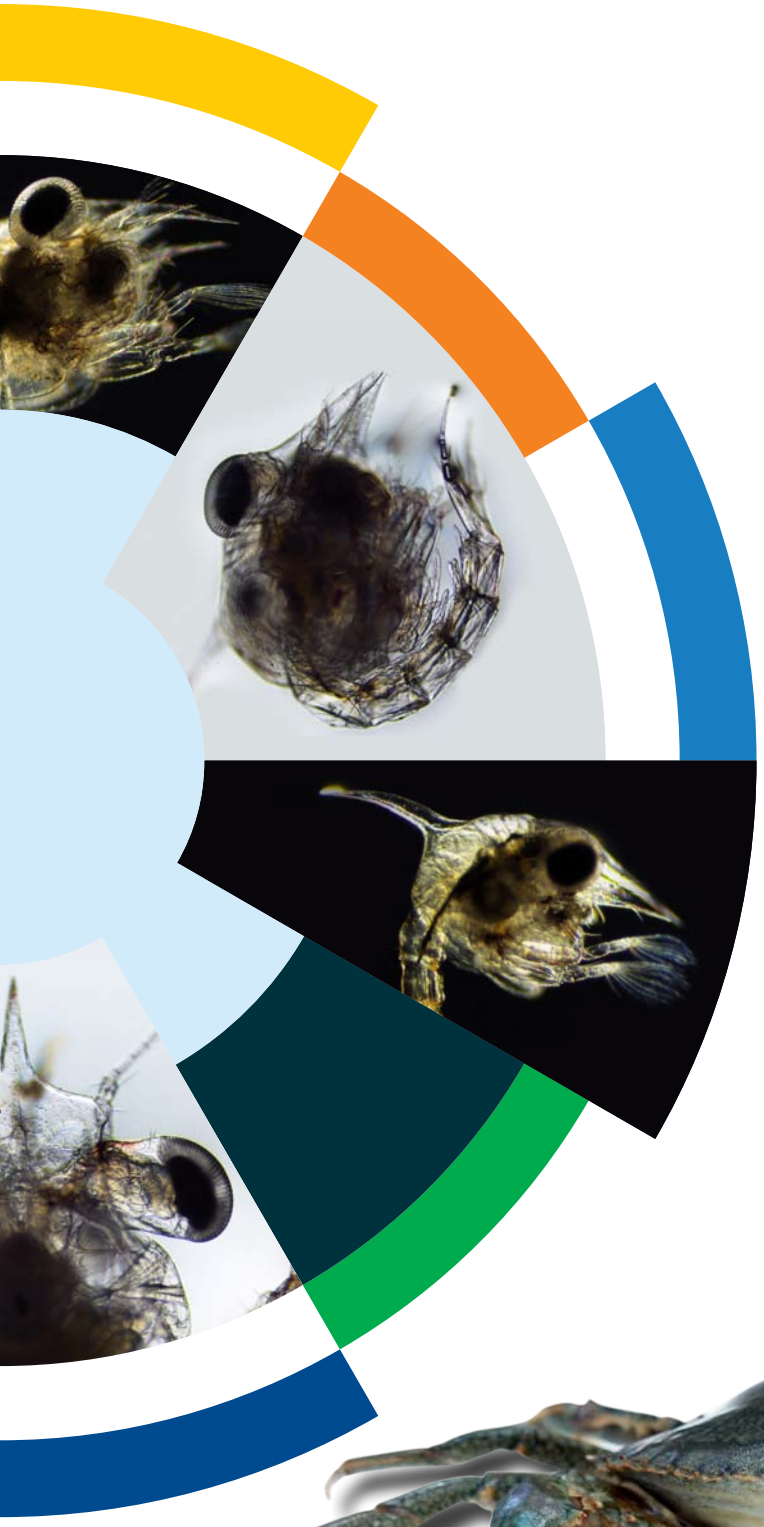
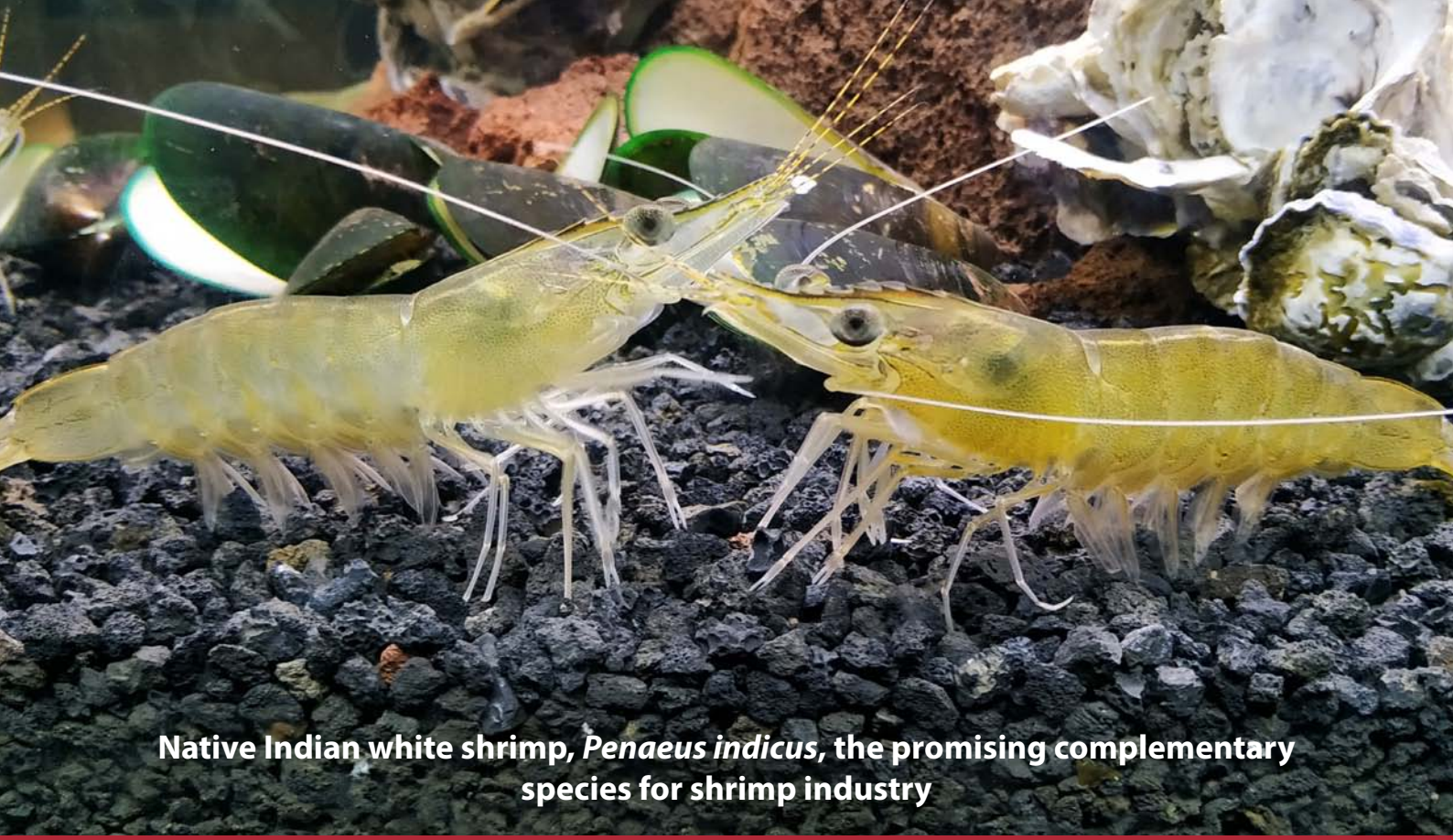


ANNUAL REPORT 2021

ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

भा कृ अनु प - केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान



Native Indian white shrimp, *Penaeus indicus*, the promising complementary species for shrimp industry

Cover page:
Mud crab (*Scylla serrata*), often called mangrove crab or green crab is a potential candidate for farming in brackishwater due to domestic and export market demand. Mud crab life cycle begins when the egg hatches out into a zoea. Zoea metamorphoses into megalopa after moulting five times. Megalopa moults again and transforms into a juvenile crab.

भाकृअनुप
ICAR

CIBA

वार्षिक प्रतिवेदन

Annual Report 2021

भा कृ अनु प - केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद)

75, संथोम हाई रोड़, एम आर सी नगर, आर ए पुरम, चेन्नई – 600 028

तमिलनाडु, भारत

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 – 600 028

Tamil Nadu, India

Published by

Dr. K. P. Jithendran
Director

Citation : CIBA, 2022. Annual Report (2021). Central Institute of Brackishwater Aquaculture, Chennai, Tamil Nadu, India, pp 1-234.
ISSN: 0976-5536

Layout and Design
Dr. M. Makesh
Dr. K. P. Jithendran
Dr. K. P. Kumaraguru Vasagam
Dr. J. Raymond Jani Angel
Mr. S. Nagarajan
Mr. V. Selvam

Photography
Mr. G.V. Sai Madhusudhanan

Printed at
Aparna Graphic Arts, Chennai

Contents

Preface

Considering the increasing demand for aquatic food and the multi-user demand for potable water resources on the land, horizontal and vertical expansions of aquaculture in brackishwater is highly recommended. CIBA continued its focus on technology backstopping initiatives in species diversification, formulated feeds, health management, stock improvement, social engineering, and livelihood development through prioritized R&D that would open up new avenues and increase confidence in the farmers and policymakers. This would provide new hope and direction for expanding the brackishwater aquaculture for increasing fish production, employment generation and economic benefits through the judicious utilization of the untapped resources.

While the ongoing pandemic has been highly stressful for the majority, it did not affect aquaculture production much. Here, we thank the policymakers for exempting all the activities related to fisheries and aquaculture from nationwide lockdown by considering this as essential for the nation. This decision helped revive the production and allowed us to execute our research activities and farming demonstrations, wherein the farm activities and logistics of feed and seed were not affected. While we were hoping for complete relief from COVID-19 in 2021, it was only partially true during this year, and we continued to work under the shadows of the pandemic. Here, I like to emphasize that we could accomplish greater progress in 2021 despite the limitations.

When looking back, 2021 has been an eventful year for CIBA, with several success stories, valuable and meaningful research outcomes, achievements and events. During this past year, we could sustain the functioning of the laboratories and our hatcheries at Muttukadu experimental station and research centres in West Bengal and Gujarat. We have continued to produce seabass and milkfish seeds on a large scale and CIBA perfected the seed production technology on the recently bred grey mullet (*Mugil cephalus*) and mangrove red snapper (*Lutjanus argentimaculatus*), for the first time in the country. These two species can play a major role in driving the brackishwater aquaculture and contribute to the envisaged blue revolution in the country. Also, we commercialized the cutting edge technologies such as 'CIBAFLOC', a biofloc product, the CIBA OXY^{Plus}, a dissolved oxygen enhancer and CIBA-Nodavac-R, recombinant viral nervous necrosis vaccine. We also had several sittings of the consultation meeting on developing a pragmatic crop insurance product for shrimp aquaculture to handhold the small and medium-scale farmers. CIBA has sequenced and independently assembled the whole genome of Indian white shrimp, *Penaeus indicus*, being first of its kind in the world. This breakthrough is expected to contribute immensely to future genetic improvement and health management programs.

We also focused on alternative aquaculture systems such as integrated multi-trophic aquaculture systems (IMTA), family farming and organic farming. Further, we have made sincere

efforts to bridge the relationship between the stakeholders and farmers, and the results are visible in the form of the partnership agreement and MOU signed on a public-private partnership (PPP) mode. Also, CIBA has developed a close working relationship between the state government and other government agencies working to develop brackishwater aquaculture in the country by sharing the strength and weakness, which provided a new synergy.

During this challenging time, with our continued perseverance, CIBA acquired about 64 acres of land from the Salt Department, Ministry of Commerce and Industry, Govt. of India, located on the scenic East Coast Road at Kovalam. This land has access to estuarine/backwater/oceanic waters, which is ideal for developing diversified farming systems, brood & nursery banks, and aquaculture based livelihood systems. Our collective dream is that the Kovalam Experimental Station of CIBA would grow and strive to become a Centre of Excellence in Brackishwater Aquaculture in South East Asia in the days to come.

Besides, we could add new infrastructure facilities *viz*., laboratory building in headquarters, a state-of-the-art aqua-climate laboratory, a mini-island area, brackishwater ornamental fish hatchery, Farmer Facilitation Centre, experimental lined ponds, several earthen ponds and a RAS facility etc. Similarly, additional laboratories, ponds and farmers hostel at KRC were created with the special disaster fund after the devastating *Yaas* cyclone in 2021. CIBA officially obtained the 10 ha farmland for research and demonstration of brackishwater aquaculture from the Department of Fisheries, Govt. of Gujarat through a MoU signed in the Pre-Vibrant Gujarat Summit in December 2021.

During the pandemic time, we conducted official meetings and trainings on various aspects of brackishwater aquaculture in the regional languages using the virtual media tools. We have produced inputs such as feeds and seeds with our R&D infrastructure available at our research centers and experimental stations to support the farmers and other stakeholders. To some farmers, we helped them to get their inputs and for some others, we assisted them in selling their produce by arranging logistics even under challenging situations.

In June 2021, while taking over the charge as the Director of this prestigious institute, we tried to draw strength and inspiration from our very supportive and committed staff. We adopted new possible ways of working environment to ensure the safety of our families, co-workers, and clients. As a way forward, we were able to disseminate our activities in a better way by organizing webinars and training programs online, but these are not without their limitations. As part of the *Azadi ka Amrit Mahotsav* celebrations to commemorate 75 years of our independence, we revived our engagements by organizing webinars, training programs, exhibitions, and farmers' meet. With the new situation, adopting the ICT technologies, we virtually reached many of our stakeholders and handholded them on technical inputs.

Our scientific team brought out more than 65 peer-reviewed research articles in various international journals in 2021. We are highly motivated by the two recent honours we received from ICAR; 1. ICAR Best Annual Report Award 2019-20 under large institute category and 2. Second prize in the Swachhta Pakhwada Award 2021. We were honoured by the visit of Shri. Bankim Chandra Hazra, Minister of Sundarban Affairs, Govt. West Bengal, who inaugurated the shrimp harvest mela and farmers interaction-meet at Kakdwip Research Centre of CIBA.

We thankfully acknowledge all our stakeholders and farmers who have supported us, and their trust in our mission, had influenced to achieve greater strides in all our endeavours. I am immensely grateful to Dr. Trilochan Mohapatra, Secretary, DARE and Director General of ICAR who was instrumental in providing his professional support, without which all these achievements would not have been made possible. We are deeply indebted to Dr. J. K. Jena, Deputy Director General (Fisheries), for his enthusiastic support and timely help in pursuing our goals.

I sincerely thank Dr. Pravin Puthra, Assistant Director General (Marine Fisheries), for his continued support and encouragement. Further, I am indeed indebted to the 'TEAM CIBA' who carries the work forward with sincere commitment and hard work.

I hope this annual report brings more exciting information to authenticate and refresh you all about the activities and achievements of ICAR-CIBA in the year 2021.

K. P. Jithendran
Director, ICAR-CIBA

कार्यकारी सारांश

मैंग्रोव रेड स्नैपर *लुट्जानस अर्जेंटीमैक्यूलेटस* के हैचरी उत्पादन में बड़ी सफलता

आईसीएआर-सीबा ने भारत में पहली बार मैंग्रोव रेड स्नैपर, *एल. अर्जेंटीमैक्यूलेटस* के कैप्टिव ब्रूडस्टॉक और बीज उत्पादन तकनीक विकसित करने में सफलता प्राप्त की है। प्रति किलोग्राम शारीरिक भार के लिए 1500 IU की दर से hCG दे कर कुल चार प्रजनन परीक्षण किए गए जिसके परिणामस्वरूप सहज रूप से स्पॉनिंग हुई। लार्वा को 60 दिनों तक हैचरी में पाला गया और एक इंच आकार के पोनों को मत्स्यपालक को आपूर्ति की गई ताकि ग्रो-आउट प्रणाली में उत्पादन का मूल्यांकन किया जा सके।

कैप्टिव ग्रे मुलेट की प्रजनन अवधि का विस्तार और अंगुलिका उत्पादन

दीर्घकालीन बहिर्जात हार्मोन थेरेपी का समय, खुराक और आवृत्ति में संशोधन के साथ साथ उच्च गुणवत्ता वाले ब्रूडस्टॉक फ़ीड सेफालस$^{प्लस}$ देते हुए और अनुकूलतम ब्रूडस्टॉक प्रबंधन द्वारा प्रजनन अवधि को एक माह (नवम्बर, 2016-17) से बढ़ाकर तीन माह किया गया जिससे ग्रे मुलेट, *मुगिल सेफालस* के कैप्टिव प्रजनन में एक अतिरिक्त मील का पत्थर स्थापित किया गया। समग्र रूप से मछली की परिपक्वता 96.1±2.3% और कार्यात्मक मादा परिपक्वता 67.3±1.9% प्राप्त किया गया। आगे वर्ष 2021 में लार्वा के चार खेप का उत्पादन किया गया।

येलोफिन ब्रीम *एकांथोपैगरस डैटनिया* के कैप्टिव ब्रूडस्टॉक विकास और प्रेरित प्रजनन पर पहली रिपोर्ट

सीबा ने पहली बार येलोफिन ब्रीम *एकांथोपैगरस डैटनिया* के कैप्टिव ब्रूडस्टॉक विकास और प्रेरित प्रजनन में सफलता प्राप्त की है। प्रजनकों को खारे पानी (5-7 पीपीटी) के रिसर्क्युलेटरी एक्वाकल्चर सिस्टम में विकसित किया गया और समुद्री जल (30 पीपीटी) में प्रेरित प्रजनन कराया गया था। एक वर्ष के पालन के बाद, उप-वयस्क मछली ने यौन परिपक्वता प्राप्त की। परिपक्व मादा (अंडकों का व्यास 400-450 माइक्रोन) और स्रावी नर मछलियों को 1:2 के लिंगानुपात में LHRHa के साथ अंडजनन हेतु प्रेरित किया गया। 26 घंटों की ऊष्मायन अवधि के बाद लार्वा का स्फुटन हुआ। नवजात लार्वा की औसत कुल लंबाई 1.75 मिमी थी। ठंड के झटके के कारण लार्वा केवल 12 घंटे ही जीवित रह सकें।

एशियन सीबास - बड़े पैमाने पर बीज उत्पादन एवं आपूर्ति

एशियन सीबास का प्रजनन और हैचरी उत्पादन किया गया और बारह प्रेरित अंडजनन सहित कुल 25 अंडजनन दर्ज किए गए। जून 2021 – दिसम्बर 2021 के दौरान कुल चार मिलियन अंडे, और 1.2 मिलियन सीबास बीजों का उत्पादन किया गया था। 42 किसानों को बीजों की आपूर्ति की गई थी और इसके अलावा, 2.2 मिलियन निषेचित अंडे एक निजी हैचरी, CANARES, एक्वा एलएलपी, कुमटा, कर्नाटक को आपूर्ति की गई थी। सीबास बीज और निषेचित अंडों की बिक्री से कुल ₹ 32.9 लाख का राजस्व प्राप्त हुआ।

हैचरी में मिल्कफिश मत्स्य बीजों का समान रूप से उत्पादन

मार्च से सितंबर, 2021 के दौरान मिल्कफिश की दो अनुकूलित समष्टियों (चेन्नई और काकीनाडा) में कुल 17 अंडजनन घटनाएं देखी गईं, जिनके परिणामस्वरूप 0.7 मिलियन निषेचित अंडे और 0.38 मिलियन लार्वा का उत्पादन हुआ। सहायक हार्मोन की समाविष्टि ने सापेक्ष विलंबता (लेटेन्सी) अवधि को 75 दिनों तक बढ़ाने में मदद की। मिल्कफिश के हैचरी उत्पादित कुल 98,920 पोनों को केरल, आंध्र प्रदेश, पश्चिम बंगाल, गुजरात, उड़ीसा, तमिलनाडु, उत्तर प्रदेश के किसानों को आपूर्ति की गई और ₹ 2.73 लाख का राजस्व प्राप्त किया गया।

फ्लोटिंग नेट केज में ऑरेंज क्रोमाइड, *स्यूडेट्रोप्लस मैक्युलेटस* की जोड़ियों के घनत्व का अनुकूलन

पांच अलग-अलग फ्लोटिंग नेट केज (2 × 1 × 1 मी.) में ऑरेंज क्रोमाइड, *पी. मैक्युलेटस* के नर (7.42±0.15 सेमी और 7.87±0.76 ग्राम) और मादा (7.35±0.13 सेमी और 8.625±0.625 ग्राम) मछलियों को 1:1 के अनुपात में 1, 5, 10, 15 और 20 जोड़ों की दर से संग्रहीत किए गए थे। *पी. मैक्युलेटस* प्रजनकों के 10 जोड़ों से 60 दिनों में कुल 35 अंडजनन घटनाएं देखे गए जिनका औसत निषेचन 294.07±13.24 दर्ज किया गया। 60 दिनों की अवधि के दौरान प्रत्येक जोड़े में 13 दिनों के अंतराल पर कुल 3.5 बार अंडजनन हुआ है।

नर्मदा ज्वारनदमुख, खंभात की खाड़ी, गुजरात से प्राप्त हिलसा, *तेनुआलोसा इलीशा* का सफल बीज उत्पादन।

नर्मदा ज्वारनदमुख, खंभात की खाड़ी, गुजरात में पहली बार कृत्रिम स्ट्रिपिंग विधि के माध्यम से हिल्सा, *टी. इलीशा* के ऑनबोर्ड निषेचन में सफलता प्राप्त की गई थी। हिल्सा प्रजनकों, मादा (कुल लंबाई 39.5 सेंटीमीटर और 850 ग्राम वजन) और नर (32 सेंटीमीटर और 330 ग्राम) मछलियों का ऑन-बोर्ड स्ट्रिपिंग किया गया। कुल 60,000 हाइड्रेटेड अंडों को पैक कर एनजीआरसी-सीबा केन्द्र में ले जाया गया। निषेचन और स्फुटन दर क्रमशः 70% और 65% आंका गया। कुल 27,300 नव स्फुटित मत्स्य बीजों (हैचलिंग्स) का उत्पादन किया गया जिन्हें विभिन्न प्रकार के संवर्धन प्रणालियों जैसे इनडोर, सेमी-इनडोर और आउटडोर टैंकों में संग्रहीत किया गया। परिणामों से पता चला कि सेमी-इनडोर (तारपालीन) टैंकों में संवर्धित हिल्सा लार्वा 30 दिनों में पोना अवस्था (25

