAR, New Delhi held on 10th June 2020
11. Webinar scheduled with Rapid Rural Community Response to COVID-19 (RCRC) at ICAR, New Delhi held on 3rd July 2020
12. Virtual Meeting of the Directors of Fisheries Research Institutes and the Senior Officers of the Fisheries Science, SMD with regard to the relevant points discussed in the ICAR SoC meeting pertaining to the Institutes, organized by DDG (Fy.), ICAR at SMD (Fisheries) ICAR, New Delhi held on 15th July 2020
13. 92nd Foundation Day of ICAR through Video Conferencing at ICAR, New Delhi held on 16th July 2020
14. Sensitization workshop on Standardized Scheme Proces in ICAR – ERP system and other FMS issues, organized by IASRI, New Delhi through online on 23rd July 2020
15. Webinar on the Topic "Biotechnology as Driver of Aquaculture", at School of Earth Ocean and Atmospheric Science, Goa University, Goa held on 27th July 2020
16. Virtual Meeting of the Directors of Fisheries Institutes and Senior Officers of SMD, organized by DDG (Fy.), ICAR on 11 August 2020
17. Inauguration of Academic and Administrative building in Rani Lakshmi Bai Central Agricultural University, by Hon'ble PM through online on 29th August 2020
18. National consultation on broodstock, seed, feed for enhancing production and productivity in aquaculture and promotion of fisheries exports, organized under the Chairmanship of Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying through online held on 4th September 2020
19. Virtual Meeting to discuss the issues regarding problems being faced by Indian seafood exporters on account of

detection of antibiotics residues and OIE listed pathogens in the exported consignments by importing countries and comprehensive strategy to ensure that the fisheries sector regains its momentum after being impacted by COVID 19 and achieves the envisaged target of doubling exports by 2024-25, under the Co-chairmanship of Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying held on 7th September 2020

20. Virtual Meeting with the Deputy Director General (Fisheries), ICAR held on 8th September 2020
21. Sixty fourth meeting of the Coastal Aquaculture Authority at CAA, Chennai through online on 9th September 2020
22. Virtual Programme on Foundation laying of various academic facilities and inauguration of "School of Agri-business and Rural Development" of Dr.Rajendra Prasad Central Agricultural University, Samastipur Bihar, by Hon'ble Prime Minister held on 10th September 2020
23. 62nd Executive Committee and 27th General Body Meetings of Rajiv Gandhi Centre for Aquaculture at MPEDA, Kochi through online held on 11th September 2020
24. Introductory meeting of Third Party Evaluation of DARE/ICAR schemes, under Fisheries Science Division, under the Chairmanship of DDG (Fisheries), ICAR through online held on 11th September 2020
25. Virtual Meeting with the Deans of Fisheries Colleges and Directors of ICAR Fisheries Institutes regarding PMMSY, under the Chairmanship of the Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, GOI held on 14th September 2020
26. Virtual Interaction Meeting with all the Deans of Fisheries College with Department of Fisheries under the Chairmanship of the Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India with regard to the overall development of Fisheries and Aquaculture in the country in general and implementation of Prime Minister's Matshya Sampada Yojana (PMMSY) held on 16th September 2020
27. Virtual Meeting to discuss on the events to celebrate the conclusion of the two-year long commemoration period of 150th Birth Anniversary of Mahatma Gandhiji on 2nd October, organized by the Secretary, DARE and Director General, ICAR held on 17th September 2020
28. Webinar on "Hydrography. Fisheries and Blue Economy", organized by the Indian High Commission at Nairobi held on 22nd September 2020
29. 4th Meeting of the Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) jointly chaired by Joint Secretary (Marine) and Joint Secretary (Inland), through Video-Conference held on 24th September 2020
30. Virtual Meeting of the Directors of Fisheries Institutes with British High Commission on ''Seed Funding and Research Linkage", organized by DDG (FY.), ICAR, New Delhi held on 9th October 2020
31. Ninety Fifth Meeting of the Board of Management of TamilNadu Veterinary and Animal Sciences University through online held on 14th October 2020
32. Online Webinar on the occasion of World Food Day and 75th Anniversary of Food and Agriculture Organization wherein Hon'able Prime Minister, Shri Narender Modi, Govt. of India released a Commemorative Coin and 17 fortified varieties of eight crops developed by ICAR, on the occasion held on 16th October 2020
33. Virtual Conference on "Sustainable, Technology led and responsible development of fishery sector" organized by CII held on 19th October 2020
34. Senior Officers Meeting of Fisheries SMD through online held on 17th November 2020
35. E-conference on "Innovation for transforming the sustainable marine economy held on 20th November 2020
36. Virtual Meeting of Directors and OICs of Research Centres for discussion on Online Training Programmes of ICAR-DOF Convergence held on 2nd December 2020
37. Monthly Meeting of Directors & Fisheries SMD through online held on 15th December 2020