मिमी. और 400 मिग्रा.) तक पहुंच गई जिनकी उत्तरजीविता दर 6.6±0.14% आंकी गई।

अलग-अलग समय अंतराल पर एकत्रित मैंग्रोव रेड स्नैपर के मत्स्य शुक्र की पोषण रूपरेखा (न्यूट्रियंट प्रोफाइलिंग)

एल. अर्जेंटीमैक्यूलेटस के मत्स्य शुक्र के तीन नमूनों का विश्लेषण इसके पोषक तत्वों की रूपरेखा के लिए किया गया था। महत्वपूर्ण फैटी एसिड जैसे एराकिडोनिक, ईकोसापेंटेनोइक और डोकोसाहेक्सैनोइक एसिड (कुल फैटी एसिड का%) जो शुक्र के परिमाण और प्रजनन क्षमता (फर्टीलिटी) के लिए बहुत महत्वपूर्ण हैं और प्रथम शुक्र स्राव से तीसरे नमूने तक में (पी <0.05) 7.23 से 9.64 तक; 10.45 से 13.19 और 20.56 से 26.91 तक बढ़ गई है।

तालाब में पालित पीनियस इंडिकस के *G3* लाइन का प्रजनन दक्षता

बंद स्थितियों के अंतर्गत पालित *पी. इंडिकस* जी3 लाइन के प्रजनकों की प्रजनन दक्षता का मूल्यांकन किया गया। मादा और नर प्रजनकों का औसत वजन क्रमशः 42.05 ग्राम और 33.04 ग्राम था, जिनकी औसत उर्वरता (फिकंडिटी) 56,000 थी। तिरसठ प्रतिशत मादाओं ने उन्नत गोनाडल विकास दर्ज किया और 25% मछलियों ने सफलतापूर्वक मेटिंग किया। तालाब में पालित G3 लाइनों में 100% संसेचन दर्ज किया गया, जिसमें 60% नर प्रजनकों में दूधिया सफेद शुक्राणु पैक थे। 14 प्रजनन परीक्षणों से कुल 2.79 मिलियन नौपली का उत्पादन किया गया।

कैप्टिव ब्रूडस्टॉक की मेटिंग दक्षता पर फोटोपीरियड का प्रभाव

बंद स्थितियों के अंतर्गत पालित *पी. इंडिकस* के प्रजनकों की परिपक्वता और प्रजनन क्षमता का मूल्यांकन इनडोर और आउटडोर परिपक्वता टैंक प्रणाली में किया गया था। बाहरी टैंक प्राकृतिक फोटोपीरियड के संपर्क में थे, जबकि इनडोर टैंकों में 12L: 12D फोटोपीरियड था। बाहरी टैंकों में बिना आईस्टॉक एब्लेशन के 100% संसेचन और गोनाडल विकास हुआ था। सीमित जैव सुरक्षित बाहरी परिपक्वता प्रणाली विकसित करने से प्रजनन और प्रजनन के मुद्दों से निपटा जा सकता है।

पीनियस इंडिकस के प्रजनन पर परिपक्वता आहार का प्रभाव

तैयार परिपक्वता फ़ीड (पेलेटेड और एक्सट्रूडेड) और लाइव फीड (पॉलीकीट) के बीच एक तुलनात्मक मूल्यांकन बंद स्थितियों में पालितम *पी. इंडिकस* के साथ किया गया था। सीबा के फीड मिल में तैयार किए गए एक्सट्रूडेड फीड के परिणामस्वरूप जननग्रंथियों का विकास (52.5%) पॉलीकीट खिलाए गए झींगों (55%) के समान ही पाया गया।

पीनियस इंडिकस के शुक्राणुओं के शीत भंडारण के लिए विस्तारक

पेनाइड्स के शुक्राणुओं के क्षेत्र स्तर पर संरक्षण के लिए गैर-क्रायोजेनिक तरीके सुविधाजनक हैं। शुक्राणुओं के शीत भंडारण हेतु परिरक्षकों/संरक्षकों के प्रभाव की जानकारी हेतु विभिन्न विस्तारकों जैसे खनिज तेल, फॉस्फेट बफर और कैल्शियम मुक्त लवण का मूल्यांकन किया गया है। अन्य उपचारों की तुलना में 5, 10 और 15 दिनों के बाद खनिज तेल संरक्षित शुक्राणुओं (72.33, 63.66, 41.66%) में शुक्राणु की जीवनक्षमता काफी अधिक पायी गयी।

सतत जलीय कृषि विकास की योजना

तमिलनाडु के छह तटीय जिलों में संभावित जलीय कृषि क्षेत्रों का मानचित्रण किया गया। चयन प्रक्रिया के दौरान जल और मृदा की गुणवत्ता विशेषताओं को ध्यान में रखा गया। प्रभावित करने वाले कारकों को पेयरवाइज मैट्रिक्स-आधारित संवेदनशील विश्लेषण और भौगोलिक सूचना प्रणाली (जीआईएस) के माध्यम से मापित, मानचित्रित, परिमाणित और जोड़ा गया है। सीएए और सीआरजेड अधिनियम के स्थानिक नियमों को ध्यान में रखते हुए मौजूदा 6,348 हेक्टेयर के अलावा जलीय कृषि के लिए कुल 3,719 हेक्टेयर की उपलब्धता आंकी गई है।

भारत के मैंग्रोव वनों पर जलीय कृषि विकास का प्रभाव

मैंग्रोव वनों की कटाई विश्व स्तर पर एक गंभीर मुद्दा है और मैंग्रोव क्षेत्रों की क्षति और ह्रास के लिए जलीय कृषि विकास को अक्सर मुख्य कारण माना जाता है। वर्ष 1988 की लैंडसैट टीएम छवियों और 2018 की सेंटिनल 2ए छवियों का उपयोग करते हुए एक उपग्रह छवि आधारित समय श्रृंखला विश्लेषण ने मैंग्रोव क्षेत्रों में परिवर्तन का खुलासा किया। जलीय कृषि विकास के कारण नष्ट हुआ क्षेत्र बहुत ही कम था और मैंग्रोव क्षेत्र में कुल मिलाकर 20.72% की बढ़ोत्तरी हुई। अध्ययन ने साबित कर दिया है कि झींगा जलीय कृषि विकास ने भारत के मैंग्रोव में कोई महत्वपूर्ण बदलाव नहीं किया है।

एशियन सीबास बीज उत्पादन और लार्वा संवर्धन प्रौद्योगिकी का हस्तांतरण

एशियाई समुद्री बास बीज उत्पादन और लार्वा पालन प्रौद्योगिकी को सीबा के साथ एक समझौता ज्ञापन के तहत मेसर्स कैनरेस एक्वा एलएलपी, कुमता, कर्नाटक को हस्तांतरित किया गया था। कैनरेस एक्वा एलएलपी को सीबास के अंडे (21.6 लाख निषेचित अंडे) की आपूर्ति की गई थी और सैटलैट मोड के माध्यम से उन्हें लार्वा संवर्धन, लाइव फीड उत्पादन और प्रजनकों के विकास पर तकनीकी जानकारी दी गई थी। फर्म ने पिंजरा पालन के लिए कर्नाटक और गोवा के 100 से अधिक किसानों को वीन्ड सीबास अंगुलिकाओं की आपूर्ति की है।

मिल्कफिश के सफल एकल पालन का निरूपण

मिल्कफिश का एकल पालन परीक्षण केईएस-सीबा में मिट्टी के तालाब में, विशेष रूप से तैयार किए गए पैलेट फीड के साथ किया गया था। मिल्कफिश की अंगुलिकाओं को 1.5 नग प्रति वर्गमीटर की दर से संग्रहीत किया गया और मिल्कफिश ग्रो-आउट$^{प्लस}$ फीड खिलाया गया। 236 दिनों की पालन अवधि (डीओसी) के बाद मछलियां औसतन 340 ग्राम की

हो गई हैं, जिनकी औसत कुल लंबाई 35.43 सेमी है। 87.46% उत्तरजीविता दर के साथ कुल 446.4 किलोग्राम मिल्कफिश की उपज पायी गयी। वर्तमान पालन परीक्षण ने 1.47 एफसीआर दर के साथ लगभग 4.5 टन / हेक्टेयर की उत्पादकता का संकेत दिया।

संग्रहण घनत्व में बदलाव करके नर्सरी चरण में एकसमान आकार की सिल्वर मूनी, *मोनोडैक्टाइलस अर्जेंटियस* के विकास और उत्पादन में बढ़ोत्तरी

अनुकूलतम भंडारण घनत्व का उपयोग करके नर्सरी पालन चरण में एक समान आकार के सिल्वर मूनी के विकास और उत्पादन का मानकीकरण किया गया था। पोनों को हापाओं (2 घनमीटर) में 25, 50, 75 और 100 संख्या के विभिन्न संग्रहण घनत्वों के तहत संग्रहीत किया गया था। परिणामों ने संकेत दिया कि उच्च वृद्धि और एकसमान आकार के उत्पादन के लिए सिल्वर मूनी के नर्सरी पालन चरण में 50 नग/हापा का संग्रहण घनत्व अनुकूलतम है।

हापा आधारित नर्सरी पालन प्रणाली में वर्मीक्यूलेटेड स्पाइन-फुट (रैबिट फिश) के भंडारण घनत्व का अनुकूलन

हापा आधारित नर्सरी पालन प्रणाली में खरगोश मछलीरैबिट फिश के अनुकूलतम भंडारण घनत्व का मूल्यांकन करने के लिए प्रयोग किए गए। अध्ययन से पता चला कि नर्सरी पालन के लिए 250 पोना/घनमीटर का भंडारण घनत्व अनुकूल पाया गया। हापा आधारित प्रणाली में *सिगानस वर्मीक्यूलेटस* पोनों (2.5 ± 0.22 सेमी और 0.64 ± 0.16 ग्राम) ने 88% उत्तरजीविता दर के साथ 6.6 ± 0.26 सेमी की कुल लम्बाई और औसत शारीरिक भार 6.5 ± 0.59 ग्राम अंगुलिकाओं का आकार प्राप्त किया।

तालाब और पिंजरा पालन प्रणालियों में *सिगानस वर्मीक्यूलेटस* की वृद्धि का तुलनात्मक मूल्यांकन

खारे पानी के तालाब प्रणाली और खारे पानी के तालाब में स्थापित पिंजरों में रैबिट फिश *एस. वर्मीक्यूलेटस* की वृद्धि का मूल्यांकन करने के लिए किए गए 150 दिनों के प्रयोग में पिंजरों में पालित मछलियों की तुलना में तालाब प्रणाली में पाले गए *एस. वर्मीक्यूलेटस* में उच्चतम औसत कुल लंबाई (28 ± 1.21 सेमी) और शारीरिक भार (187.75 ± 9.02 ग्राम), एसजीआर (2.31 ± 0.02% प्रति दिन) देखा गया।

गुजरात के आदिवासी समुदायों की आजीविका और पोषण सुरक्षा के लिए मीठे पानी के फार्म में "एकीकृत एक्वा-कृषि-कुक्कुट और बकरी पालन मॉडल" का विकास

तालाब आधारित (1.6 हेक्टेयर और 8 मीटर गहराई) एकीकृत एक्वा-कृषि-कुक्कुट और बकरी पालन मॉडल में कम परिमाण में मछलियों (पर्लस्पॉट, पंगासियस, तिलपिया, रूपचंद, रोहू, कतला) का पिंजरा पालन (4 × 4 × 2 मीटर), मल्टीपल स्टॉकिंग और मल्टीपल हार्वेस्टिंग मोड में और पशुधन (कुक्कुट और बकरी) पालन और तालाब के बांधों पर सब्जी की खेती शामिल है। मछली के साथ पशुधन के एकीकरण के परिणामस्वरूप मछली और पशुओं की अच्छी उत्तरजीविता के साथ-साथ अच्छी वृद्धि हुई। आठ महीने की अवधि में स्वयं सेवी समूह ने आंशिक रूप से निकाली गई 4,525 किलोग्राम मछली, 2,210 किलोग्राम पोल्ट्री पक्षियों, 135 किलोग्राम बकरियों और 740 किलोग्राम सब्जियों की बिक्री से ₹7.91 लाख की आय अर्जित की है।

महाराष्ट्र के खुले जल में मैंग्रोव रेड स्नैपर का पिंजरा जलीय कृषि

महाराष्ट्र के रत्नागिरी के मिर्या गांव में स्वयं सेवी समूह की भागीदारी के साथ एक संकरी खाड़ी (क्रीक) में मैंग्रोव रेड स्नैपर (वन्य रूप से एकत्रित 20 ग्रा. भार की 500 अंगुलिकाएं) का पिंजरा पालन किया गया था। मछलियों ने छह महीने के भीतर 80% उत्तरजीविता के साथ 300 से 800 ग्राम का आकार प्राप्त कर लिया। वन्य रूप से एकत्रित मैंग्रोव रेड स्नैपर आसानी से तैयार फ़ीड स्वीकार करते हैं, कम नरभक्षण था और मछुआरों के लिए वैकल्पिक आजीविका के रूप में खाड़ी में पिंजरे की खेती के लिए एक अच्छी उम्मीदवार प्रजाति है।

नवसारी गुजरात अनुसंधान केन्द्र, गुजरात में विशिष्ट रोगाणु मुक्त *पीनियस मोनोडोन* की खेती

सीबा-एनजीआरसी, नवसारी, गुजरात के प्रायोगिक तालाबों में नए सिरे से प्रवेश किए गए विशिष्ट रोगाणु मुक्त *पीनियस मोनोडोन* की खेती का प्रयास किया गया। 0.6 हेक्टेयर (6000 वर्गमीटर) के मिट्टी के तालाब में 15 नग/वर्गमीटर की दर से झींगों के पोस्ट लार्वा को संग्रहीत किया गया। का स्टॉक किया गया था। 105 दिनों की पालन अवधि के बाद एसपीएफ *पी. मोनोडोन* ने 71.6% की उत्तरजीविता और 1.40 एफसीआर के साथ 29.5 ग्राम का औसत शारीरिक भार प्राप्त किया। इस प्रयास से ₹2.56 लाख के शुद्ध रिटर्न के साथ कुल 1,901 किलोग्राम का उत्पादन हुआ।

सर्दियों के मौसम में पीनियस वन्नामेय की खेती

सर्दियों के मौसम में *पी. वन्नामेय* की खेती की संभाव्यता का विश्लेषण एनजीआरसी, गुजरात में एक वाणिज्यिक खेत परीक्षण में किया गया था। सर्दियों के मौसम (नवंबर-फरवरी) के दौरान नर्सरी में पाले गए *पी. वन्नामेय* को एक मिट्टी के तालाब (33 वर्गमीटर) में संग्रहीत किया गया था। खेती के दौरान सबसे कम वायुमंडलीय तापमान 13° से. था। हालांकि, पानी का तापमान 21 से 25° से. के बीच रहा। सर्दियों की चरम स्थितियों के दौरान 2 ग्राम/सप्ताह की वृद्धि दर देखी गई। 120 दिनों की पालन अवधि के बाद, झींगों ने 97% उत्तरजीविता दर के साथ 20.9 ग्राम का शारीरिक भार प्राप्त किया। *पी. वन्नामेय* की खेती शीत ऋतु में भी संभव है।

जिंजर श्रिम्प *मेटापीनियस कुट्चेंसिस* की खेती

जिंजर श्रिम्प, *मेटापीनियस कुट्चेंसिस* एक झींगा प्रजाति है जो कच्छ क्षेत्र की खाड़ी में बहुतायत रूप

से पायी जाती हैं। पूर्णा नदी में स्थानीय स्टेक नेट मत्स्यन से प्राप्त पोस्ट लार्वा को 500 वर्गमीटर के मिट्टी के तालाब में 12 नग/वर्गमीटर की दर से संग्रहीत किया गया था। झींगों ने 84.3% उत्तरजीविता दर के साथ 12.7 ग्राम का शारीरिक भार प्राप्त किया। *एम. कुट्चेंसिस* एक धीमी गति से बढ़ने वाली झींगा है जो 80-90 दिनों की पालन अवधि में 10 ग्राम के विपणन योग्य आकार प्राप्त कर सकती हैं।

पीनियस वन्नामेय की नर्सरी पालन के लिए कोपफ्लॉक

कोपफ्लॉक, एक कोपेपोड वर्चस्व वाली बायोफ्लॉक आधारित झींगा नर्सरी पालन प्रणाली है। कोपेपोड्स (*डायोइथोना रिगिडा, स्यूडोडायप्टोमस एनानडेली* और *इवांसुला पाइग्मिया*) का उपयोग कोपेफ्लॉक के उत्पादन के लिए किया गया था। कोपफ्लॉक प्रणाली में *पी. वन्नामेय* को विभिन्न पीएल घनत्व 1,000, 2,000 और 3,000 नग/टन की दर से संग्रहीत किया गया था। 2,000 झींगा/टन के पीएल घनत्व में उच्चतम वृद्धि (1.2 ग्राम) और उत्तरजीविता (96%) देखी गई। कोपफ्लॉक प्रणाली नर्सरी प्रणाली में फ़ीड की आवश्यकता को 20% तक कम कर सकती है।

सैंडवार्म *ओनुफिस एरेमिटा* का पालन

ओनुफिस एरेमिटा के वयस्कों और किशोरों की पालन सम्भावनाओं का मूल्यांकन प्रायोगिक इकाइयों और मास कल्चर टैंकों में किया गया था। वयस्कों और किशोरों को 100 ली. एफआरपी टैंक और 25 ली. टब में सैंड बेड के साथ रखा गया था। 500 किशोरों से संग्रहीत 1 टन एफआरपी टैंक में मास कल्चर परीक्षण किया गया। 120 दिनों की पालन अवधि के बाद, वयस्कों ने 0.2 ग्राम शारीरिक भार वाले 2,500 किशोरों का उत्पादन किया। किशोरों ने 18 सेमी की लंबाई प्राप्त की और कुल बायोमास 33.25 ग्राम था। मास कल्चर सिस्टम से 240 ग्राम का बायोमास उत्पन्न किया गया था।

पॉलीकीट *मार्फैसा मद्रासी* के लिए मास कल्चर टेक्नोलॉजी

पॉलीकीट कृमि *एम. मद्रासी* के लिए विभिन्न संवर्धन विधियों का मूल्यांकन किया गया। 25, 100 और 1000 लीटर के एफआरपी टैंकों में वयस्क, किशोरों का पालन और किशोर पॉलीकीट्स के मास कल्चर का विश्लेषण किया गया। 120 दिनों के बाद, वयस्क *एम. मद्रासी* ने 403 ग्राम बायोमास के साथ 7 सेमी और 0.2 ग्राम शारीरिक भार वाले किशोरों का उत्पादन किया। प्रत्येक वयस्क ने चार महीने की अवधि में 56 किशोर पैदा किए। मास कल्चर से 80% उत्तरजीविता के साथ लगभग 280 ग्राम पॉलीकैथ बायोमास का उत्पादन किया गया था।

फ़ीड के रूप में डायटम का उपयोग करते हुए कोपेपोड का मास कल्चर

कोपोपोड्स की तीन प्रजातियों *डायोइथोना रिगिडा, स्यूडोडायप्टोमस एनानडेली* और *इवांसुला पाइग्मिया* की मास कल्चर सम्भाव्यता का मूल्यांकन फ़ीड के रूप में *कीटोसेरॉस* एसपी का उपयोग करके किया गया था। कोपेपोड का उच्चतम घनत्व साइक्लोपॉइड कोपेपोड (*डायोइथोना रिगिडा*) से प्राप्त किया गया था। *डायोइथोना रिगिडा* का बड़े पैमाने पर उत्पादन डायटम को फ़ीड के रूप में उपयोग करके प्राप्त किया जा सकता है।

क्लोरेल्ला के बड़े पैमाने पर उत्पादन के लिए जिबरेलिक एसिड और शीरा/गुड़

क्लोरेल्ला एसपी के बड़े पैमाने पर उत्पादन के लिए विभिन्न सांद्रणताओं और अनुपात में जिबरेलिक एसिड और शीरा/गुड़ की प्रभावकारिता का विश्लेषण किया गया था। जिबरेलिक एसिड का सामान्य खुराक एवं 1 ग्राम/ली. की दर से शीरा/गुड़ के उपयोग से 72 घंटों में कोशिका घनत्व में 2.8×10^6 और 3.8×10^6 तक की वृद्धि हुई। जिबरेलिक एसिड और गुड़ 1:2 अनुपात में उपयोग से 48 घंटों में 4×10^6 कोशिकाओं के घनत्व और सर्वश्रेष्ट शैवाल उत्पादन हुआ था। 1:2 अनुपात (890 मिलीग्राम/लीटर) से उत्पादित शैवाल का कुल बायोमास पर काफी अधिक था।

स्काइला सेर्राटा का मोल्टिंग पैटर्न : विभिन्न प्रकार के आहारों का प्रभाव

अलग अलग संग्रहीत किए गए कीचड़ केकड़ों को मत्स्य मांस, केकड़े के मांस, तैयार किए गए फ़ीड और क्लैम मांस खिलाकर लगातार तीन मौल्ट्स में मोल्टिंग पैर्टन देखा गया। अलग-अलग केकड़ों को प्रथम मोल्टिंग पूरा करने में लगभग 25-32 दिन लगे हैं। मत्स्य मांस और केकड़ों के मांस खिलाए गए केकड़ों में मोल्टिंग में लगे दिनों की औसत संख्या बहुत ही कम थी। तैयार किए गए फ़ीड और क्लैम मांस खिलाए गए केकड़ों में उच्च उत्तरजीविता दर देखी गई है। प्रयोगात्मक समूहों के मोल्टिंग पर चन्द्र चरण (लूनार फेज) का कोई विशेष प्रभाव नहीं था।

पीनियस वन्नामेय के नर्सरी पालन में प्लवक बूस्टर के रूप में मत्स्य अपशिष्ट हाइड्रोलाइजेट (एफडब्ल्यूएच) का मूल्यांकन

पी. वन्नामेय में 30 दिनों तक किए गए दो बाहरी प्रयोगों से पता चला है कि 160 और 320 पीपीएम एफडब्ल्यूएच के साथ पूरक उपचारों से विभिन्न विकास पैरामीटर काफी अधिक पाए गए थे और 80 पीपीएम और उससे अधिक के एफडब्ल्यूएच पूरक के साथ *पी. वन्नामेय* की उत्तरजीविता काफी अधिक थी। एफडब्ल्यूएच पूरकता ने सिस्टम में फ्लॉक पीढ़ी को सकारात्मक रूप से बढ़ाया और यह झींगों के पोषण का पूरक होगा।

खारा जलीय कृषि प्रणाली में समुद्री शैवाल की खेती

खारा जलीय प्रणाली में समुद्री शैवाल की खेती कम लोकप्रिय है और बड़े पैमाने पर इसकी खोज नहीं की गई है। खारा जलीय तालाबों में लाल शैवाल की दो प्रजातियों (*हाइड्रोपंटिया एडुलिस, ग्रेसिलेरिया सैलिकोर्निया*) को जाल से बने थैलों (2×1×1 मीटर) में 500 ग्राम/वर्गमीटर के प्रारंभिक संग्रहण के साथ

संवर्धन किया गया था, एक महीने की पालन अवधि के बाद, *एच. एडुलिस* और *जी. सैलिकोर्निया* समुद्री शैवाल का कुल बायोमास 1.3 और 1.1 किग्रा/वर्गमीटर का उत्पादन हुआ। अध्ययन ने संकेत दिया कि समुद्री शैवाल का उत्पादन खारे पानी में भी किया जा सकता है।

आरएएस के लिए बायोफिल्टर के रूप में मेक्रोएल्गल बायोरिएक्टर

समुद्री शैवाल आधारित बायोरिएक्टर के तीन अलग-अलग मॉडल: ए) ट्यूबिंग बायोरिएक्टर के साथ आरएएस; बी) रेसवे टाइप बायोरिएक्टर के साथ आरएएस, सी) रोटेटिंग व्हील बायोरिएक्टर के साथ आरएएस डिजाइन किए गए और जैव-निस्पंदन दक्षता का विश्लेषण किया गया। बायोरिएक्टरों में एक्स्ट्रेक्टिव प्रजाति के रूप में *अगारोफाइटन टेनुइस्टिपिटेटम* का उपयोग किया गया था। रेसवे-प्रकार के शैवाल बायोरिएक्टरों के उपयोग ने अन्य प्रकारों की तुलना में NH_4-N, NO_2-N, NO_3-N और PO_4-P की मात्रा को काफी कम कर दिया। आरएएस सिस्टम में मेक्रोएल्गल बायोरिएक्टर का उपयोग CO_2 डिगैस्सेर की आवश्यकता को समाप्त कर सकता है।

पीनियस वनामेय के विकास में स्थानीय रूप से पृथक *आर्थ्रोस्पिरा मैक्सिमा* से निकाले गए आहारीय सी-फाइकोसाइनिन का प्रभाव

एक गहरे नीले रंग के रंगद्रव्य, सी-फाइकोसाइनिन (सीपीसी) स्थानीय रूप से पृथक साइनोबैक्टीरियम, *ए मैक्सिमा* से निकाला गया था और *पी. वन्नामेय के तरूण झींगों* (एबीडब्ल्यू: 3.99±0.11 ग्रा.) में आहारीय सीपीसी के प्रभाव को जानने के लिए 45 दिन का आहारीय प्रयोग किया गया था। परिणामों से पता चला कि *पी. वन्नामेय* को 800 मिलीग्राम/किलोग्राम ($सीपीसी_{800}$) और 1600 मिलीग्राम/किलोग्राम ($सीपीसी_{1600}$) आहार पूरकता के साथ काफी अधिक (पी <0.05) वजन बढ़ाने का प्रतिशत और उत्तरजीविता देखा गया।

पीनियस वन्नामेय पालन के व्यावहारिक आहार में सरसों की खली का अनुकूलतम आहारीय समावेशन स्तर

पी. वन्नामेय के आहार में सरसों की खली का अनुकूलतम समावेशन स्तर निर्धारित करने के लिए, सरसों की खली के तीन अलग-अलग स्तरों (0%, 5% और 10%) के साथ चारा तैयार कर परीक्षण किया गया। 120 दिनों के पालन अवधि के अंत में, परिणामों से पता चला कि सरसों की खली को *पी. वन्नामेय* के आहार में 10% के स्तर तक शामिल किया जा सकता है।

मिल्कफिश के आहार में आलू के अपशिष्ट मील का अनुकूलतम आहारीय समावेशन स्तर

आलू के महत्वपूर्ण भाग को फसल के बाद या आलू को फ्रेंच फ्राइस और आलू चिप्स के रूप में प्रसंस्करण के दौरान अपशिष्ट (कच्चा प्रोटीन-12.63±0.03%, लिपिड- 1.61±0.13%) के रूप में फेंक दिया जा रहा है। आलू अपशिष्ट मील (पीडब्लूएम) को गेहूं के प्रतिस्थापन के रूप में 0%, 25%, 50%, 75% और 100% प्रतिशत में शामिल किया गया था और मिल्कफिश पोनों (एबीडब्ल्यू-1.22 ग्राम) में अध्ययन किया गया था और परिणामों से पता चला कि पीडब्लूएम का मिल्कफिश पोनों में कुल मिलाकर 50% गेहूं/चावल के आटे के स्थान पर 18% के स्तर तक उपयोग किया जा सकता है।

मिल्कफिश के आहार में अजोला मील का अनुकूलतम आहारीय समावेशन स्तर

पारंपरिक पादप प्रोटीन सोयाबीन मील की कीमतों में उच्च वृद्धि ने पखमीन मत्स्य आहार में आहारीय लागत को कम करने के लिए वैकल्पिक पादप प्रोटीन स्रोतों के उपयोग की खोज को आवश्यक बना दिया है। अजोला मील में 18.17±0.09% कच्चा प्रोटीन, 4.23±0.02% लिपिड, 14.34±0.01% फाइबर और 18.04±0.09% राख सामग्री की मौजूदगी का विश्लेषण किया गया था, जिसमें 0, 7, 14, 21 और 28% को शामिल कर मिल्कफिश तरूण मछलियों को 42 दिनों तक खिलाया गया था। अजोला लीफ मील 21% तक समावेशन करने पर भार वृद्धि प्रतिशत में कोई महत्वपूर्ण अंतर (पी>0.05) नहीं था और आहार में अजोला को 28% स्तर तक समावेशन करने पर फ़ीड रूपांतरण अनुपात में उल्लेखनीय रूप से वृद्धि हुई (पी <0.05)।

जीरो फिशमील और फिश ऑयल आधारित आहार खिलाए गए मिल्कफिश की आंतों का मेटाजीनोमिक प्रोफाइलिंग

फिश मील और फिश ऑयल दोनों को पूरी तरह से प्रतिस्थापित कर एक प्रयोगात्मक फ़ीड तैयार किया गया था और शाकाहारी मिल्कफिश, *चानोस चानोस* में परीक्षण किया गया था। मेटाजीनोमिक विश्लेषण से पता चला है कि जीरो फिशमील और फिश ऑयल वाले आहार दिए गए मिल्कफिश में फाइलम एसिडोबैक्टीरिया से संबंधित बैक्टीरिया की महत्वपूर्ण परिमाण में मौजूदगी है और सेल्युलेसेस एवं अन्य फाइब्रिनोलाइटिक एंजाइमों की उपस्थिति के कारण पौध आधारित पॉलीसेकेराइड के पाचन में योगदान कर सकते हैं।

सीबास मछलियों के नर्सरी आहार में नमक पूरकता का उत्तरजीविता और वृद्धि पर प्रभाव

कम खारे पानी में पाले गए सीबास पोनों के सीबास नर्सरी$^{प्लस}$ फीड में 2% अतिरिक्त नमक की अनुपूरकता के प्रभाव का मूल्यांकन किया गया। परिणामों से पता चला कि नमक की खुराक ने उत्तरजीविता में सुधार किया और शूटर्स के प्रतिशत में कमी लाई। कम लवणीय परिस्थितियों में सीबास के नर्सरी पालन में नमक अनुपूरण लाभकारी होता है।

पीनियस वन्नामेय के आहार में रेशम कीटों के प्यूपा (एसडब्ल्यूपी) की पोषण क्षमता

पी. वन्नामेय के तरूण झींगों में 1.00±0.03 ग्राम के एबीडब्ल्यू के साथ 0, 2.5, 5 और 10% (डब्ल्यू/डब्ल्यू) फीडिंग पर आठ सप्ताह के प्रयोग में एसडब्ल्यूपी मील से पता चला कि विभिन्न स्तरों

वाले परीक्षण फ़ीड के स्वाद में कोई समस्या नहीं थी। एसडब्ल्यूपी भोजन और परिणामों से अनुमान लगाया गया कि इसे *पी. वन्नामेय* के आहार में 10% तक शामिल किया जा सकता है।

जयंट ट्रेवेली *कैरेंक्स इग्नोबिलिस* के आहार में प्रोटीन एवं ऊर्जा की आवश्यकता का प्रारंभिक मूल्यांकन

चालीस दिवसीय आहारीय परीक्षण ने आहारीय प्रोटीन और ऊर्जा का आकलन किया : तरूण जाइंट ट्रेवेली, *सी. इग्नोबिलिस* के अनुकूलतम विकास के लिए प्रोटीन अनुपात की आवश्यकताएं। व्यावहारिक आहार में 35%, 40%, या 45% क्रूड प्रोटीन और 8 या 12% लिपिड शामिल किए गए थे। 35 और 40% प्रोटीन युक्त आहार और 8 या 12% लिपिड वाले आहार से विकास के प्रदर्शन और फ़ीड की खपत में कमी आई। परिणामों से ज्ञात होता है कि तरूण जायंट ट्रेवेली की अनुकूलतम विकास और फीडिंग प्रतिक्रिया 12% लिपिड के साथ 45% प्रोटीन वाले आहार से प्राप्त की जा सकती है।

मिल्कफिश के प्रारंभिक विकास (ऑंटोजेनी) के दौरान पाचन एंजाइम गतिविधियां

मिल्कफिश *सी. चनोस* लार्वा में पाचक एंजाइम एमीलेज, लाइपेज, ट्रिप्सिन, काइमोट्रिप्सिन, ल्यूसीन एमिनोपेप्टिडेज और आल्कालाइन फॉस्फेटेज के ऑंटोजेनेटिक विकास का अध्ययन किया गया। इन एंजाइमों की गतिविधियों की पहचान बाहरी आहार से पहले हुई थी, लेकिन उनके विकास के पैटर्न उल्लेखनीय रूप से भिन्न थे। कुल ट्रिप्सिन एंजाइम गतिविधि 9वीं dph तक बढ रही थी, फिर 18वीं dph तक घट रही थी और 21वें dph पर फिर से तीव्र वृद्धि की प्रवृत्ति देखी गई थी। 25 dph के बाद ट्रिप्सिन गतिविधि बहुत कम थी।

मिल्कफिश चानोस चानोस *लार्वा की आहारीय अल्फा टोकोफेरॉल आवश्यकता*

मिल्कफिश *सी. चनोस* लार्वा के विकास, उत्तरजीविता और प्रतिरक्षा पर आहारीय विटामिन ई (अल्फा टोकोफेरॉल) अनुपूरक 0, 100, 200, 300 और 400 मि.ग्रा./कि.ग्रा. α- टोकोफेरॉल एसीटेट के प्रभाव का अध्ययन 45 दिनों तक किया गया। 200 मिलीग्राम/किलोग्राम की दर से आहार पूरक दिए गए मिल्कफिश लार्वा में शारीरिक भार के संदर्भ में (अंतिम शारीरिक भार 371.7±12.80 मिलीग्राम) वृद्धि हुई। ब्रोकेन लाइन रिग्रेशन विश्लेषण से स्पष्ट रूप से पता चला है कि *सी. चनोस* लार्वा के अनुकूलतम विकास के लिए आहारीय विटामिन ई की आवश्यकता 248.8 मिलीग्राम α-टोकोफेरॉल एसीटेट प्रति किग्रा थी।

मिल्कफिश चनोस चनोस लार्वा की आहारीय एस्कॉर्बिक एसिड आवश्यकता

मिल्कफिश, *सी. चनोस* लार्वा की वृद्धि पर आहारीय एस्कॉर्बिक एसिड (एए) पूरकता (0, 250, 500, 1000 और 2000 मिलीग्राम/किलोग्राम) के प्रभाव की जांच के लिए 45 दिनों का एक आहारीय परीक्षण किया गया था। परिणामों से पता चला कि 500 और 1000 मिलीग्राम/किलोग्राम विटामिन सी खिलाई गई मिल्कफिश ने अंतिम शारीरिक भार, भार प्राप्ति, विशिष्ट विकास दर और उत्तरजीविता दर के मामले में काफी बेहतर (पी <0.05) प्रदर्शन दर्शाया।

झींगा पालन में ईएचपी, डब्ल्यूएसएसवी और आईएमएनवी प्रमुख बीमारियां हैं

वर्ष 2021-22 के दौरान, तमिलनाडु और आंध्र प्रदेश में *पी. वन्नामेय* झींगों के 140 फार्मों में रोग निगरानी की गई। वर्ष 2021 के दौरान तीन रोग अर्थात हेपाटिक माइक्रोस्पोरिडिओसिस (ईएचपी), व्हाइट स्पॉट सिंड्रोम (डब्ल्यूएसएसवी) और संक्रामक मायोनेक्रोसिस रोग (आईएमएनवी) खेती वाले झींगों में अधिक प्रचलित थे, जिनमें से ईएचपी का प्रसार काफी अधिक (40%) पाया गया, इसके बाद डब्ल्यूएसएसवी (10%) और आईएमएनवी (3.6%) का स्थान रहा है।

तमिलनाडु में *स्काइला सेर्राटा* से मड क्रैब रियोवायरस (एमसीआरवी) का पता चला है

मड क्रैब रियोवायरस (एमसीआरवी) के कारण वन्य और पालित *स्काइला* प्रजातियों में होने वाली मौतों को तमिलनाडु, भारत में प्रलेखित किया गया है। एक सफल संवर्धन और मोटाई के लिए आरटी-पीसीआर नकारात्मक बीजों/केकड़ों को संग्रहीत करना उचित है।

एशियन सीबास और मिल्कफिश लार्वा की तुलनात्मक माइक्रोबियल प्रोफाइल

एशियन सीबास लार्वा में सापेक्षिक रूप से विब्रियोस की बहुलता थी, जबकि मिल्कफिश के प्रारंभिक लार्वा चरण में स्यूडोमोनास प्रचुर मात्रा में था और जब लार्वा बाद के चरणों में विकसित हुई तो इसकी सापेक्ष बहुतायत कम हो गई है।

पश्चिम बंगाल में पालित तिलापिया में पाए गए तिलापिया लेक वायरस (TiLV) का आण्विक गुणचित्रण

पश्चिम बंगाल के उत्तर एवं दक्षिण 24 परगना और हुगली जिलों से प्राप्त नमूनों में से 45.9% नमूनों में तिलपिया लेक वायरस पाया गया। तिलपिया लेक वायरस आइसोलेट्स में विश्व स्तर पर विभिन्न भौगोलिक स्थानों से रिपोर्ट किए गए अन्य आइसोलेट्स के साथ 95% समरूपता थी। अनुक्रमणों में आइसोलेट्स के बीच 99.74% समानता थी। इन अनुक्रमों के फाइलोजेनेटिक विश्लेषण ने भारत में पहले सूचित समान भौगोलिक क्षेत्र के आइसोलेट्स के साथ आनुवंशिक रूप से घनिष्ठ संबंध का खुलासा किया।

खारा जलीय कृषि के लिए विभिन्न प्रत्याशी पखमीन मछलियों से परजीवियों का पृथककरण एवं पहचान

विभिन्न मत्स्य प्रजातियों से अनेक परजीवियों जैसे *अर्गुलस* एसपीपी, *कैलीगस* एसपीपी, *लर्निया* एसपीपी, *साइमोथोआ* एसपीपी, *लर्नानथ्रोप्सिस* एसपीपी, *एमाइलोडिनियम* एसपीपी, एंसीरोसेफालिड, *ज़ेलेनिकोबडेला* एसपीपी, अनीसाकिस एसपीपी और

ऑक्टोलास्मिस एसपीपी की पहवान की गई। *एल. कैलकेरीफर और एम. सेफालस से लर्निया साइप्रीनेसी* और *लर्नानथ्रोप्सिस मुगिली* की पहचान की गई।

पीनियस वन्नामेय ग्रो-आउट फार्म में *एंटरोसाइटोज़ून हेपाटोपेनाई* (ईएचपी) संक्रमण से जुड़े जोखिम कारक।

ईएचपी मुक्त बीज, पर्याप्त रूप से सूखे तालाब और क्लोरीनयुक्त पानी के उपयोग ने झींगा फार्मों में ईएचपी की घटनाओं को काफी कम कर दिया। जबकि सफेद मल सिंड्रोम के पिछले इतिहास वाले तालाब और लगातार पालन वाले तालाबों में ईएचपी घटनाओं में वृद्धि देखी गई है। हालांकि ईएचपी की घटनाओं में प्रमुख झींगा रोगों का कोई महत्व नहीं था, ईएचपी की घटनाओं में वृद्धि के साथ सफेद मल सिंड्रोम (डब्ल्यूएफएस) महत्वपूर्ण रूप से जुड़ा था।

प्रजनक झींगों में ईएचपी के ऊर्ध्वाधर संचरण की संभावना नहीं है

ईएचपी चुनौती वाले प्रजनकों के अंडाशय गीले माउंट, हिस्टोलॉजी, *इन-सीटू* संकरण और पीसीआर द्वारा ईएचपी से मुक्त पाए गए। इसलिए, यह स्पष्ट है कि ईएचपी के ऊर्ध्वाधर संचरण की संभावना नहीं है।

ईएचपी संक्रमित पैसीफिक सफेद झींगा में हेपाटोपैनक्रियास का आणविक रोगजनन

एचपी में एपोप्टोटिक जीन कैस्पेज़ 2, 4 और हेमोलिम्फ में कैस्पेज़ 3, 5 की अभिव्यक्ति अधिक थी। संक्रमण के प्रारंभिक चरण में अपग्रेड हुए P^{53} और ProPo जीन बाद में नीचे की ओर विनियमित हुआ। ईएचपी संक्रमण के लिए हेपाटोपैनक्रियास प्रमुख लक्षित अंग है और संक्रमण के प्रारंभिक चरण के दौरान एचपी कायाकल्प दवाओं के उपयोग से संभवतः एचपी को अपनी सामान्य संरचना हासिल करने में मदद मिल सकती है और इस तरह जीव के स्वास्थ्य में सुधार हो सकता है।

एंटरोसाइटोज़ून हेपाटोपेनाई का *संपूर्ण* जीनोम अनुक्रमण

डिफ़ॉल्ट मापदंडों के साथ SPAdes जीनोम असेंबलर का उपयोग करके जीनोम को इकट्ठा करने के लिए पांच मिलियन पेयर्ड एंड रीड्स उपयोग किया गया जिसके परिणामस्वरूप 1,18,181 बीपी लंबाई का सबसे लंबा स्कैफोल्ड था और N50 18,395 था जिसकी कुल लंबाई 3.92 मेगा-बेस थी। प्रारंभिक संयोजन में, स्कैफोल्ड को 1,750 बीपीएस की न्यूनतम लंबाई के आधार पर फ़िल्टर किया गया, जिसके परिणामस्वरूप 354 स्कैफोल्ड की कुल लंबाई 3.25 मेगा-बेस और 26,934 की एन 50 थी। नतीजतन, ईएचपी जीनोम के पहले रिपोर्ट किए गए स्कैफोल्ड स्तर की एसेम्बली के साथ जीनोम समानता में 99.8% समानता का पता चला है।

विब्रियो कैंपबेली के लिए रियल टाइम पीसीआर डायग्नोस्टिक का विकास

वी. कैंपबेली की पहचान के लिए *hdc, fatA* और *angR* जीनों को लक्षित करने वाले परिमाणात्मक रियल टाइम पीसीआर का मानकीकरण किया गया। जांच *को* 100% *संवेदनशील और विशिष्ट पाया गया।*

रिकाम्बीनेंट वायरल नरवस नेक्रोसिस वैक्सीन का खेत परीक्षण

आईसीएआर-सीबा द्वारा एक इंजेक्शन द्वारा लगाए जाने वाला रिकाम्बीनेंट वायरल नरवस नेक्रोसिस वैक्सीन विकसित किया गया था। यह टीका एशियन सीबास अंगुलिकाओं और प्रजनकों के लिए सुरक्षित और गुणकारी पाया गया।

ड्रग्स ने एंटी-ईएचपी बीजाणु एक्सट्रूज़न गतिविधि का प्रदर्शन किया

जैविक दवा बायोसाइड ट्राइकोलिन-एलएफ (ट्राइकोडर्मा विरिडे) और रासायनिक दवाएं फेनबेंडाजोल, केटोकोनाजोल, निफेडिपाइन, और मेट्रोनिडाजोल को एंटी-ईएचपी बीजाणु एक्सट्रूज़न गतिविधि के लिए परीक्षण किया गया, जिसमें निफेडिपाइन और मेट्रोनिडाजोल के साथ ईएचपी बीजाणु अंकुरण का पूर्ण निषेध पाया गया था। हालांकि, इन दवाओं को एंटी ईएचपी थेरेप्यूटिक्स के रूप में उनके अनुप्रयोग की व्यवहार्यता के लिए झींगा में *इन वीवो* परीक्षण करने की आवश्यकता है।

विब्रियो एसपीपी से हिस्टामाइन और साइडेरोफोर उत्पादन

वी. कैंपबेली हिस्टामाइन का एक विपुल उत्पादक है। EDTA की विभिन्न सांद्रता में, *वी. कैंपबेली* के साथ उच्चतम स्तर पर साइडेरोफोर उत्पादन देखा गया, उसके बाद *वी. हार्वेई* और सबसे कम *वी. ओवेन्सि* द्वारा। कुल मिलाकर, *वी. कैंपबेली* में साइडेरोफोर का उत्पादन *वी. हार्वेई* की तुलना में 60 से 184% अधिक और *वी. ओवेन्सि* के संबंध में 240 से 480% अधिक था। परिणाम से पता चलता है कि प्रतिकूल परिस्थितियों में *वी. कैंपबेली* को *वी. हार्वेई* और *वी. ओवेन्सि* पर प्रतिस्पर्धात्मक लाभ प्राप्त है और झींगा हैचरी में इसके प्रभुत्व के पीछे संभावित कारण हो सकता है।

EDTA विब्रियो एसपीपी का विकास अवरोधक

बैक्टीरियल रोगजनकों जैसे वी. हार्वेई, वी. कैंपबेली और वी. ओवेन्सी के विकास को नियंत्रित करने की दक्षता हेतु तीन धात्विक चीटर यौगिकों, दोनों जैविक रूप से गैर-अवक्रमणीय (EDTA), और जैविक रूप से अवक्रमणीय यौगिकों (GLDA, ग्लूटामिक एसिड डायसेटेट और EDDS, Ethlenediamine-N, N'-disuccinic acid) का मूल्यांकन किया गया था। इन यौगिकों में, EDTA बायोडिग्रेडेबल यौगिकों GLDA और EDDS की तुलना में अधिक प्रभावी पाया गया।