SCIENTISTS

1. Third International symposium on Marine Ecosystems Challenges and Opportunities (MECOS3) organized by the Marine Biological Association of India (MBAI) during 7-10th January, 2020 at Kochi – Dr. Sherly Tomy, Dr. R.Ananda Raja, Shri I.F.Biju
2. Bengal Aqua Expo at Nachinda, Purba Medinipur on 3rd February, 2020 – Dr.Sanjoy Das
3. Vision and Mission Workshop on Initiating a partnership for healthy mangroves, thriving coastal communities, and a robust aquaculture value chain in the Sundarbans: India, Bangladesh, and beyond organized by Global Nature Fund, German and Collective Leadership Institute during 3-4th February, 2020 - Dr. Debasis De
4. Brackishwater Aquaculture Farmers Conclave (BAFAC-2020), during 19-20th February, 2020 in Surat, Gujarat - Dr. Debasis De, Shri Pankaj Patil
5. Oral presentation in National Conference on Recent Advances In Aquaculture (NCRAA 2020), Sir Theagaraya College, Chennai during 6-7th February, 2020 Dr.Aritera Bera
6. Delivered an Invited talk on 'Emerging shrimp diseases with special reference to prevention and control measures' at a training programme organized by Export Inspection Agency, Kolkata on 29th February, 2020 – Dr.Sanjoy Das
7. "150 years of science through the pages of nature" organized by Nature India and MSSRF, Chennai on 6th March 2020 at Taramani, Chennai - Shri I.F.Biju
8. Webinar: Introducing ISO Seq; the present and future of Transcriptome studies conducted by Nucleome information Pvt Ltd, Hyderabad, 29th April 2020 - Dr. M.S. Shekhar
9. CPCSEA meeting by video conferencing at Madras Veterinary College (MVC), Chennai on 20th April 2020 - Dr. R.Ananda Raja
10. Webinar on 'Eukaryotic genome sequencing and hybrid assembly approaches, conducted by Nucleome information Pvt Ltd, Hyderabad, 8th May 2020 - Dr. M.S. Shekhar
11. Challenges and Opportunities in post Covid Era for Human and Shrimp Industry, organized by ICAR-CIFE on 20th May, 2020 - Dr.Prem Kumar
12. Online meeting on "Network project on Ornamental Fish Breeding and Culture (NPOFBC)" on 21st May 2020 hosted by CMFRI, Kochi- Shri Tanveer Hussain
13. CIBA Digital Conference on "Brackishwater aquaculture scenario in India with Focus on shrimp Farming during COVID-19: Challenges and Way Forward" 3rd June 2020 - Dr. M.S. Shekhar, Dr.Syama Dayal, Dr. R.Ananda Raja, Dr. Krishna Sukumaran, Dr.Aritera Bera
14. Consultation workshop for "After-Amphan situation of Sundarban blocks on agriculture and allied sector" organized by State Agriculture Management and Extension Training Institute, West Bengal on 4th June, 2020 -- Dr. Debasis De
15. Webinar on Biodiversity for natural resources. 05th June, 2020, conducted by ICAR-CIBA - Dr.Syama Dayal, Dr. Debasis De, Dr. Krishna Sukumaran, Dr.Aritera Bera, Dr. Premkumar
16. Delivered a lecture for online class on Aquatic Animal Health in Aquaculture on 10-6-2020 for the MFSc and BFSc students of West Bengal University of Animal & Fishery Sciences – Dr.Sanjoy Das
17. ISVPT Webinar on Animal Models: Challenges and Future by Dr. A. Sankaranarayana, President, Vivo BioTech Ltd., Hyderabad on 27th June 2020 – Dr. R.Ananda Raja
18. CIBA Digital Conference on New-Age Technologies for Sustainable Brackishwater Aquaculture, 18th July 2020 - Dr. M.S. Shekhar, Dr.Syama Dayal, Dr. Debasis De, Dr. R.Ananda Raja, Dr. Krishna Sukumaran, Dr.Prem Kumar, Dr.Aritera Bera
19. Webinar on: Pearlspot Seed Production and Aquaculture-Present status and future prospects with reference to Kerala state on 7th August 2020 organized by ICAR-CIBA – Dr. R.Ananda Raja
20. National Webinar on "COVID pandemia-herbal solutions for health care of livestock and poultry" held on 13–14th August 2020 organised by the Department of Veterinary Pharmacology and Toxicology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu, India –– Dr. R.Ananda Raja