एमीलूडिनियम के भारतीय पृथक का आणविक गुणचित्रण

भारत से पृथक किए गए एमीलूडिनियम को अनुक्रमित किया गया था। सार्वजनिक डोमेन में उपलब्ध विभिन्न मत्स्य प्रजातियों से पहले रिपोर्ट किए गए अनुक्रमों के साथ एमीलूडिनियम आइसोलेट

के फ़ाइलोजेनेटिक विश्लेषण से 100% समानता का पता चला। इटली, चीन और मैक्सिको की खाड़ी से रिपोर्ट किए गए आइसोलेट्स के साथ भारतीय आइसोलेट एमीलूडिनियम क्लस्टर्ड है।

BKC व्हाइट स्पॉट सिंड्रोम वायरस (WSSV) निष्क्रियता के लिए एक उपयुक्त सैनिटाइज़र

क्लोरीन, फॉर्मेलिन, बीकेसी, आयोडोफोर और $KMNO_4$ जैसे विभिन्न सैनिटाइज़रों के व्यापक प्रभाव का अध्ययन किया गया और डब्ल्यूएसएसवी संक्रमण के खिलाफ विभिन्न सैनिटाइज़रों की उपयुक्त सांद्रता ने दर्शाया कि ये सैनिटाइज़र प्रायोगिक और कृत्रिम खेत स्थितियों के तहत डब्ल्यूएसएसवी संक्रमित झींगे की जीवित रहने की दर को बढ़ाते हैं। परीक्षण किए गए सैनिटाइजर में बीकेसी डब्ल्यूएसएसवी को निष्क्रिय करने के लिए तुलनात्मक रूप से अधिक प्रभावी पाया गया।

ऑक्सोलिनिक एसिड (ओए) और फ्लोरफेनिकॉल से उपचारित *पीनियस वन्नमेय* प्रत्याहार (विथड्राल) अवधि के बाद खाने योग्य

एफएसएसएआई द्वारा निर्धारित एमआरएल अनुसार ओए दवा के अनुप्रयोग के 96 घंटे के बाद इसका अवशेष स्तर 0.3 पीपीएम से कम हो गया है, इससे यह इंगित होता है कि ओए का मौखिक रूप से उपचार (5 ग्राम/किलोग्राम फ़ीड) करने के चार दिन बाद, झींगा मानव उपभोग के लिए सुरक्षित है और कटाई के लिए उपयुक्त है। फ्लोरफेनिकॉल दवा उपचार के 2 घंटे के भीतर अपने एमआरएल तक पहुंच गई और यह 32 घंटे में 2 माइक्रोग्राम / ग्राम ऊतक से कम था, यह दर्शाता है कि उपचार के दो दिनों के बाद झींगा का उपभोग किया जा सकता है।

जलीय कृषि के संकेतक जीवों पर महत्वपूर्ण एंटीबायोटिक दवाओं का कम प्रतिकूल प्रभाव

जलीय कृषि के गैर-लक्षित जीवों में वृद्धि, प्रकाश संश्लेषक गतिविधि और एंटीऑक्सिडेंट एंजाइम के स्तर पर ऑक्सीटेट्रासाइक्लिन, सल्फैडीमेथॉक्सिन, फ्लोरफेनिकॉल, क्लोरैमफेनिकॉल, फ़राज़ोलिडोन और नाइट्रोफ़ुराज़ोन जैसे महत्वपूर्ण एंटीबायोटिक दवाओं के प्रभाव ने उनके पर्यावरणीय रूप से प्रासंगिक सांद्रता पर कम प्रतिकूल प्रभाव का खुलासा किया।

इमामेक्टिन बेंजोएट भारतीय जलीय कृषि तालाब के तलछट में तेजी से निम्नीकृत हुई है

सूर्य के प्रकाश के संपर्क में आने वाली हल्की बनावट वाली मिट्टी में ईएमबी का क्षरण तेजी से होता है। भारत जैसे उष्णकटिबंधीय देशों में, ईएमबी का क्षरण तेजी से होता है क्योंकि खेत पूरे वर्ष धूप के संपर्क में रहते हैं।

बदलती पर्यावरणीय परिस्थितियों में सल्फाडाइमेथॉक्सिन की अटलता

अम्लीय स्थिति में सल्फाडाइमेथॉक्सिन का क्षरण तेज था और पीएच में वृद्धि के साथ फोटोलाइसिस में कमी आई थी। लवणता में वृद्धि के साथ सल्फाडाइमेथॉक्सिन के फोटोडिग्रेडेशन में कमी आई। मीठे पानी की प्रणाली की तुलना में खारे पानी की प्रणाली (उच्च पीएच और लवणता) के तहत सल्फाडाइमेथॉक्सिन की अटलता अधिक थी।

अमरूद की पत्ती के सार वाले पूरक आहार, पीनियस वन्नामेय की वृद्धि और स्वास्थ्य में सुधार

वजन बढ़ने और विशिष्ट विकास दर सहित संवर्धित *पी. वन्नामेय* का विकास प्रदर्शन अमरूद की पत्ती के अर्क वाले पूरक आहार में काफी बेहतर था। सभी उपचार समूहों में झींगे के आंत और हेपाटोपैनक्रियास में कुल विब्रियो का स्तर काफी कम था।

उच्च क्षारीयता का उपचार

सोडियम बाइसल्फेट रासायनिक उपचार ने उपचार के बाद के 1 घंटे के भीतर क्रमशः 2 और 30 पीपीटी में टीए 25 और 28% कम कर दिया, और उपचार के 10 दिनों तक भी इसे बनाए रखा। झींगा की उत्तरजीविता और पानी की गुणवत्ता के अन्य मानकों पर उपचार का कोई प्रतिकूल प्रभाव नहीं पड़ा।

मिट्टी की गुणवत्ता पर ईएचपी प्रबंधन के लिए प्रयुक्त रसायनों का प्रभाव और उपचार के लिए जैविक संशोधन

EHP के नियंत्रण के लिए CaO और NaOH जैसे रसायनों के प्रयोग से तालाब की मिट्टी की गुणवत्ता पर प्रतिकूल प्रभाव पड़ा; मृदा पीएच में वृद्धि और मृदा माइक्रोबियल एंजाइम गतिविधियों में उल्लेखनीय कमी। 5 टन/हेक्टेयर की दर से फार्मयार्ड खाद और मत्स्य हाइड्रोलाइज़ेट अपशिष्ट जैसी जैविक खाद डालने पर 8 सप्ताह में एंजाइम गतिविधियों में सुधार हुआ है जबकि इन संशोधनों के बिना 16 सप्ताह में सुधार हुआ है।

ईएचपी संक्रामकता पर लवणता का प्रभाव

पानी की लवणता के संबंध में झींगा में ईएचपी रोगजनकता देखी गई है। 15 या 30 पीपीटी पर पालित झींगे की तुलना में 5 पीपीटी में पालित झींगे में ईएचपी कॉपी संख्या कम थी। कुल हेमोसाइट्स की संख्या 5 पीपीटी पर सामान्य थी, जबकि 28 दिनों के बाद उच्च लवणता पर नियंत्रण से नीचे थी।

निम्न लवणीय झींगा खेती के लिए मृदा और खनिज पूरक

कम लवणीय वातावरण में बेहतर झींगा खेती के लिए खनिज पूरकता के अलावा मिट्टी के योगदान का आकलन करने के लिए प्रयोग किए गए। खनिजों की इष्टतम सांद्रता को कम लवणीय जल (एलएसडब्ल्यू) + मृदा (चिकनी, रेतीली चिकनी दोमट-एससीएल) और एलएसडब्ल्यू के साथ प्रयोगात्मक टैंकों के लिए पूरण किया गया था। इन टैंकों में 60 दिनों तक संबंधित नियंत्रण और खारे जल (बीडब्ल्यू) में *पी. वन्नामेय* की उत्तरजीविता और वृद्धि की तुलना ने मृदा में बेहतर उत्तरजीविता (खनिज के साथ 90% और 80 से 85% खनिजों के

बिना), एलएसडब्ल्यू + खनिज में 43% और एलएसडब्ल्यू में 38% दर्शाया दर्शाया। इसी तरह, एलएसडब्ल्यू नियंत्रण पर प्रतिशत में वृद्धि खनिजों के साथ मृदा में अधिक थी, इसके बाद मृदा नियंत्रण, बीडब्ल्यू और एलएसडब्ल्यू + खनिज, एलएसडब्ल्यू में झींगा खेती के लिए मृदा की महत्वपूर्ण भूमिका को दर्शाता है।

झींगा पालन में प्रीबायोटिक्स के रूप में किण्वित फिल्टरेट्स

पी. वन्नामेय खेती में पानी की गुणवत्ता में सुधार के लिए कम खारे पानी (5 पीपीटी) में प्रीबायोटिक्स के रूप में गेहूं के चोकर, मक्के की गुल्ली के अपरद्द, नारंगी फलों के गूदे के अपरद्द और चावल की भूसी के किण्वित फिल्टरेट्स की क्षमता का परीक्षण किया गया था। निम्न लवणीय स्थितियों में अन्य उपचारों की तुलना और खाले जल की तुलना में फलों के गूदे के अपरद्द से *बेसिलस एक्वीमारिस*, एक अमोनियम ऑक्सीडाइजिंग बैक्टीरिया, मेटाबोलाइट्स और कार्बनिक भार को प्रभावी ढंग से कम करके कम करके पानी की गुणवत्ता में सुधार होता है।

उच्च तापमान के लिए रोटिफ़र ब्रैचिसनस प्लिकैटिलिस के क्रोनिक एक्सपोजर का प्रभाव

अनुकूलतम पालन तापमान (29°C) की तुलना में रोटिफ़र, *ब्राचिसनस प्लिकैटिलिस*, आकार, घनत्व, अंडे देने वाली मादा, अंडे के औसत व्यास पर उच्च तापमान (32°C) के क्रोनिक एक्सपोजर के प्रभाव का आकलन किया गया था। पांच दिवसीय अध्ययन में रोटिफर के आकार और घनत्व में कोई महत्वपूर्ण परिवर्तन नहीं हुआ, हालांकि 29°C की तुलना में 32 डिग्री सेल्सियस पर अंडे देने वाली मादाओं (22 से 15%), अंडे के आकार (104.39 से 77.51 माइक्रोन) और अंडे सेने की दर (22.21 से 7.23%) में कमी आई। यह रोटिफ़र्स पर उच्च तापमान के प्रतिकूल प्रभाव को इंगित करता है, और मछली के लार्वा पोषण को नकारात्मक रूप से प्रभावित कर सकता है।

पीनियस वन्नामेय में तीव्र तापमान और लवणता तनाव के प्रतिलेखात्मक प्रतिक्रियाएं

तीव्र तापमान और लवणता के तनाव के कारण झींगा से जुड़े आणविक तंत्र को समझने के लिए, पी. वन्नामेय को 27 डिग्री सेल्सियस से 22 और 32 डिग्री सेल्सियस और 3 घंटे के लिए 30 पीपीटी से 5 और 45 पीपीटी के संपर्क में लाया गया। कुल 336 और 407 जीन क्रमशः तापमान और लवणता तनाव के कारण अलग-अलग अभिव्यक्त करते पाया गया था। आणविक कार्यों से संबंधित महत्वपूर्ण समृद्ध जीन ऑन्कोलॉजी शब्द तनाव प्रतिक्रियाओं के सुधार के लिए अधिक उपयोगी जानकारी प्रदान करेंगे।

झींगा एक्सोस्केलेटन पर खनिजों के जमाव पर लवणता का प्रभाव

झींगा एक्सोस्केलेटन पर लवणीय भिन्नता के प्रभाव का अध्ययन किया गया था। कम लवणता (3 पीपीटी) पर 42 दिनों तक पालित झींगे की एसईएम छवियों ने अनुकूलतम लवणता (20 पीपीटी) की तुलना में कैरपेस पर खनिजों के असमान जमाव का खुलासा किया, जो एक्सोस्केलेटन के असंगत रूप से सख्त होने का संकेत देता है, जो मोल्टिंग प्रक्रिया पर प्रतिकूल प्रभाव डाल सकता है।

व्हाइट फेकल सिंड्रोम के साथ तालाब पर्यावरणीय मानकों का जुड़ाव

पी. वन्नामेय प्रक्षेत्रों में व्हाइट फेकल सिंड्रोम (डब्ल्यूएफएस) की घटना प्रमुख चिंताओं में से एक रही है। WFS घटनाओं के साथ पर्यावरणीय मापदंडों के जुड़ाव का आकलन करने के लिए तमिलनाडु (n=30) और आन्ध्र प्रदेश (n=20) के झींगा प्रक्षेत्रों (फार्मों) में एक अध्ययन किया गया था। अध्ययन से पता चला है कि हालांकि ईएचपी डब्ल्यूएफएस के लिए एक अग्रदूत है, बिगड़ते तालाब के वातावरण ने इसकी गंभीरता को बढ़ा दिया है। मल्टीपल करेसपांडेंस विश्लेषण से पता चला है कि एकल महत्वपूर्ण कारक के बजाय, महत्वपूर्ण कारकों जैसे कि TAN, NO_2 और संग्रहण घनत्व का संयोजन WFS की अलग-अलग स्तर के लिए जिम्मेदार है।

खारा जलीय कृषि के लिए उत्तर प्रदेश के अंतर्स्थलीय खारे जल की उपयुक्तता

अंतर्स्थलीय लवणीय क्षेत्रों में झींगा पालन खारा जलीय कृषि के लिए एक उभरता हुआ क्षेत्र रहा है। उत्तर प्रदेश के मथुरा जिले में अंतर्स्थलीय खारा जल (n=88) झींगा पालन के लिए उपयुक्त माना जाता है। कुल क्षारीयता (40-1000) में काफी भिन्नता थी अतः और 600 पीपीएम से कम क्षेत्र को ही खेती के लिए अनुशंसित किया जाता है। खनिज सांद्रता और आयनिक अनुपात अत्यधिक असंगत थे, उच्च Ca सांद्रता Ca/Mg और Ca/K अनुपातों को विचलित कर रही थी, जो सामान्य मूल्यों से बहुत दूर थी। चूंकि >5 पीपीटी वाले जल को कृषि के लिए अनुशंसित नहीं किया जाता है, खनिजों के पूरक के साथ, इस क्षेत्र की बंजर भूमि को खारा जलीय कृषि के लिए खोजा जा सकता है।

पीनियस वन्नामेय पालन में कार्बन अंशों की गतिशीलता पर संग्रहण घनत्व

पी. वन्नामेय के उच्च (60/वर्गमीटर), अर्ध उच्च (40/वर्गमीटर) और निम्न (20/वर्गमीटर) घनत्व वाले पालन के अंतर्गत तालाब के जल में कार्बन अंशों पर कार्बन इनपुट का उपयोग निर्धारित किया गया था। झींगों की अधिकतम वृद्धि और उत्तरजीविता क्रमशः उच्च और मध्यम संग्रहण घनत्व में दर्ज की गई थी। अकार्बनिक कार्बन अंश (पीपीएम) में सभी उपचारों में डीओसी के साथ कमी आयी और संग्रहण घनत्व (निम्न-29.5; मध्यम-30.7; उच्च-32.6) के साथ वृद्धि देखी गई। कार्बनिक कार्बन (पीपीएम) सामग्री डीओसी के साथ बढ़ी और मध्यम (9.73) और निम्न (6.64) की तुलना में उच्च एसडी (11.39) में अधिकतम थी। कार्बन बजटिंग के आकलन और बदले में ग्लोबल वार्मिंग में इसके योगदान के लिए झींगा पालन के विभिन्न इनपुट और आउटपुट प्रक्रियाओं पर कार्बन अंशों का डेटाबेस आवश्यक है।

केरल में झींगे की खेती के लिए परित्यक्त (डेरीलिक्ट) धान के खेतों की उपयुक्तता

केरल राज्य के त्रिशूर (एन = 24) और एर्नाकुलम (एन = 52) जिलों के विभिन्न स्थानों में पर्यावरणीय और सामाजिक प्रभाव का मूल्यांकन किया गया था, ताकि झींगों की खेती के लिए परित्यक्त धान के खेतों की उपयुक्तता का आकलन किया जा सके, जिनका उपयोग किसी भी कृषि गतिविधियों के लिए नहीं किया जा रहा है। त्रिशूर और एर्नाकुलम जिलों में क्रमश: 117.4 और 179 हेक्टेयर क्षेत्र झींगों के गहन पालन/झींगों एवं पखमीन मछलियों के पॉलीकल्चर के लिए उपयुक्त पायी गयी है। झींगों की खेती करने के लिए किसानों की इच्छा के आधार पर, त्रिशूर और एर्नाकुलम जिलों में क्रमशः 39 और 154 हेक्टेयर क्षेत्र से लगभग 23,400 और 92,400 मानव दिवसों का रोजगार और 6.76 और 26.7 करोड़ के राजस्व का अनुमान है।

मिट्टी और अस्तर लगे हुए तालाबों में *पीनियस वन्नामेय* की खेती का अर्थशास्त्र

मिट्टी के तालाबों का अस्तर लाभदायक और टिकाऊ झींगा पालन के लिए पालन प्रथाओं में से एक है और यह मिट्टी के नीचे की प्रतिकूल परिस्थितियों में खेती को सक्षम बनाता है। आर्थिक विश्लेषण से पता चला कि मिट्टी के तालाब से ₹20.31 लाख/हेक्टेयर/वर्ष रूपयों के सकल लाभ की तुलना में अस्तर लगे तालाब से ₹24.05 लाख/हेक्टेयर/वर्ष का सकल लाभ प्राप्त होता है जिनका लाभ लागत अनुपात क्रमशः 1.16 और 1.25 है।

पीनियस इंडिकस के लिए एक बेहतर, सन्निहित संपूर्ण जीनोम असेंबली

पी. इंडिकस जीनोम के लिए एक सन्निहित असेंबली तैयार की गई है जो कि >1.5 जीबी असेंबली लंबाई के जीनोम के बीच 1 एमबी कॉन्टिग एन 50 और 10 एमबी स्कैफोल्ड एन 50 लंबाई के संदर्भ मानकों को पूरा करने वाला एकमात्र क्रस्टेशियन जीनोम असेंबली है।

मुगिल सेफालस के लिए क्रोमोसोम-स्केल जीनोम असेंबली

एम. सेफालस के लिए एक क्रोमोसोम-स्केल जीनोम असेंबली 24 स्यूडोक्रोमोसोम के साथ उत्पन्न किया गया है, जिसमें 634 एमबी असेंबली लंबाई 28.3 एमबी के एन 50 के साथ होती है। जीनोम में 96% BUSCO पूर्णता स्कोर और 11.72% दोहराव वाले तत्व हैं।

इट्रोप्लस सुराटेंसिस में GnRH अभिव्यक्ति

मादा *इट्रोप्लस सुराटेंसिस* के मस्तिष्क में गोनैडोट्रोपिन रिलीजिंग हार्मोन के mRNA ट्रांसक्रिप्ट स्तर डिम्बग्रंथि के विकास के उन्नत चरणों में अधिक थे, जो डिम्बग्रंथि कार्यों में उनकी नियामक भूमिका का संकेत देते हैं।

पर्लस्पॉट फुल-सिब परिवार और उनके विकास का प्रदर्शन

छह पर्लस्पॉट फुल-सिब परिवार को उत्पन्न किए गए। इन परिवारों को एक ही तालाब में अलग-अलग पिंजरों में पालन किया गया था। संग्रहण के बाद 120 दिनों में उत्तरजीविता दर 91.4 से 100% के बीच थी। संग्रहण के 30वें और 60वें दिन के बीच सभी परिवारों में शारीरिक भार लगभग दोगुना हो गया।

पीनियस वनामेय में कोशिका चक्र नियमन, श्वसन क्रिया और साइटोप्लाज्मिक मुक्त कैल्शियम सांद्रता पर WSSV संक्रमण का प्रभाव

संक्रमण के दौरान मेजबान और वायरस के बीच पारस्परिक आणविक क्रियाओं में मेजबान सेलुलर प्रक्रियाओं को दबाने, या प्रतिरक्षा प्रतिक्रिया को प्रोत्साहित करने के लिए कई तंत्र शामिल हैं। झींगा की प्रतिरक्षा प्रतिक्रिया पर WSSV संक्रमण के प्रभाव का अध्ययन करने के लिए, WSSV संक्रमित *पी. वन्नामेय* झींगे के हेमोलिम्फ में 1.5 hpi, 18 hpi और 56 hpi पर कोशिका-चक्र विनियमन, श्वसन क्रिया और साइटोप्लाज्मिक मुक्त कैल्शियम ($Cf\text{-}Ca^{2+}$) का फ्लो साइटोमेट्री द्वारा विश्लेषण किया गया। WSSV संक्रमित *पी. वन्नामेय* में श्वसन फटने के उच्च स्तर और साइटोप्लाज्मिक मुक्त Ca^{2+} सांद्रता के साथ, हेमोसाइट्स के WSSV प्रेरित प्रसार, इन मापदंडों के बीच कार्यात्मक इंटरलिंक को दर्शाता है जिसकी WSSV संक्रमित *पी. वन्नामेय* में हानिकारक भूमिका हो सकती है।

झींगे के चयापचय मार्गों पर विभिन्न आहारीय प्रोटीन स्तरों का प्रभाव

झींगे के चयापचय पर आहार के प्रभाव का न्यूट्रीजेनोमिक्स दृष्टिकोण के माध्यम से अध्ययन किया जा रहा है। इस गतिविधि से उत्पन्न जानकारी विभिन्न पालन प्रणालियों के लिए तैयार फ़ीड विकसित करने के लिए उपयोगी होगी। *पी. वन्नामेय* पर अलग-अलग प्रोटीन स्तरों के साथ पांच अलग-अलग फ़ीड का प्रयोग किया गया था और चयापचय पथ पर फ़ीड प्रोटीन के प्रभाव का मूल्यांकन किया गया था। नियंत्रण समूह (37%) के साथ उपचार समूहों की तुलना करने पर कुल 2575 विभेदित रूप से व्यक्त जीन (डीईजी) की पहचान की गई।

पैसिफिक व्हाइटलेग श्रिम्प, *पीनियस वन्नामेय* में आहारीय सी-फाइकोसायनिन (सीपीसी) आंत माइक्रोबायोटा को बदल देता है

पी. वन्नामेय को 0 (नियंत्रण), 50, 100, 400, 800 और 1600 मिलीग्राम/किलोग्राम आहार की दर से 6 सप्ताह तक सी-फाइकोसाइनिन खिलाया गया था। आंत माइक्रोबायोम अध्ययन ने पूरक समूहों में निरपेक्ष रूप से *रोडोबैक्टीरियासी* परिवार की प्रमुख उपस्थिति का संकेत दिया। नियंत्रण एवं निम्न पूरक

(50 और 100) वाले समूहों में प्रमुख परिवार के बाद, क्रमशः *प्लेंक्टोमाइसेटासी* और *फ्लेवोबैक्टीरियासी* को देखा गया। उच्च पूरक समूह (800) में, प्रमुख परिवार के बाद *वेरुकोमाइक्रोबियासी*, *फ्लेवोबैक्टीरियासी* और *सेल्युलोमोनैडेसी* परिवारों को लगभग समान मात्रा में देखे गए थे।

भारत में झींगा पालन का क्षेत्रवार विकास

भारत में झींगा खेती के क्षेत्र, उत्पादन और उत्पादकता की विकास दर के प्रवृत्ति विश्लेषण से पता चला है कि क्षेत्र, उत्पादन में मध्यम वृद्धि दर और उत्पादकता में उच्च वृद्धि दर क्रमशः पूर्वी तट की तुलना में पश्चिमी तट पर देखी गई थी। झींगा उत्पादन पर क्षेत्र और उत्पादकता के अपघटन विश्लेषण ने संकेत दिया कि क्षेत्र और उत्पादकता पर इंटरएक्शन एफेक्ट तथा उत्पादकता का प्रभाव तुलनात्मक रूप से झींगा उत्पादन में अधिक है।

सीबा में सामाजिक विज्ञान अनुसंधान के परिप्रेक्ष्य

सीबा में विस्तार अनुसंधान के सामग्री विश्लेषण से पता चला कि अग्रपंक्ति प्रदर्शनों के माध्यम से प्रौद्योगिकी मूल्यांकन और शोधन, उत्पादन प्रणाली आधारित क्षेत्रीय अध्ययन, मोबाइल अनुप्रयोगों का अध्ययन और खारे पानी के जलीय कृषि में उद्यमिता विकास (ईडीपी) ध्यान आकर्षण क्षेत्र थे। सीबा प्रौद्योगिकियों का प्रभाव विश्लेषण, विपणन और व्यापार विश्लेषण और फार्म प्रबंधन पर अध्ययन जलीय कृषि अर्थशास्त्र में अनुसंधान के व्यापक क्षेत्र थे। ज्ञान प्रबंधन मंच और निर्णय समर्थन प्रणाली खारा जलीय कृषि में सूचना संचार प्रौद्योगिकी (आईसीटी) अनुसंधान अनुप्रयोग थे।

झींगा फसल बीमा के लिए उत्पाद अंतराल विश्लेषण

झींगा किसानों के साथ बातचीत ने झींगा फसल बीमा लेने की उनकी इच्छा का खुलासा किया, हालांकि, उन्हें सरकार से प्रीमियम सब्सिडी सहायता की उम्मीद थी। वांछित बनाम वर्तमान स्थिति के विश्लेषण से संकेत मिलता है कि किक स्टार्ट अवधि के दौरान सरकारी समर्थन और बीमाकर्ताओं और किसानों के बीच राष्ट्रव्यापी जागरूकता अभियान चलाने से अंतराल को पाटने में सुविधा हो सकती है।

झींगा निर्यात पर कोविड 19 का प्रभाव

कोविड 19 महामारी ने विभिन्न आयातक देशों में भारतीय झींगा की मांग पर प्रतिकूल प्रभाव डाला और पिछले वर्ष (2019-2020) की तुलना में 20,000 टन की गिरावट आई, जो मूल्य में 9.47 प्रतिशत और परिमाण के संदर्भ में 9.50 प्रतिशत थी। इसके अलावा, भारत की अस्वीकृति का हिस्सा अन्य झींगा निर्यातक देशों की तुलना में संयुक्त राज्य अमेरिका को निर्यात के उनके हिस्से से कम है। आगे की अंतर्दृष्टि से पता चला कि संयुक्त राज्य अमेरिका द्वारा भारतीय झींगा इनकार मुख्य रूप से कथित गंदी, साल्मोनेला, पशु चिकित्सा दवाओं और नाइट्रोफुरान की उपस्थिति के कारण था।

जलीय कृषि आधारित आजीविका विकास

तटीय गरीब परिवारों के आजीविका विकास के लिए कृषि आधारित उत्पादन प्रणालियों के साथ एकीकृत सामुदायिक मत्स्य पालन पर अग्रपंक्ति प्रदर्शनों ने आजीविका संपत्ति, क्षमता विकास और बढ़ी हुई आय के विकास के साथ उन्हें मुख्यधारा में लाने की सुविधा प्रदान की। अनुवर्ती अध्ययनों से पता चला है कि पहल ने उन्हें आजीविका प्रदान की है और राज्य सरकार की विकासात्मक पहलों में भागीदारी को बढ़ाया है।

झींगा किसानों का समर्थन करने में CIBA ShrimpApp की कथित प्रभावशीलता

झींगा किसानों ने दृढ़ता से महसूस किया कि मोबाइल एप्लिकेशन CIBA ShrimpApp उत्कृष्ट साधन है और उन्हें गुणवत्ता वाले बीज चयन, विभिन्न आदानों के आकलन, रोग निदान एवं रोकथाम और जल गुणवत्ता प्रबंधन में सुविधा प्राप्त हुई है। इसने विस्तार शिक्षा कार्य को प्रभावी ढंग से पूरा किया और एक कुशल ज्ञान प्रबंधन उपकरण के रूप में पाया गया। इसके अलावा, उपयोगकर्ता की वरीयताएँ और ऐप मॉड्यूल की रैंकिंग से पता चलता है कि मॉड्यूल में इनपुट कैलकुलेटर और रोग निदान अधिकतम परामर्शक मॉड्यूल थे।

झींगा फार्म प्रबंधन के लिए सीबा श्रिम्प कृषि ऐप का विकास

एक एंड्राइड मोबाइल एप्लिकेशन CIBA Shrimp KrishiApp को झींगों किसानों को खेत स्तर पर रीयल-टाइम डेटा आधारित निर्णय लेने में मदद करने के लिए विकसित किया गया था। इस इंटरैक्टिव मोबाइल एप्लिकेशन का उपयोग करते हुए, किसान अपने कृषि डेटा को दिन-प्रतिदिन की खेती के संचालन / स्टॉकिंग से लेकर कटाई तक के अवलोकनों पर इनपुट कर सकते हैं और झींगों की उत्तरजीविता, बायोमास, फ़ीड रूपांतरण अनुपात, तालाब के पानी की गुणवत्ता और व्यय पर तालाब-वार जानकारी प्राप्त कर सकते हैं। झींगा किसानों को स्मार्ट झींगा खेती पर किसान फील्ड स्कूलों के संचालन के माध्यम से अनुप्रयोगों पर प्रशिक्षित किया गया था।

जलीय कृषि को अपनाने पर आदिवासी किसानों की सामाजिक-आर्थिक स्थिति का प्रभाव

जलीय कृषि को आजीविका गतिविधि के रूप में अपनाने पर आदिवासी किसानों की सामाजिक-आर्थिक स्थिति प्रभावित हुई। मत्स्य पालन संस्थानों तक पहुंच, शिक्षा स्तर, जलीय कृषि गतिविधियों में भागीदारी, पालन प्रथाओं में ज्ञान और खेती के अनुभव ने उनके द्वारा अपनाए जाने को प्रभावित किया है। हापाओं में सीबास का नर्सरी पालन, पिंजरों में सीबास कल्चर, हापाओं में मिल्कफिश का नर्सरी पालन, मीठे पानी में मत्स्य पालन और एकीकृत मत्स्य पालन (आईएफएफ) को अपनाने की दर अधिक थी।

Executive Summary

Breakthrough in hatchery production of mangrove red snapper, *Lutjanus argentimaculatus*

ICAR-CIBA has succeeded in developing captive broodstock and seed production technology for Mangrove Red Snapper, *L. argentimaculatus* for the first time in India. A total of four breeding trials were conducted by administering hCG @ 1,500 IU/kg body weight resulting in spontaneous spawning. The larvae were reared in the hatchery for 60 days and the fry of one inch size were supplied to a fish farmer to evaluate the production performance in the grow-out system.

Extension of the reproductive period, and fingerlings production of captive grey mullet

An added milestone in captive reproduction of grey mullet, *Mugil cephalus*, was achieved by extending the reproductive period from one month (November; 2016-17) to three months (November to January; 2021-22) by modifying the timing, dose and frequency of sustained exogenous hormone therapy, providing high-quality broodstock feed Cephalus^{Plus} and optimal broodstock management. An overall fish maturity of 96.1 ± 2.3% with a functional female maturity of 67.3 ± 1.9% was achieved. Further, four batches of larvae were produced in 2021.

First report on captive broodstock development and induced breeding of yellowfin bream, *Acanthopagrus datnia*

Captive broodstock development and induced breeding of yellowfin bream, *Acanthopagrus datnia* was achieved for the first time by CIBA. Broodstock was developed in brackishwater (5-7 ppt) recirculatory aquaculture system and induced breeding was carried out in seawater (30 ppt). After one year of rearing, sub-adult fish attained sexual maturity. Mature female (oocyte diameter 400-450 µm) and oozing male in sex ratio of 1:2 were induced to spawn with LHRHa. Larvae hatched out after an incubation period of 26 h. Average total length of newly hatched larvae was 1.75 mm. The larvae could survive only for 12 h due to cold shock.

Asian seabass - mass seed production and supply

Breeding and hatchery production of Asian seabass were carried out, and a total of 25 spawning including twelve induced spawning were recorded. A total of four million eggs, and 1.2 million seabass seed were produced during June 2021-December 2021. Seeds were supplied to 42 farmers, and further, 2.2 million fertilized eggs were supplied to a private hatchery, CANARES, Aqua LLP, Kumta, Karnataka. Total revenue of ₹32.9 lakhs was realized through seabass seed and fertilized eggs sales.

Consistent hatchery seed production of milkfish

A total of 17 spawning were observed in two domesticated populations (Chennai and Kakinada) of milkfish during March to September, 2021 resulting in 0.7 million fertilized eggs and 0.38 million larvae. Assisted hormone implantation helped to enhance the relative latency period by 75 days. Total 98,920 hatchery produced milkfish fry were supplied to farmers from Kerala, Andhra Pradesh, West Bengal, Gujarat, Orissa, Tamil Nadu, Uttar Pradesh and a revenue of ₹2.73 lakhs was generated.

Optimization of pair density of orange chromide, *Pseudetroplus maculatus* in floating net cages

Orange chromide, *P. maculatus* male (7.42 ± 0.15 cm and 7.87 ± 0.76 g) and female (7.35 ± 0.13 cm and 8.625 ± 0.625 g) were stocked at a ratio of 1:1 in five different floating net cages (2 ×1× 1 m) with 1, 5, 10, 15 and 20 pair each. A total of 35 spawning were observed in 60 days from 10 pairs of *P. maculatus* brooders with an average fecundity of 294.07 ± 13.24. Each pair has spawned at an interval of 13 days with 3.5 times in 60 days.

Successful seed production of hilsa, *Tenualosa ilisha* caught from Narmada estuary, Gulf of Khambat, Gujarat

Onboard fertilization of hilsa, *T. ilisha* was successfully achieved through artificial stripping method for the first time in Narmada estuary, Gulf of Khambat, Gujarat. Hilsa brooders, female (39.5 cm total length and 850 g weight) and male (32 cm and 330 g) were stripped on-board. A total of 60,000 hydrated eggs were packed and transported to NGRC-CIBA facility. The fertilization and hatching rates were estimated as 70% and 65%, respectively. A total of 27,300 hatchlings were produced and stocked in different larval rearing systems: indoor, semi-indoor and outdoor tanks. Results revealed that hilsa larvae reared in

semi-outdoor (tarpaulin tanks) for a period of 30 days, attained fry stage (25 mm and 400 mg) with 6.6 ±0.14% survival rate.

Nutrient profiling of milt from mangrove red snapper collected at different time intervals

Three milt samples of *L. argentimaculatus* were analysed for its nutrient profiling. The important fatty acids like arachidonic, eicosapentaenoic and docosahexaenoic acids (% of total fatty acids) which are very crucial for milt volume and fertility increased ($p < 0.05$) from 7.23 to 9.64; 10.45 to 13.19 and 20.56 to 26.91 respectively from first milt oozing to third sampling.

Reproductive performance of pond reared G3 line of *Penaeus indicus*

The breeding efficacy of captive-reared broodstock of *P. indicus* G3 line was evaluated. The average weight of female and male broodstock that spawned were 42.05 g and 33.04 g, respectively with an average fecundity of 56,000-90,000. Sixty three percent of female recorded advanced gonadal development and 25% of animals mated successfully. Pond reared G3 lines recorded 100% impregnation, with 60% of male broodstock with milky white sperm pack. A total of 2.79 million nauplii were produced from 14 breeding trials.

Effect of photoperiod on mating efficiency of captive broodstock

Maturation and mating efficiency of captive reared *P. indicus* broodstock were evaluated in indoor and outdoor maturation tank systems. Outdoor tanks were exposed to natural photoperiod, whereas indoor tanks had 12 L: 12 D photoperiod. There was 100% impregnation and gonadal development without eyestalk ablation in the outdoor tanks. Developing confined biosecure outdoor maturation systems can tackle issues in breeding and reproduction.

Effect of maturation diet on reproductive performance of *Penaeus indicus*

A comparative evaluation between the formulated maturation feeds (pelleted and extruded) and live feed (polychaete) was carried out with captive reared *P. indicus.* Formulated extruded feed prepared at the feed mill of CIBA resulted in similar gonadal development (52.5%) compared to Polychaete fed shrimp (55%).

Extenders for chilled storage of spermatophores of *Penaeus indicus*

Non-cryogenic methods are convenient for field level preservation of spermatophores of penaeids. Effect of different extenders: mineral oil, phosphate buffer and calcium free saline where evaluated for chilled preservation of spermatophores. The sperm viability was significantly higher in mineral oil preserved spermatophores (72.33, 63.66, 41.66%) after 5, 10 and 15 days compared to the other treatments.

Planning for sustainable aquaculture development

Mapping of potential aquaculture regions was conducted in six coastal districts of Tamil Nadu. The water and soil quality characteristics were taken into account during the selection process. Influencing factors have been measured, mapped, quantified, and linked through pairwise matrix-based sensitive analysis and Geographical Information System (GIS). A total of 3,719 ha was available for aquaculture in addition to the existing 6,348 ha taking into account the spatial regulations of CAA and CRZ Act.

Impact of aquaculture development on the mangrove forests of India

Mangrove deforestation is a serious issue globally and aquaculture development was often implicated as the main reason for mangrove loss and degradation. A satellite image based time series analysis using Landsat TM images of 1988 and Sentinel 2A images of 2018 revealed the changes in the mangrove stretches. The area lost to aquaculture development was meagre and the extent of mangroves increased overall by 20.72%. Study has proved that shrimp aquaculture development has not made any significant changes in mangroves of India.

Transfer of technology of Asian seabass seed production and larval rearing

Asian seabass seed production and larval rearing technology was transferred to Canares Aqua LLP, Kumta, Karnataka through an MoU with CIBA. Canares Aqua LLP was supplied seabass eggs (21.6 lakhs fertilized eggs) and was given technical know-how on larval rearing, live feed production and broodstock development on satellite mode. The firm has supplied weaned seabass fingerlings to more than 100 farmers from Karnataka and Goa for cage culture.

Demonstration of successful monoculture of milkfish

Monoculture trial of milkfish was carried out at KES-CIBA in an earthen pond feeding with specially prepared pellet feed. Milkfish fingerlings were stocked at 1.5 numbers/ m^2 and fed with milkfish grow-out^{Plus} feed. After 236 days of culture (DOC) fishes have grown to an average of 340 g having an average total length of 35.43 cm. A total of 446.4 kg milkfish were harvested with a survival of 87.46%. Present culture trial indicated a productivity of around 4.5 t/ ha with an FCR of 1.47.

Growth enhancement and production of uniform-sized silver moony, *Monodactylus argenteus* in nursery phase by manipulating stocking density

Growth and production of uniform-sized silver moony in the nursery rearing phase was standardized by using optimum stocking density. The fry was stocked at various stocking densities of 25, 50, 75 and 100 numbers in hapas (2 m^3). The results indicated that a stocking density of 50 numbers /hapa is optimal for the nursery rearing phase of silver moony to produce higher growth and uniform size production.

Optimization of stocking density of vermiculated spine-foot (Rabbit fish) in hapa based nursery rearing system

Experiments were carried out to evaluate the optimum stocking density of Rabbit fish in hapa based nursery rearing system. The study revealed that stocking density of 250 fry/m^3 was found to be ideal for nursery rearing. *Siganus vermiculatus* fry (2.5 ± 0.22 cm and 0.64 ± 0.16 g) attained fingerling size of total length 6.6 ± 0.26 cm and mean bodyweight 6.5 ±0.59 g in 60 days in hapa based system with 88% survival rate.

Comparative evaluation of growth performance of *Siganus vermiculatus* in pond and cage system

Experiment was conducted for 150 days to evaluate the growth performance of rabbit fish *S. vermiculatus* in brackishwater pond system and cages installed in brackishwater pond revealed that the highest mean total length (28 ± 1.21 cm) and body weight (187.75 ± 9.02 g), Specific Growth Rate, SGR (2.31 ± 0.02% 1/day) was observed in *S. vermiculatus* reared in pond system as compared to cages.

Development of an "Integrated Aqua-Agri-Poultry and Goat-rearing model" in freshwater farm for the livelihood and nutritional security of tribal communities of Gujarat

The pond based (1.6 ha and 8 m depth) integrated aqua-agri-poultry and goat-rearing model consists of low volume cage culture (4 × 4 × 2 m) of fishes (pearlspot, pangasius, tilapia, roopchand, rohu, catla) in a multiple stocking and multiple harvesting mode and livestock (poultry and goat), and vegetable farming on dykes of the pond. Integration of livestock with fish resulted in good growth as well as survival of fish and livestock. In a span of eight months the SHG has earned an income of ₹7.91 lakhs from the sale of partially harvested 4,525 kg fish, 2,210 kg poultry birds, 135 kg goats and 740 kg vegetables.

Cage aquaculture of mangrove red snapper in open waters of Maharashtra

Cage culture of mangrove red snapper (500 fingerlings, wild caught; 20 g) in a creek with participation of SHG was conducted at Mirya village of Ratnagiri, Maharashtra. Fish attained a size of 300 to 800 g within six months with 80% survival. Wild caught mangrove red snapper easily accept formulated feed, had less cannibalism and is a good candidate species for cage culture in creeks as an alternative livelihood for fisher folks.

Farming of SPF *Penaeus monodon* at NGRC, Gujarat

A farming attempt of the newly introduced SPF *P. monodon* was carried out at the experimental ponds of CIBA-NGRC, Navsari, Gujarat. A 0.6 ha (6,000 m^2) earthen pond was stocked with post larvae at the rate of 15/m^2. After 105 Days of Culture (DOC) SPF *P. monodon* attained an average body weight of 29.5 g with survival rate of 71.6% and FCR 1.40. The attempt yielded a total production of 1,901 kg with a net return of ₹2.56 lakhs.

Farming of *Penaeus vannamei* during winter season

The feasibility of farming *P. vannamei* during winter season was analyzed in a commercial farming trial at NGRC, Gujarat. Nursery reared *P. vannamei* were stocked into an earthen pond (33/m^2) during winter season (November-February). The lowest atmospheric temperature experienced during farming was 13°C. However, the water temperature ranged between 21 and 25°C. Growth rate of 2 g/week was observed during peak winter. After 120 days of culture, shrimps attained a bodyweight of 20.9 g with 97% survival. Farming of *P. vannamei* in winter season is feasible.

Farming of ginger shrimp, *Metapenaeus kutchensis*

Ginger shrimp, *Metapenaeus kutchensis* is a shrimp species that is abundantly caught in the Gulf of Kutch region. A 500 m^2 earthen pond was stocked with post larvae (12/m^2) sourced from local stake net fishery in the Poorna river. Shrimps attained a bodyweight of 12.7 g with 84.3% survival. *M. kutchensis* is a slow growing shrimp that can attain marketable size of 10 g by 80-90 DOC.

Copefloc for nursery rearing of *Penaeus vannamei*

Copefloc is a copepod dominated biofloc based shrimp nursery rearing system. Copepods (*Dioithona rigida*, *Pseudodiaptomus annandalei* and *Evansula pygmaea*) were used to produce copefloc. *P. vannamei* was stocked at different PL

densities 1,000, 2,000 and 3,000/tonne in Copefloc system. Highest growth (1.2 g) and survival (96%) were observed in PL density of 2,000 shrimp/tonne. Copefloc system can reduce the feed requirement in nursery system by 20%.

Culture of sand worm, *Onuphis eremita*

Culture potential of adults and juveniles of *Onuphis eremita* were evaluated in experimental units and mass culture tanks. Adults and juveniles were stocked in 100 L FRP tanks and 25 L tubs with sand beds. Mass culture trial was carried out in 1 tonne FRP tank stocked with 500 juveniles. After 120 days of culture, adults produced 2,500 juveniles of 0.2 g body weight. Juveniles attained a length of 18 cm and the total biomass harvested was 33.25 g. A biomass of 240 g was generated from the mass culture system.

Mass culture technology for polychaete, *Marphysa madrasi*

Different culture methods were evaluated for the polychaete worm *M. madrasi*. Culture of adult, juveniles and mass culture of juvenile polychaetes were analysed in 25, 100 and 1,000 L FRP tanks. After 120 days, adult *M. madrasi* produced juveniles of size 7 cm and 0.2 g bodyweight with biomass of 403 g. Each adult produced 56 juveniles in a span of four months. About 280 g of polychaete biomass was produced with 80% survival from mass culture.

Copepod mass culture using diatom as feed

Mass culture potential of three species of copepods: *Dioithona rigida*, *Pseudodiaptomus annandalei* and *Evansula pygmaea* were evaluated using *Chaetoceros* sp. as feed. Highest copepod density was obtained from the cyclopoid copepod (*Dioithona rigida*). Mass production of *Dioithona rigida* can be achieved using diatom as feed.