21. ICAR-CIFA -NFDB Virtual Stakeholder Consultation, organized by ICAR-CIFA on 19-20th August, 2020 - Dr.Prem Kumar
22. Perspectives of Private Sector Stakeholders and Developmental Agencies in Accelerating Freshwater Aquaculture Development, organized by ICDAR-CIFA on 25th August, 2020 – Dr.Prem Kumar
23. National Webinar on "Impact of COVID-19 on Dairying, Poultry and Fisheries" held on 29th August 2020 organized by Indian journal of animal health – Dr. R.Ananda Raja
24. International Webinar on "Phage directory: Making the world's phages more accessible, manageable and shareable" held on 3rd September 2020 organized by the Society for bacteriophage research and therapy – Dr. R.Ananda Raja
25. E Conference on "Alternatives to animal experimentation in pharmacology" organized by the Department of Pharmacology, V.V. Institute of Pharmaceutical Sciences, Seshadri Rao Knowledge Village, Gudlavalleru Post, Krishna District, Andhra Pradesh in association with Acharya Nagarjuna University, College of Pharmaceutical Sciences, Nagarjuna Nagar, Guntur District, Andhra Pradesh on 3-4th September 2020 – Dr. R.Ananda Raja
26. Webinar on "Orientation to Funding Opportunities for Investors in Aquaculture under PMMSY & FIDF", 8th September 2020 - Dr. M.S. Shekhar
27. Online International Seminar on "Diagnostic Veterinary Pathology" on 12th September 2020 organized by the Department of Veterinary Pathology, Madras Veterinary College, Chennai-600007 – Dr. R.Ananda Raja
28. International Webinar on "Novel Approaches and Emerging issues in Parasitic Diseases of Veterinary and Medical Importance" organized by the Department of Veterinary Parasitology, Veterinary College, Bengaluru during 16-18th September 2020 – Dr. R.Ananda Raja
29. 7th meeting of Scientific Advisory committee of Sasya Shyamala Krishi Vigyan Kendra, Ramkrishna Mission Vivekananda Educational and Research Institute on 25th September, 2020 - Dr. Debasis De
30. Webinar on RAISE 2020 - Responsible AI for Social Empowerment. 5-9th October 2020 - Dr. M.S. Shekhar
31. Regional 25th ICAR Regional Committee-II meeting on 8th October, 2020 - Dr. Debasis De
32. Virtual conference "Fifth National Conference on Agricultural Scientific Tamil" organized by Agricultural Scientific Tamil Society, New Delhi and Tamil Nadu Agricultural University, Coimbatore during 9-10th October 2020 – Dr. R.Ananda Raja
33. Vishwik Bharatiya Vaigyanik Summit (VAIBHAV), Modern Fisheries, Aquaculture and Seed production, organized by DRDO-CIFA on 16th October, 2020 - Dr. Prem Kumar
34. Webinar on Biofloc based Aquaculture: A way forward" held on 6th November 2020 – Dr. R.Ananda Raja
35. IAEC meeting of Melmaruvathur Adhiparasakthi Institute of Medical Sciences and Research (MAPIMS) on 20th November 2020 – Dr. R.Ananda Raja
36. Webinar on Innovation for Transforming the Sustainable Marine Economy Way forward to Self-Reliant India, 20th November 2020 - Dr. M.S. Shekhar
37. Webinar on Antimicrobial Awareness Talk on World Antimicrobial Awareness Week - 2020 celebration on 24th November 2020 – Dr. R.Ananda Raja
38. "AQUAEXPO 2020" Exhibition on 7-8th December, 2019 at Surat, Gujarat – Shri Pankaj Patil
39. International webinar on "Beauty and the Beast: Important Parasites of Fish" from Bangkok on 09th December 2020 – Dr. R.Ananda Raja
40. Scientific Advisory committee of Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, South 24 Parganas on 19th December, 2020 -- Dr. Debasis De
41. Virtual conference "Sixth National Conference on Agricultural Scientific Tamil" organized by Agricultural Scientific Tamil Society, New Delhi during 21-22nd December 2020 – Dr. R.Ananda Raja