Gibberellic acid and molasses for mass production of *Chlorella*

Efficacy of gibberellic acid and molasses in different concentrations and ratios was analysed for mass production of *Chlorella* sp. Nominal dosage of gibberellic acid and molasses at 1 g/L increased the cell density to 2.8×10^6 and 3.8×10^6 cells/ml in 72 hours. Gibberellic acid and molasses at 1:2 provided the best algal production with a cell density of 4×10^6 cells/ml in 48 hours. The total biomass of algae produced at 1:2 ratio (890 mg/L) was significantly higher.

Molting pattern of *Scylla serrata*: effect of different diets

Molting pattern in individually stocked mud crabs fed with fish meat, crab meat, formulated feed and clam meat was followed for three successive moults. Individual crabs took approximately 25-32 days to complete the first molt. Average number of days taken for molting was significantly lower in fish and crab meat fed crabs. Higher survival was observed in crabs fed with formulated feed and clam meat. The experimental groups did not have significant influence of the lunar phase on molting.

Evaluation of fish waste hydrolysate (FWH) as plankton booster in nursery rearing of *Penaeus vannamei*

Two outdoor experiments conducted for 30 days in *P. vannamei* showed that various growth parameters were significantly higher in treatments supplemented with 160 and 320 ppm FWH and the survival of *P. vannamei* with FWH supplementation of 80 ppm and above are significantly higher. The FWH supplementation positively enhanced the floc generation in the system and it would have supplemented the nutrition of the shrimp.

Seaweed farming in brackishwater culture system

Farming of seaweeds in the brackishwater system is less popular and not explored in large scale. Two species of red algae (*Hydropuntia edulis*, *Gracilaria salicornia*) were cultured in net bags (2×1×1 m) in brackishwater ponds with an initial stocking of 500 g/m^2. After one month of culture, *H. edulis* and *G. salicornia* produced a total biomass of 1.3 and 1.1 kg/m^2 of seaweed. The study indicated that seaweed production can also be achieved in brackishwater.

Macroalgal bioreactors as biofilter for RAS

Three different models of seaweed-based bioreactor: a) RAS with tubing bioreactor; b) RAS with raceway type bioreactor, c) RAS with rotating wheel bioreactor were designed and the bio-filtration efficiency was analyzed. *Agarophyton tenuistipitatum* was used as extractive species in bioreactors. Use of raceway-type algal bioreactors significantly reduced the amount of NH_4-N, NO_2-N, NO_3-N, and PO_4-P compared to other types. Use of macroalgal bioreactors can eliminate the need of CO_2 degasser in RAS systems.

Effect of dietary C-Phycocyanin extracted from locally isolated *Arthrospira maxima* in growth of *Penaeus vannamei*

An intense blue pigment, C-Phycocyanin (CPC) was extracted from a locally isolated cyanobacterium, *A. maxima* and a 45 day feeding experiment was conducted to unravel the effect of dietary CPC in *P. vannamei*, juveniles (Average Body Weight, ABW: 3.99 ± 0.11 g). The results revealed that *P. vannamei* fed with dietary supplementation at 800 mg/ kg (CPC_{800}) and1,600 mg/ kg (CPC_{1600}) of CPC showed significantly higher ($p < 0.05$) weight gain percentage and survival.

Optimum dietary inclusion level of mustard cake in practical diet of *Penaeus vannamei culture*

To determine optimum inclusion level of mustard cake in diet of *P. vannamei,* feed was prepared with three different levels of (0%, 5% and 10%) of mustard cake inclusion and tested. At the end of 120 days culture, the results revealed that mustard cake can be included at 10% level in diet of *P. vannamei*

Optimum dietary inclusion level of potato waste meal in the diet of milkfish

Significant portion of potato is being discarded as waste (crude protein- 12.63 ± 0.03%, lipid- 1.61 ± 0.13%) during post-harvest or processing of potato as French fries and potato chips. The potato waste meal (PWM) was included at 0%, 25%, 50%, 75% and 100% percent as a replacer for wheat and studied in milkfish fry (ABW-1.22 g) and the results revealed that PWM can be used up to 18% level with the replacement of 50% of wheat/rice flour in total in milkfish fry.

Optimum dietary inclusion level of Azolla meal in the diet of milkfish

The high price rise of conventional plant protein soybean meal necessitates exploring the utilization of alternative plant protein sources to reduce feed cost in finfish diet. Azolla meal analysed to contain 18.17 ± 0.09% crude protein, 4.23 ± 0.02% lipid, 14.34 ± 0.01% fiber and 18.04 ± 0.09% ash content was evaluated with inclusion of 0, 7, 14, 21 and 28% and fed to milkfish juveniles for 42 days. There was no significant difference ($P > 0.05$) in weight gain percent up to 21% inclusion of azolla leaf meal and the feed conversion ratio increased significantly ($P < 0.05$) at 28% level of inclusion of azolla in the diet.

Metagenomic profiling of milkfish gut, fed on zero fishmeal and fish oil based diet

An experimental feed was prepared by completely replacing both fish meal and fish oil and tested in herbivorous fish milkfish, *Chanos chanos*. The metagenomic analysis revealed the presence of significant amounts of bacteria belonging to the phylum Acidobacteria in milkfish fed on zero fishmeal and fish oil diets and could contribute in digestion of plant based polysaccharides due to the presence of cellulases and other fibrinolytic enzymes.

Effect of salt supplementation in the nursery diet of seabass on survival and growth

The effect of additional supplementation of 2% salt in the seabass nursery^{Plus} feed was evaluated in the seabass fry reared in low saline water. The results revealed that salt supplementation improved the survival and decreased the shooters percentage. Salt supplementation is beneficial in the nursery rearing of seabass under low saline conditions.

Nutritional potency of silk worm pupae (SWP) in the diet of *Penaeus vannamei*

An eight week SWP meal at 0, 2.5, 5 and 10% (*w/w*) feeding experiment in the juvenile *P. vannamei* with an ABW of 1.00 ± 0.03 g revealed there was no problem in palatability of the test feeds containing varying levels of SWP meal and results inferred that it can be included up to 10% in the diet of *P. vannamei*.

A preliminary assessment of protein and energy requirement in the diet of giant trevally *Caranx ignobilis*

A 40-day feeding trial assessed the dietary protein and energy: protein ratio requirements for optimum growth performance of juvenile giant trevally, *C. ignobilis*. Practical diets were formulated to contain 35%, 40% or 45% crude protein and either 8 or 12% lipid. Diets containing 35 and 40% protein, either at 8 or 12% lipids resulted in reduced growth performance and feed consumption. Results suggest that optimum growth and feeding response of juvenile giant trevally can be attained at a dietary protein level of 45% with 12% lipid.

Digestive enzyme activities during the early ontogeny of milkfish

The ontogenetic development of the digestive enzymes amylase, lipase, trypsin, chymotrypsin, leucine aminopeptidase and alkaline phosphatase in milkfish *C. chanos* larvae were studied. The activities of these enzymes were detected prior to exogenous feeding, but their developmental patterns differed remarkably. Total trypsin enzyme activity was increasing up to 9th dph and then decreasing till 18th dph and again sharp increasing trend at 21th dph. After 25th dph trypsin activity was very low.

Dietary alpha tocopherol requirement of milkfish, *Chanos chanos* larvae

A-45 day study was conducted to examine the effect of dietary vitamin E (alpha tocopherol) supplementation: 0, 100, 200, 300 and 400 mg of α-tocopherol acetate per kg on growth, survival and immunity of milkfish, *C. chanos* larvae. Milkfish larvae fed with dietary supplementation at 200 mg/kg showed enhanced growth performance, in terms of final body weight (371.7 ± 12.80 mg). The broken line regression analysis clearly revealed that the dietary vitamin E requirement for optimal growth of *C. chanos* larvae was 248.8 mg α-tocopherol acetate per kg.

Dietary ascorbic acid requirement of milkfish, *Chanos chanos* larvae

A-45 days feeding experiment was conducted to examine the effect of dietary ascorbic acid (AA) supplementation (0, 250, 500, 1,000 and 2,000 mg/kg) on the growth of milkfish, *C. chanos* larvae. The results revealed that milkfish fed with 500 and 1,000 mg/kg of vitamin C showed significantly better ($p<0.05$) performance in terms of final body weight, weight gain, specific growth rate and survival rate.

EHP, WSSV and IMNV are the major diseases in shrimp farming

During 2021-22, disease surveillance was carried out in 140 *P. vannamei* shrimp farms in Tamil Nadu and Andhra Pradesh. Three diseases i.e. Hepatic microsporidiosis (EHP), White spot syndrome (WSSV) and Infectious Myonecrosis disease (IMNV) were more prevalent in farmed shrimp during the year 2021, of which, EHP prevalence was found high (40%) followed by WSSV (10%) and IMNV (3.6%).

Mud Crab Reovirus (MCRV) detected from *Scylla serrata* in Tamil Nadu

Mortalities due to Mud Crab Reovirus (MCRV) in wild and farmed *Scylla* species have been documented from Tamil Nadu, India. It is advisable to stock RT-PCR negative seeds/crabs for a successful culture and fattening.

Comparative microbial profiles of Asian seabass and milkfish larvae

Asian seabass larvae have shown a relative abundance of *Vibrios,* whereas *Pseudomonas* was abundant in early larval stage of milkfish, and its relative abundance reduced when the larvae develop to later stages.

Molecular characterization of Tilapia Lake Virus (TiLV) detected in farmed Tilapia from West Bengal

Tilapia Lake Virus was detected in 45.9% of samples obtained from North and South 24 Parganas and Hooghly districts of West Bengal. The TiLV isolates had 95% homology with other isolates reported from different geographical locations globally. The sequences had 99.74% similarity among the isolates. Phylogenetic analysis of these sequences revealed genetically close relation with the isolates of same geographical region reported earlier from India.

Isolation and identification of parasites in various candidate finfishes for brackishwater aquaculture

Parasites such as *Argulus* spp., *Caligus* spp., *Lernaea* spp., *Cymothoa* spp., *Lernanthropsis* spp., *Amyloodinium* spp., Ancyrocephalid, *Zeylanicobdella* spp. *Anisakis* spp. and *Octolasmis* spp. were identified from different fish species. *Lernaea cyprinaceae* and *Lernanthropsis mugilii* were identified from *L. calcarifer* and *M. cephalus*.

Risk factors associated with *Enterocytozoon hepatopenaei* (EHP) infection in *Penaeus vannamei* grow-out farms.

EHP free seeds, adequately dried ponds and use of chlorinated water significantly reduced the EHP incidences in shrimp farms. Whereas ponds with previous history of white faecal syndrome and continuous culture were significantly associated with increase in the EHP incidences. Although major shrimp diseases had no significance in the incidence of EHP, white feces syndrome (WFS) was significantly associated with increase in occurrences of EHP.

Vertical transmission of EHP in brooder shrimp is unlikely

Ovaries of broodstock challenged with EHP were found free from EHP by wet mount, histology, *in-situ* hybridization and PCR. Hence, it is apparent that the vertical transmission of EHP is unlikely.

Molecular pathogenesis of hepatopancreas in EHP infected Pacific white shrimp

The expression of apoptotic gene caspase 2, 4 in hepatopancreas and caspase 3, 5 in haemolymph was high. The P^{53} and ProPo genes upregulated initial phase of infection were down regulated later. Hepatopancreas is the key target organ for EHP infection and use of hepatopancreas rejuvenating drugs during early stage of infection probably can facilitate hepatopancreas to regain its normal architecture and thereby recoup the animal health.

Whole genome sequencing of *Enterocytozoon hepatopenaei*

Five million paired end reads used to assemble the genome using SPAdes genome assembler with default parameters had resulted in the longest scaffold of 1,18,181 bp lengths and N50 was 18,395 with a total length of 3.92 mega-bases. In preliminary assembling, the scaffolds further filtered based on a minimum length of 1,750 bps, resulted in 354 scaffolds with a total length of 3.25 mega-bases and an N50 of 26,934. Consequently, the genome similarity with earlier reported scaffold level assembly of EHP genome revealed 99.8% similarity.

Real time PCR diagnostic developed for *Vibrio campbellii*

Quantitative real-time PCR targeting the genes *hdc, fatA* and *angR* for detection of *V. campbellii* was

standardized. The assay was found 100% sensitive and specific.

Field evaluation of recombinant viral nervous necrosis vaccine

An injectable recombinant viral nervous necrosis vaccine was developed by ICAR- CIBA. The vaccine was found to be safe and potent for Asian seabass fingerlings and broodstock.

Drugs demonstrated anti-EHP spore extrusion activity

The biological drug biocide Tricholin- LF (*Trichoderma viridae*) and chemical drugs Fenbendazole, ketoconazole, nifedipine, and metronidazole tested for anti-EHP spore extrusion activity showed absolute inhibition of the EHP spore germination with nifedipine, and metronidazole. However, these drugs need to be tested *in vivo* in shrimp for the feasibility of their application as anti EHP therapeutics.

Histamine and siderophore production from *Vibrio* spp.

V. campbellii is a prolific histamine producer. At various concentration of EDTA, siderophore production was observed at highest level with *V. campbellii* followed by *V. harveyi* and the least by *V. owensii*. Overall, siderophore production in *V. campbellii* was 60 to 184% higher compared to *V. harveyi* and 240 to 480% higher with respect to *V. owensii*. The result suggests that *V. campbellii* has competitive advantage over *V. harveyi* and *V. owensii* under adverse condition and could be probable reason behind its dominance within shrimp hatcheries.

EDTA is a growth inhibitor of *Vibrio* spp.

Three metallic cheater compounds, both biologically non degradable (EDTA), and biologically degradable compounds (GLDA, glutamic acid diacetate and EDDS, Ethlenediamine-N, N'-disuccinic acid) were evaluated for the efficiency in controlling growth of bacterial pathogens such as *V. harveyi, V. campbellii* and *V. owensii*. Among these compounds, EDTA was found to be more effective than biodegradable compounds GLDA and EDDS.

Molecular characterization of Indian isolate of *Amyloodinium*

*Amyloodiniu*m isolated from India was sequenced. The phylogenetic analysis of *Amyloodinium* isolate with previously reported sequences from different fish species available in public domain revealed 100% similarity. The Indian isolate *Amyloodinium* clustered with isolates reported from Italy, China and Gulf of Mexico.

BKC is an ideal sanitizer for white spot syndrome virus (WSSV) inactivation

The comprehensive effect of various sanitizers such as chlorine, formalin, BKC (Benzal Konium Chloride), Iodophor and $KMNO_4$ were studied and the ideal concentration of various sanitizers against WSSV infection showed these sanitizers prolonged the survival rate of the WSSV infected shrimp under experimental and simulated field conditions. Among the sanitizer tested BKC found to be comparatively more effective for inactivation of WSSV.

Oxolinic acid (OA) and Florfenicol treated *Penaeus vannamei* edible after withdrawal period

The OA drug residue level reached below 0.3 ppm, at 96 h post drug administration, the MRL set by FSSAI. This indicates, the shrimp orally administered with OA (5 g/kg feed) is safe for human consumption by four days post treatment and good to harvest. Florfenicol drug reached its MRL within 2 h of treatment and it was less than 2 µg/g of tissue by 32 h indicating, shrimp can be consumed within two days after treatment.

Important antibiotics had a diminutive adverse effect on indicator organisms of aquaculture

Effect of important antibiotics like oxytetracycline, sulfadimethoxine, florfenicol, chloramphenicol, furazolidone and nitrofurazone on growth, photosynthetic activity and antioxidant enzyme levels in non-target organisms of aquaculture revealed low adverse effect at their environmentally relevant concentrations.

Emamectin Benzoate degraded rapidly in Indian aquaculture pond sediment

Emamectin Benzoate (EMB) degradation is faster in light-textured soil exposed to sunlight. In tropical countries like India, EMB degradation is rapid as the farms are exposed to sunlight throughout the year.

Persistence of sulphadimethoxine under varying environmental condition

Sulphadimethoxine degradation was faster under acidic condition and with increase in pH there was reduction in photolysis. With increase in salinity there was reduction in photodegradation of Sulphadimethoxine. Persistence of sulphadimethoxine was high under brackishwater system (high pH and salinity) than freshwater system.

Guava leaf extract supplemented feed augments growth and health status of *Penaeus vannamei*

The growth performance of the cultured *P. vannamei* including weight gain and specific growth rate was significantly better in feed supplemented with guava leaf extract. The total *Vibrio* level in gut and hepatopancreas of shrimp was significantly lower in all treatment groups.

Remediation of high alkalinity

Sodium bisulphate chemical treatment reduced the TA by 25 and 28% in 2 and 30 ppt, respectively within 1 h post-treatment, and maintained the same even until 10 days post-treatment. The treatment had no adverse impact on the shrimp survival and other water quality parameters.

Impact of chemicals used for EHP management on soil quality and organic amendments for remediation

The application of chemicals such as CaO and NaOH for the control of EHP had adverse effects on pond soil quality; an increase in soil pH and a significant reduction in soil microbial enzyme activities. The addition of organic manures such as farmyard manure and fish hydrolysate waste at 5 t/ha, improved the enzyme activities within 8 weeks post amendment against 16 weeks without amendment.

Effect of salinity on EHP infectivity

EHP pathogenicity in shrimp with respect to water salinity has been observed. EHP copy numbers were low in the shrimp reared at 5 ppt in comparison with the shrimp reared at 15 or 30 ppt. Total haemocytes count was normal at 5 ppt, whereas below control at 28 days post-challenge at higher salinities.

Soil and minerals supplementation for low saline shrimp farming

Experiments were conducted to assess the contribution of soil besides minerals supplementation for better shrimp farming in low saline environment. Optimal concentration of minerals was supplemented to experimental tanks with low saline water (LSW) + soils (clay, sandy clay loam - SCL) and LSW. The comparison of survival and growth of *P. vannamei* reared in these tanks for 60 days with the respective controls and brackishwater (BW) showed better survival in soils (90% with and 80 to 85% without minerals), 43% in LSW + mineral and 38% in LSW. Similarly, increased weight gain in percent over the LSW control was more in soils with minerals followed by soil controls, BW and LSW + mineral, indicating the significant role of soil for shrimp farming in LSWs.

Fermented filtrates as prebiotics in shrimp farming

Efficiency of fermented filtrates of wheat bran, maize corn cob waste, orange fruit pulp waste, and rice husk as prebiotics in low saline water (5 ppt) was tested for improving the water quality in *P. vannamei* farming. Fruit pulp waste derived fermented filtrate containing *Bacillus aquimaris,* an ammonium oxidizing bacteria, improved water quality by reducing metabolites and organic load effectively, compared to other treatments in the low saline environment compared to brackishwater.

Impact of chronic exposure of rotifer *Brachionus plicatilis* to elevated temperature

Effect of chronic exposure to high temperature (32°C) on rotifer, *Brachionus plicatilis,* size, density, egg-bearing female, average egg diameter was assessed in comparison to the optimum rearing temperature (29°C). The five-day study revealed no significant change in the rotifer size and density, however a reduction in egg-bearing females (22 to 15%), egg size (104.39 to 77.51 µm) and hatching rate (22.21 to 7.23%) at 32°C in comparison to 29°C was observed. This indicates adverse effect of high temperatures on rotifers, and may negatively impact fish larval nutrition.

Transcriptional responses to acute temperature and salinity stress in *Penaeus vannamei*

To understand the molecular mechanism associated in shrimp due to acute temperature and salinity stress, *P. vannamei* were exposed to 22 and 32°C from 27°C, and 5 and 45 ppt from 30 ppt for 3 hours. A total of 336 and 407 genes were found to be differentially expressed due to temperature and salinity stress, respectively. The important enriched gene ontology terms related to molecular functions would provide more useful information for the amelioration of stress responses.

Effect of salinity on mineral deposition on the shrimp exoskeleton

The effect of salinity variation on the shrimp exoskeleton was studied. SEM images of the shrimp reared for 42 days at low salinity (3 ppt) revealed uneven deposition of minerals on the carapace compared to optimum salinity (20 ppt) indicating the inconsistent hardening of the exoskeleton, which may adversely impact the moulting process.

Association of pond environmental parameters with White Faecal Syndrome

Occurrence of the white faecal syndrome (WFS) in *P. vannamei* farms has been one of the major concerns. A study was conducted in shrimp

farms in TN (n=30) and AP (n=20) to assess the association of environmental parameters with WFS incidence. The study revealed that though EHP is a precursor for WFS, deteriorated pond environment aggravated its severity. Multiple Correspondence Analysis revealed that rather than a single critical factor, a combination of critical factors such as TAN, NO_2 and stocking density are responsible for varying degrees of WFS.

Suitability of inland saline waters of Uttar Pradesh for brackishwater aquaculture

Shrimp farming in the inland saline regions has been an emerging area for brackishwater aquaculture. Inland saline waters (n=88) in Mathura District of Uttar Pradesh were characterised for their suitability to shrimp farming. Total alkalinity (40-1,000) was highly varying, and the sites with below 600 ppm are only recommended for farming. Minerals concentration and ionic ratios were highly inconsistent, high Ca concentration deviating the Ca/Mg and Ca/K ratios, much away from the normal values. Since waters with >5 ppt are not recommended for agriculture, with minerals supplementation, the barren lands in this region may be explored for brackishwater aquaculture.

Stocking density on dynamics of carbon fractions in *Penaeus vannamei* culture

Usage of carbon inputs *on* carbon fractions in pond water was determined in high (60/m^2), semi (40/m^2) and low (20/m^2) density farming of *P. vannamei*. Maximum shrimp growth and survival were registered in high and medium stocking densities, respectively. The inorganic carbon fraction (ppm) showed a decrease with DOC in all the treatments and an increase with stocking density (Low-29.5; Medium-30.7; High-32.6). The organic carbon (ppm) content increased with DOC and was maximum with high SD (11.39) compared to medium (9.73) and low (6.64). The database on carbon fractions of different input and output processes of shrimp culture is essential for estimation of carbon budgeting and in turn its contribution to global warming.

Suitability of derelict paddy fields for shrimp farming in Kerala

An environmental and social impact assessment was carried out in different locations of Thrissur (n=24) and Ernakulam (n=52) districts of Kerala state to assess the suitability of the derelict paddy fields, which are not being used for any agriculture activities for shrimp farming. About 117.4 and 179 ha area was suitable for the extensive system of shrimp farming/polyculture of shrimp and finfish in Thrissur and Ernakulam districts, respectively. Based on the willingness of farmers to take up shrimp farming, about 23,400 and 92,400 man-days employment and revenue of 6.76 and 26.7 crores are projected, from 39 and 154 ha area, respectively in Thrissur and Ernakulam districts.