INVITED LECTURES

1. Delivered an invited talk on Indigenous micro-feeds for Indian Aquaculture and aquariculture: Challenges and opportunities in the 3rd International Symposium on Marine Ecosystems Challenges and Opportunities (MECOS3) organized by the Marine Biological Association of India (MBAI) at Cochin during 7-10th January 2020 -Dr.K.Ambasankar
2. Delivered a guest lecture on "Sustainable shrimp farming training" at a training program organized by Tari Aqua Farm and KOKAN BHUMI PRATISTHAN (NGO) on 15th January, 2020- Mr. Jose Antony
3. Delivered a guest lecture entitled Formulation and Preparation of fish and shrimp feed on 29th January 2020 in the one month Skill development certificate course conducted by College of Fishery science, Muthukur, Nellore, Sri Venkateswara veterinary University -Dr.K.Ambasankar
4. Delivered a invited talk on " Significance of Nutrient Requirement of Fish and Shrimp" at the National Conference on recent advances in Aquaculture 2020 organized by Sir Theyagaraya college, Chennai during 06.02.2020 to 07.02.2020 at Chennai-Dr.K.Ambasankar
5. Delivered a invited lecture entitled Current status of Aquaculture Nutrition in India on 28.02.2020 in the International Conference on Recent Biotechnological Innovation in Aquaculture Organized by Bharathiar University & ICAR- NBFGR at Coimbatore during 27-28th February 2020 -Dr.K.Ambasankar
6. Delivered a guest lecture on 'Vannamei diseases'. at Bengal Aqua Expo at Nachinda, Purba Medinipur on 3rd February, 2020 – Dr.Sanjoy Das
7. Delivered a invited lecture in online mode on "Successful shrimp farming during the COVID-19 pandemic and best practices" in AQUA ARMOUR webinar sponsored by Adity Birla, Grasim Division, on 1st July, 2020- Mr. Jose Antony
8. Invited speaker on 26th Foundation Day of the Faculty of Fishery Sciences. West Bengal University of Animal and Fishery Sciences on 25.09.2020. Kolkata, West Bengal – Dr.Aritera Bera
9. Delivered a invited lecture on "Brackishwater aquaculture development for livelihood generation" in webinar lecture series organised by Agrivision Gujarat, Ahmedabad on World fisheries day 21st November 2020 – Shri Tanveer Hussain
10. Delivered a guest lecture on "Application of Nutraceuticals for environmentally safe production of aqua / poultry / livestock products" in the international webinar on "Climate Smart Livestock and Poultry Production through Nutritional Interventions" organized by TANUVAS 23 & 24, November, 2020 -Dr.K.Ambasankar
11. Invited speaker on 26th Foundation Day of the Faculty of Fishery Sciences. West Bengal University of Animal and Fishery Sciences on 25.09.2020. Kolkata, West Bengal – Dr.Aritera B

ABOUT ICAR-CIBA

Central Institute of Brackishwater Aquaculture (CIBA) is one of the premier research institutes under the Indian Council of Agricultural Research (ICAR). Established on 1" April 1987, it serves as the nodal agency for research and development of brackishwater aquaculture in the country. As an organization of international repute, CIBA has been at the forefront in developing brackishwater aquaculture in India. ICAR CIBA with a vision of environmentally sustainable, economically viable, and socially acceptable brackishwater aquaculture, involved in R&D related to the production of seeds in finfishes and shellfishes, genetic improvement, cost-effective feeds, environment monitoring, farm and hatchery management, disease diagnosis, disease monitoring, and capacity enhancement and technology transfer. The headquarters of the Institute is located in Chennai with an Experimental Field Station at Muttukadu, about 35 km south of the city. It has two Regional Research Centres, one at Kakdwip (West Bengal and the other at Navasari, Gujarat, on the west coast.

Headquarters

ICAR-Central Institute of Brackishwater Aquaculture
75 Santhome High Road, MRC Nagar, R.A. Puram
Chennai - 600 028, Tamil Nadu.
Telephone: +91 44 24616948, 24618817, 24610565, 24611062
Fax: +91 44 24610311
E-mail: director.ciba@icar.gov.in

Research Centres

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

Navsari Gujarat Research Centre of CIBA
1st Floor, Animal Husbandry Polytechnic Building
Navsari Agricultural University Campus
Eru Char Rasta, Dandi Road,
Navsari - 396 450, Gujarat.
Telephone: +91 2637-283509

www.ciba.res.in

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ICAR-Central Institute of Brackishwater Aquaculture
ISO 9001:2015
(Indian Council of Agricultural Research)
#75, Santhome High Road, MRC Nagar, RA Puram,
Chennai, Tamil Nadu - 600 028.

Phone : +91 44 24618817, 24616948, 24610565
Fax : +91 44 24610311
Web : www.ciba.res.in
Email : director.ciba@icar.gov.in

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