Economics of *Penaeus vannamei* farming in earthen and lined ponds

The lining of earthen ponds is one of the practices for profitable and sustainable shrimp culture and it enables farming in unfavourable soil bottom conditions. The economic analysis revealed a gross return of ₹20.31 lakh ha/year in the earthen pond compared to ₹24.05 lakh ha/year in the lined pond with benefit cost ratio of 1.16 and 1.25, respectively.

A superior, contiguous whole genome assembly for *Penaeus indicus*

A contiguous assembly has been generated for *P. indicus* genome which is the only crustacean genome assembly to meet the reference standards of 1 Mb contig N50 and 10 Mb scaffold N50 lengths, among genomes of >1.5 Gb assembly length.

Chromosome-scale genome assembly for *Mugil cephalus*

A chromosome-scale genome assembly is generated for *M. cephalus* with 24 pseudochromosomes covering 634 Mb of assembly length with N50 of 28.3 Mb. The genome has 96% BUSCO completeness score and 11.72% of repetitive elements.

GnRH expression in Etroplus suratensis

The mRNA transcripts levels of gonadotropin releasing hormone in brains of female *Etroplus suratensis* were higher at advanced stages of ovarian development suggesting their regulatory role in ovarian functions.

Pearlspot full-sib families and their growth performance

Six pearlspot full-sib families were generated. The families were cultured in separate cages in the same pond. Survival rate on 120 days post stocking ranged between 91.4 to 100%. Bodyweight almost doubled in all the families between 30th and 60th day of stocking.

Effect of WSSV infection on cell cycle regulation, respiratory burst and cytoplasmic free calcium concentration in *Penaeus vannamei*

Molecular interactions between the host and viruses during the course of infection involves several mechanisms to suppress host cellular processes, or stimulate immune response. In

order to study the effect of WSSV infection on shrimp immune response, cell-cycle regulation, respiratory burst and cytoplasmic free calcium (Cf-Ca^{2+}) were analysed at 1.5 hpi, 18 hpi and 56 hpi in haemolymph of WSSV infected *P. vannamei* shrimp by flow cytometry. WSSV induced proliferation of haemocytes, with very high levels of respiratory burst and cytoplasmic free Ca^{2+} concentration in WSSV-infected *P. vannamei*, indicating functional interlink between these parameters which might have a damaging role in WSSV-infected *P. vannamei*.

Impact of varying dietary protein levels on metabolic pathways of shrimp

Effect of diets on shrimp metabolism is being studied through nutrigenomics approach. The information generated from this activity would be useful for developing formulated feeds for different culture systems. An experiment using five different feeds with varying protein levels was conducted on *P. vannamei* and impact of feed protein on metabolic pathways was evaluated. A total of 2,575 differentially expressed genes (DEGs) were identified on comparing treatment groups with control group (37%).

Dietary *C*-Phycocyanin (CPC) alters the gut microbiota in Pacific whiteleg shrimp, *Penaeus vannamei*

P. vannamei were fed with varying levels of C-Phycocyanin at 0 (control), 50, 100, 400, 800 and 1,600 mg/kg diet for 6 weeks. The gut microbiome study indicated the predominant presence of family *Rodobacteraceae* irrespective of the supplementation groups. Next to the predominant family, *Planctomycetaceae* and *Flavobacteriacea* were observed respectively in control and low (50 and 100) supplementation groups. In higher supplementation group (800), Families *Verrucomicrobiaceae, Flavobacteriaceae* and *Cellulomonadaceae* were observed in almost equal amounts next to the predominant family.

Sectoral growth of shrimp farming in India

The trend analysis of growth rates for shrimp farming area, production and productivity in India has shown that moderate growth rate in area, production and higher growth in productivity were respectively observed in the east coast vis-à-vis the west coast. The decomposition analysis of area and productivity effect on shrimp production indicated that interaction effect of area and productivity and effect of productivity are comparatively more in shrimp production.

Perspectives of social sciences research in CIBA

Content analysis of extension research in CIBA revealed that technology assessment and refinement through frontline demonstrations, production system based field studies, studies on mobile applications and Entrepreneurship Development (EDP) in brackishwater aquaculture were the focus areas. Impact analysis of CIBA technologies, studies on marketing and trade analysis and farm management were the broad areas of research in aquaculture economics. Knowledge management platforms and decision support systems were the Information Communication Technology (ICT) research applications in brackishwater aquaculture.

Product gap analysis for shrimp crop insurance

Interactions with shrimp farmers' revealed their willingness to take up shrimp crop insurance, however, they expected a premium subsidy support from the government. The analysis of desired vs current state of offer indicated that government support during the kick start period and conducting nationwide awareness campaigns to insurers and farmers may facilitate in bridging the gaps.

Impact of COVID-19 on shrimp exports

COVID-19 pandemic adversely impacted the Indian shrimp demand in various importing countries and a decline of 20,000 tonnes which was 9.47 per cent in value and 9.50 per cent in quantity terms was observed compared to the previous year in 2021. Further, India's share of rejections is less than their share of exports to USA in comparison with other shrimp exporting countries. Further insights revealed that Indian shrimp refusals by USA were mainly due to the presence of alleged filthy, salmonella, veterinary drugs and nitrofuran.

Aquaculture based livelihood development

Front-line demonstrations on community fish farming integrated with agro-based production systems for the livelihood development of coastal poor families facilitated their mainstreaming with development of livelihood assets, capacity development and increased income. Follow up studies have shown that the initiatives have provided them livelihood security and enhanced their participation in the developmental initiatives of the state government.

Perceived effectiveness of CIBA ShrimpApp in supporting shrimp farmers

The shrimp farmers strongly felt that the mobile application CIBA ShrimpApp was efficient and facilitated them in quality seed selection, estimation of various inputs, disease diagnosis and prevention and water quality management. It served the extension education function effectively and found to be an efficient knowledge management tool. Further, user preferences and ranking of app modules show that among the modules input calculators and disease diagnosis were the maximum consulted modules.

Development of CIBA Shrimp KrishiApp for shrimp farm management

An android mobile application-CIBA Shrimp KrishiApp-was developed for handholding shrimp farmers in making real-time data based decisions at the farm level. Using this interactive mobile application, the farmers could input their farm data on day-to-day farming operations/observations from stocking to harvest and receive pond-wise information on shrimp survival, biomass, feed conversion ratio, pond water quality, and the expenditure incurred. Shrimp farmers were trained on the applications through conduction of farmer field schools on smart shrimp farming.

Influence of socio-economic status of tribal farmers on their adoption of aquaculture

Socio-economic status of the tribal farmers influenced their adoption of aquaculture as livelihood activity. Access to fisheries institutions, education level, participation in aquaculture activities, knowledge in culture practices and farming experience has influenced their adoption. Nursery rearing of seabass in hapas, seabass culture in cages, nursery rearing of milkfish in hapas, freshwater fish culture, and Integrated Fish Farming (IFF) had higher adoption rates.

Introduction

Brackishwater aquaculture is an important food production system in the coastal agro-ecosystem which utilizes the otherwise unusable coastal waters and land area for fish production. Despite COVID-19 disturbances which caused a 9-10% decline in shrimp production, shrimp continued to be the major item of seafood export accounting for a share of 51.36% in quantity and 74.31% of the value. The sustained growth, despite of pandemic, is due to the innate capacity of shrimp farming for income generation and employment guarantee to the rural coastal poor. The Indian Council of Agricultural Research has upgraded then All India Coordinated Research Project (AICRP) on Brackishwater Aquaculture into a full-fledged institute namely Central Institute of Brackishwater Aquaculture (CIBA) in 1987. The Central Institute of Brackishwater Aquaculture (CIBA) serves as national Nodal Agency for the development of technologies for sustainable coastal aquaculture. Over the years, the Institute has established itself as an organization of global standing. The institute has developed technologies for breeding and production of finfish and shell fish, genetic improvement of aquatic species, cost effective feed and other inputs, environment monitoring and aquatic animal health. The Institute also helped the sector with capacity building, technology communication and human resources development.

The headquarters of the Institute is located in Chennai, Tamil Nadu. The ICAR-CIBA has an experimental field station (with 36 hectares of farmland) at Muttukadu located 35 km south of Chennai and two regional research centers, one at Kakdwip, West Bengal (with 13.4 hectares of farmland) and the other at Navsari, Gujarat (with 10 hectares of farm land). A new research centre at Kovalam nearer to Muttukadu field station has also come up in the last year (with 7.6 hectares of farm land). It is being developed as farm facility for research and technology development. Overall, the institute has superlative facilities to carry out frontier research programmes in the areas of Genetics, Breeding, Nutrition technology, Molecular biology, Aquatic Animal Health, Therapeutics and Diagnostics along with strong capability for Environmental and Techno-Economic analyses. With these capacities, the institute has developed multi-disciplinary technological outputs in captive breeding, sustained diagnostics, seed and feeding, environmental, technology communication, extension and socio economic impact evaluation.

Status of brackishwater aquaculture sector in 2021

The country showed an increasing trend in spite of Covid-19 pandemic. The area under brackishwater shrimp farming increased to 1,66,722 hectares in 2021 from 1,58,859 hectares in the previous year. The production also increased to 8,43,361 tonnes in 2021 from 7,47,111 tonnes in 2019-20. Freshwater aquaculture may not provide for more fish production due to competing use of freshwater along with dwindling capture fishing, brackishwater resources are the only hope to increase aquaculture production in India. It is estimated that from the 1.2 million hectares of available brackishwater area resources, hardly 15 percent is utilized so far. Another set of 8 million hectares of salt affected inland areas available in Punjab, Haryana, Rajasthan and Gujarat belt can also be brought under brackishwater aquaculture. Though shrimp farming will be the spearhead for brackishwater aquaculture development, which is bringing in more than 4 billion USD to the national income every year, the finfish farming also needs to be developed to make aquaculture more resilient. Finfish farming is more sustainable and withstands many issues like climate change, diseases and price variations. Diseases continue to be the major production risk in shrimp farming and Hepatic microsporidiosis (EHP), White spot syndrome (WSSV) and Infectious myonecrosis disease (IMNV) were more prevalent in farmed shrimp during the year 2021.

ICAR-CIBA supports coastal aquaculture of shrimps, finfishes and determinedly popularizes shrimp, fish farming technologies among the farmers, diversification of brackishwater aquaculture with other candidate species and introduction of new age systems like Biofloc and Recirculatory Aquaculture System and Smart Farming. Introduction of SPF Tiger shrimp for farming is a welcome development and would help in diversification, however, the results of field performance throw light on the way both the shrimp species need to be farmed. Similarly Indian white shrimp *P. indicus* also needs to be promoted and selective breeding of the species is a priority. It appears that the domestic consumption of farmed shrimp is in a growing trend and the evolving model of partial harvesting for domestic market

needs to be validated. Providing sustainable and safe seafood are the objectives of the institute for increasing income, employment generation and nutritional security. CIBA believes in widespread stakeholder participation in making aquaculture more resilient. CIBA is working with institutional insurance companies for developing an insurance product for shrimp farming. CIBA has developed and launched mobile applications as technology communication and facilitate real-time based decision making at the farm level.

The Annual Report is a compendium of comprehensive compilation on progress of ICAR-Central Institute of Brackishwater Aquaculture during the year 2021. It also gives the gist of infrastructural development and other administrative activities carried out during the last year. Adequate information is provided about the events and programmes conducted by the institute as per its mandate.

ICAR-CIBA HEADQUARTERS AND RESEARCH CENTRES

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

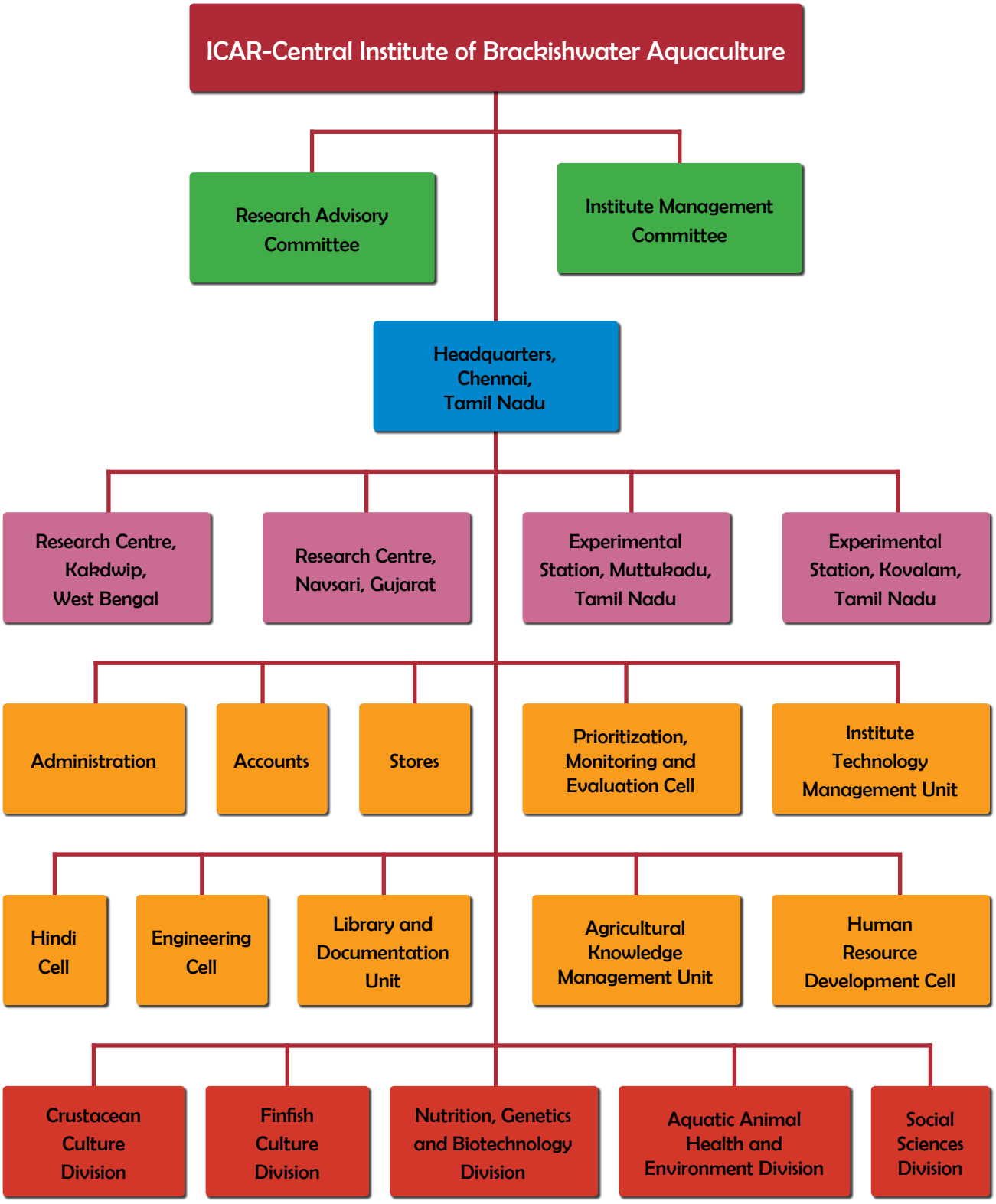
Our mission is to realize this vision through basic and applied research, and providing technological backstopping suitable for Indian conditions for the development of sustainable brackishwater aquaculture, which would provide much-needed food, nutritional security, employment, economic well-being and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

ICAR-CIBA Organizational Structure



Unified Budget

(₹ in lakhs)

S.No.	Name of the Head of Account	Unified Budget		
		RE 2021-22	Expenditure from 01.04.2021 to 31.03.2022	Closing Balance as on 31.03.2022
	Grants for creation of Capital Assets (CAPITAL)			
1	Works			
	(A) Land			
	(B) Building			
	i. Office building	47.00	47.00	0.00
	ii. Residential building			
	iii. Minor Works			
2	Equipments	92.07	92.07	0.00
3	Information Technology	25.00	25.00	0.00
4	Library Books and Journals	1.68	1.68	0.00
5	Vehicles & Vessels			
6	Livestock			
7	Furniture & Fixtures	15.03	15.03	0.00
8	Others (TSP)	28.00	28.00	0.00
9	Others (SCSP)	25.00	25.00	0.00
	Total Capital (Grants for creation of Capital Assets)	**233.78**	**233.78**	**0.00**
	Grants in Aid - Salaries (REVENUE)			
1	**Establishment Expenses**			
	(A) Salaries			
	i. Establishment charges	2,320.00	2,320.00	0.00
	ii. Wages			
	iii. Overtime Allowance			
	(B) Loans & Advances	10.00	10.00	
	Total - Establishment Expenses (Grants in Aid-Salaries)	**2,330.00**	**2,330.00**	**0.00**
	Grants in Aid - General (REVENUE)			
1	**Pension & Other Retirement Benefits**	**2,210.00**	**2,210.00**	**0.00**

S.No.	Name of the Head of Account	Unified Budget		
		RE 2021-22	Expenditure from 01.04.2021 to 31.03.2022	Closing Balance as on 31.03.2022
2	**Travelling Allowance**			
	(A) Domestic TA/Transfer TA	8.48	8.48	0.00
	(B) Foreign TA			
	Total - Travelling Allowances	**8.48**	**8.48**	**0.00**
3	**Research & Operational Expenses**			
	(A) Research Expenses	185.00	185.00	0.00
	(B) Operational Expenses	290.00	290.00	0.00
	Total - Res. & Operational Exp.	**475.00**	**475.00**	**0.00**
4	**Administrative Expenses**			
	(A) Infrastructure	193.00	193.00	0.00
	(B) Communication	3.44	3.44	0.00
	(C) Repairs & Maintenance			
	i. Equipments, Vehicles & others	46.00	46.00	0.00
	ii. Office building	228.36	228.36	0.00
	iii. Residential building			
	iv. Minor Works	40.00	40.00	0.00
	(D) Others (excluding TA)	141.90	141.90	0.00
	Total - Administrative Expenses	**652.70**	**652.70**	**0.00**
5	**Miscellaneous Expenses**			
	A. HRD	2.72	2.72	0.00
	B. Other Item (Fellowships, Scholarships etc.)			
	C. Publicity & exhibitions			
	D. Guest House - Maintenance	1.10	1.10	0.00
	E. Other Miscellaneous (TSP)	65.50	65.50	0.00
	F. Others (SCSP)	100.00	100.00	0.00
	Total - Miscellaneous Expenses	**169.32**	**169.32**	0.00
	Total Revenue (Grants in Aid-salaries + Grants in Aid - General)	**5,845.50**	**5,845.50**	**0.00**
	Grand Total (CAPITAL + REVENUE)	**6,079.28**	**6,079.28**	**0.00**

Staff Position

Position	Sanctioned	Filled	Vacant
Director (R.M.P)	1	0	1
HOD/HoRs/PS	7	0	7
Sr. Scientist	14	7	7
Scientist	52	54	(+2)
Technical Officers/ Technical Assistant	23	18	5
Chief Administrative Officer	1	0	1
Senior Administrative Officer	1	0	1
Administrative Officer	1	1	0
CFAO/Dy. Director Finance	1	0	1
Senior Finance & Accounts Officer	1	0	1
Finance & Accounts Officer	0	1	0
Assistant Finance & Accounts Officer	1	1	0
Assistant Administrative Officer	4	2	2
Principal Private Secretary	1	0	1
Private Secretary	2	2	0
Personal Assistant	3	2	1
Assistant	13	2	11
Upper Division Clerk (UDC)	5	5	0
Lower Division Clerk (LDC)	6	3	3
Skilled Support Staff (SSS)	28	16	12

Ongoing Research Projects

Sl.No	Project Title	Funding	Project Team
CRUSTACEAN CULTURE DIVISION			
Institute Projects			
1	Technology upgradation and optimization of protocols for diversified systems and species of crustaceans through sustainable approaches	ICAR	PI: Dr. A. Panigrahi Co-PI: Dr. M. Jayanthi, Dr. C. P. Balasubramanian, Dr. P. Nila Rekha, Dr. M. Muralidhar, Dr. S. Kannappan, Dr. P. Shyne Anand, Mrs. Leesa Priyadarsani, Mr. Jose Antony, Mr. R. Arvind, Dr. N. S. Sudheer, Mr. Biju I. Francis, Dr. T. N. Vinay, Dr. K. Ambasankar, Dr. T. K. Ghoshal, Dr. M. Kumaran, Dr. Sherly Tomy, Dr. P. Ezhil Praveena, Dr. R. Geetha, Dr. Sanjoy Das, Dr. Suvana Sukumaran, Mr. K. P. Sandeep, Mr. Pankaj Amrut Patil, Ms. Misha Soman, Dr. S. Sivagnanam, Dr. S. Rajamanickam
2	Captive maturation, breeding biology and larviculture of candidate crustacean species for brackishwater aquaculture	ICAR	PI: Dr. C. P. Balasubramanian Co-PI: Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. P. Nila Rekha, Dr. S. Kannappan, Dr. P. Shyne Anand, Dr. K. P. Kumaraguru Vasagam, Ms. L. Christina, Dr. T. N. Vinay, Dr. N. S. Sudheer, Mr. Biju I. Francis, Mr. Jose Antony, Mr. R. Arvind
Externally Funded Projects			
3	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-PI Dr. C. P. Balasubramanian
4	Resource Mapping of Brackishwater Aquaculture in Tamil Nadu	Dept. of Fisheries, Tamil Nadu	PI: Dr. M. Jayanthi Co-PI: Dr. M. Muralidhar, Mr. J. Ashok Kumar, Dr. M. Kailasam

5	Development of grow-out technology for mass culture of sand and muddy polychaete worms and assessment of their seasonal nutritional profiling for use in shell and finfish hatcheries	DBT	PI: Dr. S. Kannappan Co-PI: Dr. C. P. Balasubramanian, Dr. P. Ezhil Praveena, Dr. B. Sivamani, Mr. R. Aravind, Dr. N. S. Sudheer
FINFISH CULTURE DIVISION			
Institute Projects			
6	Development of hatchery technologies for breeding and seed production of candidate brackishwater finfish species under improved captive rearing systems	ICAR	PI: Dr. M. Kailasam Co-PI: Dr. M. Makesh, Dr. K. P. Kumaraguru vasagam, Dr. T. Senthil Murugan, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Mrs. Babita Mandal, Mr. Pankaj Amrut Patil, Mr. Tanveer Hussain, Mr. Dani Thomas, Dr. P. Kumararaja, Dr. Raymond Jani Angel, Dr. T. K. Ghoshal, Mr. T. Sivaramakrishnan, Dr. B. Sivamani, Ms.Misha Soman, Mr. D. Rajababu, Dr. R. Subburaj, Mr. G. Thiagarajan
7	Development and demonstration of novel brackishwater finfish farming technologies	ICAR	PI: Dr. M. Makesh Co-PI: Dr. M. Kailasam, Dr. T. Senthil Murugan, Dr. Krishna Sukumaran, Dr. B. Sivamani, Dr. K. P. Kumaraguru Vasagam, Dr. K. Ambasankar, Mr. Ashok Kumar Jangam, Dr. Prem Kumar, Dr. Aritra Bera, Mrs. Babita Mandal, Mr. Tanveer Hussain, Mr. Dani Thomas, Dr. Raymond Jani Angel, Dr. R. Geetha, Mr. K. P. Sandeep, Mr. Pankaj Amrut Patil, Dr. P. Kumararaja, Mr. T. Sivaramakrishnan, Mr. D. Rajababu, Dr. R. Subburaj, Mr. G. Thiagarajan
Externally Funded Projects			
8	Development of brackishwater aquariculture through optimisation of captive breeding protocols of potential and emerging ornamental fish species, technology transfer and livelihood generation	ICAR	PI: Dr. M. Kailasam Co-PI: Dr. M. Makesh, Dr. K. P. Kumaraguru Vasagam, Dr. T. Senthil Murugan, Dr. Krishna Sukumaran, Dr. Prem Kumar, Dr. Aritra Bera, Mrs. Babita Mandal, Mr. Dani Thomas, Mr. Tanveer Hussain

AQUATIC ANIMAL HEALTH & ENVIRONMENT DIVISION			
Institute Projects			
9	Investigation of existing/ emerging diseases in candidate brackishwater species and development of preventive/ treatment strategies for effective management	ICAR	PI: Dr. K. P. Jithendran Co-PI: Dr. M. Poornima, Dr. P. K. Patil, Dr. S. K. Otta, Dr. M. Makesh, Dr. Sanjoy Das, Dr. R. Ananda Raja, Dr. P. Ezhil Praveena, Dr.Sanjoy Das, Dr. Sujeet Kumar, Dr. T. Bhuvaneswari, Dr. Viday Rajendran, Dr. T. Sathish Kumar, Dr. T. N. Vinay, Dr. Prem Kumar, Dr. Shyne Anand, Mr. Tanveer Hussain, Mrs. Leesa Priyadarsani, Dr. Joseph Sahayarajan, Dr. Satheesha Avunje, Ms. Misha Soman, Dr. Aritra Bera, Dr. Krishna Sukumaran, Shri T. Sivaramakrishnan
10	Development of technologies for amelioration of pond soil and water quality in brackishwater aquaculture	ICAR	PI: Dr. M. Muralidhar Co-PI: Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. Satheesha Avunje, Dr. Suvana Sukumaran, Dr. A. Nagavel, Dr. M. Jayanthi, Dr. J. Syama Dayal, Dr. P. K. Patil, Dr. Aritra Bera, Mr. Jose Antony, Dr. A. Nagavel
Externally Funded Projects			
11	National initiative on climate resilient agriculture (NICRA)- Impact of climate change on aquaculture and mitigation option for minimizing greenhouse gases from aquaculture sector	NICRA	PI: Dr. M. Muralidhar Co-PI: Dr. M. Jayanthi, Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Mr. J. Ashok Kumar, Dr. Prem Kumar, Dr. P. Kumararaja, Dr. R. Geetha, Dr. Aritra Bera, Dr. Satheesha Avunje, Mr. T. Sathish Kumar, Dr. Suvana Sukumaran, Mr. Jose Antony, Dr. A. Nagavel
12	National surveillance programme for Aquatic Animal Health - Surveillance of brackishwater finfish and shellfish diseases in Tamil Nadu and Andhra Pradesh	NFDB	PI: Dr. S. K. Otta Co-PI: Dr. K. P. Jithendran, Dr. M. Poornima, Dr. Sanjoy Das, Dr. Sujeet Kumar, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Mr. T. Sathish Kumar, Dr. R. Ananda Raja, Dr. Vidya Rajendran, Mrs. Leesa Priyadarsani, Dr. Joseph Sahayarajan
13	National surveillance programme for Aquatic Animal Health - National Referral Laboratory for brackishwater finfish and shellfish diseases	NFDB	PI: Dr. S. K. Otta Co-PI: Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari

14	Network Project on Anti-microbial resistance	ICAR	PI: Dr. S. K. Otta Co-PI: Dr. T. Bhuvaneswari, Dr. Vidya Rajendran
15	All India Network project on fish health	ICAR	National Coordinator: Dr. K. P. Jithendran PI: Dr. P. K. Patil Co-PI: Dr. S. K. Otta, Dr. R. Ananda Raja, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. Satheesha Avunje, Dr. M. Makesh, Dr. R. Saraswathy, Dr. P. Kumararaja, Mr. J. Ashok Kumar, Dr. T. Ravisankar, Dr. T. N. Vinay, Dr. R. Geetha
16	Consortium Research Platform on Vaccines & Diagnostics (a) Development of vaccine for betanodavirus infecting seabass *Lates calcarifer* (b) Development of probiotics and immunostimulants for shrimp (c) Development of diagnostics for differentiation and quantification of pathogenic *Vibrio harveyi* clade species	ICAR	Project Coordinator: Dr. M. Makesh PI: Dr. M. Makesh Co-PI: Dr. K. P. Jithendran, Dr. M. Poornima, Dr. P. K. Patil, Dr. Sujeet Kumar PI: Dr. P. K. Patil Co-PI: Dr. S. V. Alavandi, Dr. Satheesha Avunje, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja PI: Dr. Sujeet Kumar Co-PI: Mr. T. Sathish Kumar, Dr. Joseph Sahayarajan
17	Environmental and Social Impact assessment study for assessing the suitability of derelict paddy fields for shrimp Farming in Kerala	Seafood Exporters Association of Kerala	PI: Dr. M. Muralidhar Co-PI: Dr. M. Kumaran, Dr. M. Jayanthi, Mr. K. P. Sandeep, Dr. Suvana Sukumaran, Mr. Dani Thomas
18	Monitoring impacts of physico-chemical characteristics on system generated syndromes of shrimp in a pond environment	Indo-UK	Project Co-ordinator Dr. K. P. Jithendran PI: Dr. S. K. Otta Co-PI: Dr. M. Shashi Shekhar, Dr. K. Vinaya Kumar, Dr. P. Ezhil Praveena

NUTRITION, GENETICS AND BIOTECHNOLOGY DIVISION			
Institute Projects			
19	Integrating biotechnological and bioinformatics approaches for molecular and genetic characterization of brackishwater fish and shellfish candidate species	ICAR	PI: Dr. M. Shashi Shekhar Co-PI: Dr. Sherly Tomy, Dr. K. P. Kumaraguru Vasagam, Mr. J. Ashok Kumar, Dr. B. Sivamani, Dr. K. Vinaya Kumar, Dr. T. N. Vinay, Dr. J. Raymond Jani Angel, Mrs. Misha Soman, Mr. Dani Thomas, Dr. Krishna Sukumaran
20	Sustainable aqua feed formulations and feeding approaches for improved growth and health.	ICAR	PI: Dr. K. Ambasankar Co-PI: Dr. J. Syama Dayal, Dr. T. K. Ghoshal, Dr. Debasis De, Dr. Sherly Tomy, Dr. K. P. Kumaraguru Vasagam, Dr. Sujeet Kumar, Dr. T. Senthil Murugan, Mr. K. P. Sandeep, Mr. T. Sivaramakrishnan, Dr. P. Shyne Anand, Mr. Tanveer Hussain, Dr. Suvana Sukumaran, Dr. Shyne Anand
Externally Funded Projects			
21	Outreach activity on fish feed and Nutrient profiling of Brackishwater fish and shrimp	ICAR	PI: Dr. K. Ambasankar Co-PI: Dr. J. Syama Dayal, Dr. T. K. Ghoshal, Mr. Debasis De, Dr. K. P. Kumaraguru Vasagam, Mr. K. P. Sandeep, Mr. T Sivaramakrishnan
22	Genomic resources for augmentation of economic traits in Indian white shrimp *Penaeus indicus* and whole genome sequencing of brackishwater aquaculture candidate species	ICAR	PI: Dr. M. Shashi Shekhar Co-PI: Dr. K. Vinaya Kumar, Mr. J. Ashok Kumar, Dr. J. Raymond Jani Angel, Dr. M. Kailasam, Dr. Krishna Sukumaran
23	Network Project on Investigations on dietary alterations in shrimp for abiotic stresses using nutrigenomics approach	ICAR	PI: Mr. J. Ashok Kumar Co-PI: Dr. J. Syama Dayal, Dr. Shashi Skekhar, Dr. K. Vinaya Kumar, Dr. P. Shyne Anand, Mr. K. P. Sandeep
24	Solid state fermentation technology for development of cost effective customized plant protein products as fishmeal alternate for shrimp feed	DBT	PI: Dr. J. Syama Dayal Co-PI: Dr. Sujeet Kumar, Mr. K. P. Sandeep

25	Unravelling signatures of growth and salinity adaptation in *Etroplus surentensis* through omics approaches	DBT	PI: Dr. K. Vinaya Kumar Project Co-ordinator Dr. K. P. Jithendran Co-PI: Dr. J. Raymond Jani Angel, Dr. M. Shashi Shekhar, Mr. J. Ashok Kumar, Dr. K. P. Kumaraguru Vasagam
26	Diversification of potential crop species in brackishwater aquaculture, adaptation for climate resilience	Indo-UK	PI: Dr. K. Ambasankar Co-PI: Dr. M. Shashi Shekhar, Dr. K. Vinaya Kumar, Dr. J. Raymond Jani Angel, Mr. K. P. Sandeep, Mr. T. Sivaramakrishnan
SOCIAL SCIENCES DIVISION			
Institute Project			
27	Communication and socio-economic validation of brackishwater aquaculture technologies for sustainable development	ICAR	PI: Dr. C. V. Sairam Co-PI: Dr. T. Ravisankar, Dr. B. Shanthi, Dr. D. Deboral Vimala, Dr. M. Kumaran, Dr. P. Mahalakshmi, Dr. R. Geetha, Dr. Debasis De, Mr. Ashok Kumar Jangam, Mr. Pankaj Kumar Patil
Externally Funded Project			
28	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. K. Ambasankar, Dr. D. Deboral Vimala, Dr. P. Mahalakshmi, Mr. J. Ashok Kumar, Mr. T. Sathish Kumar, Mr. Jose Antony, Mr. S. Nagarajan
KAKDWIP RESEARCH CENTRE			
Institute Project			
29	Evolving brackishwater aquaculture technologies and its dissemination for livelihood security of Sundarban farmers	ICAR	PI: Dr. Debasis De Co-PI: Dr. T. K. Ghoshal, Dr. Sanjoy Das, Dr. Prem Kumar, Mrs. Babita Mandal, Ms. Christina Lalramchhani, Mrs. Leesa Priyadarsani
Externally Funded Project			
30	Elucidation of molecular mechanism of dopamine action on final oocyte maturation of Goldspot mullet (*Liza parzia*, Hamilton, 1822)	DBT	PI: Dr. Prem Kumar Co-PI Dr. T. K. Ghoshal
31	Captive Breeding of Hilsa, *Tenualosa ilisha*: Phase II	NASF	PI: Dr. Debasis De Co-PI: Mrs. Babita Mandal, Mr. Tanveer Hussain, Dr. T. K. Ghoshal

NAVSARI GUJARAT RESEARCH CENTRE			
Institute Project			
32	Development of sustainable and cost-effective brackish-water farming technologies for shellfish and finfish in the north-west coast	ICAR	PI: Mr. Jose Antony Co-PI: Mr. Pankaj Amrut Patil, Mr. Tanveer Hussain, Dr. M. Kailasam, Dr. C. P. Balasubramanian, Dr. P. Mahalakshmi, Dr. R. Saraswathy, Dr. K. Ambasankar
Externally Funded Project			
33	Brackishwater integrated multi-trophic cage aquaculture of different species, pearlspot breeding & Crab box culture in diverse rearing systems for alternate livelihood and Societal development of mangrove based fisher folks of Maharashtra	Mangrove cell, Maharashtra	PI: Mr. Pankaj Amrut Patil Co-PI: Mr. Tanveer Hussain, Mr. Jose Antony, Dr. M. Kailasam, Dr. Krishna Sukumaran, Dr. C. P. Balasubramanian, Dr. P. Mahalakshmi, Dr. K. Ambasankar
Other Projects			
34	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) Mr. Dani Thomas, FCD
35	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 Dr. R. Geetha, SSD Dr. T. N.Vinay, CCD Dr. J. Raymond Jani Angel, NGBD (Genetics) Dr. K. P. Sandeep, NGBD (Nutrition) Mr. Dani Thomas, FCD

RESEARCH HIGHLIGHTS

Brackishwater Production System

Backwater cage farming of Asian seabass in low volume cages by fisher youth as an additional income generation activity

Low volume cage culture of seabass was demonstrated with the participation of Shri Ashok Kumar, fisherfolk from Chinnakuppam, Chengalpet District, Tamil Nadu. A total of 420 numbers of seabass fingerlings with the mean size of 40 g were supplied from the fish hatchery during November 2020 and stocked into small 20 × 15 ft cage. Feeding was done with Seabass^{plus} pellet feed prepared by CIBA and later combined with chopped trash fish. After 10 months culture period, a total of 390 kg fish with an average weight of 1.2 kg (77.0% survival rate) was harvested and an amount of ₹1.50 lakhs was realised from the sales.

Harvesting of cage cultured seabass

Technology transfer: Success story of partnership between Canares Aqua LLP and ICAR-CIBA

Canares Aqua LLP, Kumta, Karnataka signed MoU with CIBA and was supported by supplying fertilised seabass eggs on a regular basis for establishing fingerling production in the West Coast. A total of 21.6 lakh eggs were transported by air with transport time of upto 14 hours. After weaning to formulated diet and rearing to fingerling size (3-4 inch) for a period of 3-4 months, the firm has supplied around 3.0 lakh fingerlings to the cage culture farmers from Goa, Karnataka, Kerala, Maharashtra and Gujarat along the west coast. Due to regular supply of these fingerlings, a total of 1,500 cages could be stocked with seabass seeds, the farming activities are under progress.

CIBA and Canares Aqua LLP staff in front of their facility

Demonstration of low volume pen culture of seabass in Muttukkadu brackishwater lake

Low volume pen culture of seabass was demonstrated with the participation of fisherfolk youth Mr. Satya from Karikattukuppam Village in Muttukkadu. The pen (25 m^2) was stocked with 100 numbers of seabass advanced fingerlings (average size - 70 g). Fishes were fed with formulated feed of CIBA along with fish by-catch. After 100 days of culture, production of 32.5 kg could be obtained @ 1.3 kg/m^3 (average size 500 g). This demonstration provided promising results as short term income generation activity and has scope to expand the pen culture activities in open water bodies.

Harvesting of pen cultured seabass

Maiden harvest of Asian Seabass (*Lates calcarifer*) from a saltern pond at KES of CIBA, Kovalam

Grow out trial of Asian seabass, *Lates calcarifer,* was conducted in an earthen saltern pond at the newly established Kovalam experimental station of ICAR-CIBA. 300 seabass fingerlings (77 g ± 2.0; 23.1 kg initial biomass) were stocked in a 0.1 ha earthen pond. The fishes were grown for 115 days using the Seabass^{plus} feed developed by CIBA. The salinity and temperature varied between 33-34 ppt and 30 to 34°C respectively during the culture period. The fishes attained a size of 550-650 g (34-40 cm length) with a FCR of 1.20. Total biomass of 121 kg (173 numbers) was harvested at the end of the grow out period with a survival of 57.6%. This short term grow-out model may be an alternative livelihood option and a progressive employment opportunity for the unemployed youth.

Asian Seabass harvest from a saltern pond at KES of CIBA, Kovalam

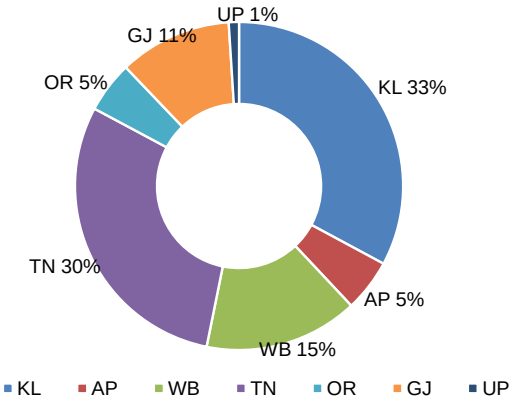
Experimental trial on monoculture of milkfish (*Chanos chanos)* fed with formulated floating pellet feed in newly developed pond in KES- CIBA

Milkfish is a suitable candidate species for diversification of brackishwater aquaculture, and the availability of hatchery produced seed created momentum in scientific farming of milkfish. Real time production data of different farming models are scanty from farmer's pond. In this connection, milkfish monoculture trials have been initiated in a newly established KES-CIBA farm to formulate a cost-effective farming protocol. A 1,156 m^2 pond has been renovated and prepared with organic manures. Milkfish fingerlings (20 g ABW, 11.6 cm tl.) were stocked @ 1.5 / m^2. Fishes were fed with CIBA Milkfish Grow-Out^{Plus} pellet feed (Protein 30-35%, Fat 6%) @ 3-5% of body weight. This culture trial was conducted for 160 days from July to December, 2021 covering pre-monsoon and monsoon seasons. As a climate resilient species, milkfish survival rate was 90%. Pond plankton diversity and water quality showed significant variation in different months. After 160 DOC, fishes have grown to an average 222 g and 31.62 cm tl. Specific growth rate (SGR) was found to be 1.96. DDG (Fy.) ICAR visited the KES-CIBA and witnessed the farming trial.

Milkfish seed production and nursery rearing during Covid-19 pandemic

Milkfish is a suitable candidate species for the diversification of brackishwater aquaculture. Despite COVID 19 scenario and lockdown, there is an increased demand for hatchery produced milkfish seed for monoculture and polyculture among farmers from all the coastal states and a few inland saline areas of India. Maximum seed demand was from Kerala (33%), followed by Tamil Nadu (30%). Milkfish farming is picking up in West Bengal and Gujarat also, with seed demand of 15% and 11%, respectively.

An experiment was designed to assess the stocking density on growth and survival of milkfish juveniles reared in four different nursery systems i.e., earthen ponds (t1), lined ponds (t2), periphyton based FRP tanks (t3) and FRP tanks (t4) for two months. Square shaped shade-net (1 × 1 × 1 ft) fitted in PVC frames were placed in FRP tanks for periphyton formation. Milkfish fry (0.4 g ABW; 3.0 cm average tl.) were stocked @ 8 /m^2 in ponds (both lined and earthen), whereas 200/m^3 were stocked in FRP tanks. Fishes were fed with 500–1,000 µm CIBA milkfish nursery^{plus} feed (Crude Protein 35-40%, Fat 8%) in all the treatments @ 8-10% body weight. After 60 days of rearing, maximum growth (17.13 g ABW and 13.3 cm average tl.) was obtained from earthen ponds compared to lined ponds (14.24 g ABW & 12.5 cm average tl.). Lined ponds and earthen ponds recorded survival of 92% and 89.34% respectively at the end of experiments with no significant difference. It was found easy to collect fingerlings from lined ponds compared to earthen ponds due to the presence of artificial bottoms having less organic matter. In contrast, the formation of lab-lab and the presence of other natural feeds contributed to the higher growth in earthen ponds compared to lined ponds. In tank experiment, periphyton based FRP tanks showed higher growth (10.5 g ABW, 8.7 cm average tl.) and survival (75%) compared to FRP tanks without periphyton (8.26 g ABW, 6.7 cm average tl.). Lesser growth and survival in tank-based systems may be due to reduced space which in turn triggers stunted fingerling production. Milkfish fingerling production may be advisable in pond-based systems with artificial feed for higher growth and survival in short duration.



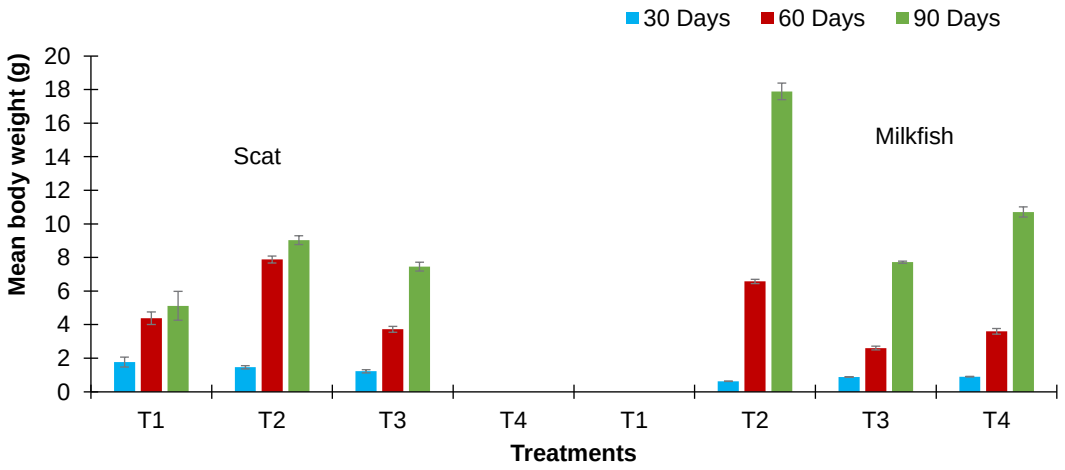
State wise milkfish seed distribution during 2021

Use of periphyton improve survival and growth of milkfish: Hapa nursery

Periphyton-based farming is widely used in the nursery rearing and grow-out farming of freshwater fishes. Like biofloc, periphyton is also a heterogenous mixture of biota, including bacteria, fungi, phytoplankton, zooplankton, benthic organisms, detritus, etc. But unlike a biofloc-based system, here the mixture of biota is generally attached to any submerged substrate. In the present experiment, milkfish nursery was attempted in net cage hapa (2 × 1 × 1 m) with and without periphyton. Hatchery produced seed (Avg. wt. 0.08 g; Avg. total length: 12 mm) were distributed in three experimental groups viz. T1 (4 m^2 periphyton), T2 (2 m^2 periphyton) and T3 (without periphyton) at a stocking density of 250/ m^2. All the animals were fed with formulated feed (size: 500 µ, protein: 42%). After 90 days of nursery, 90, 70 and 50% survival were observed in T1, T2 and T3 groups, respectively. Similarly, the final weight was highest in T1 group (3.86 g) followed by T2 (2.87 g) and T3 (2.28 g). Therefore, supplementation with periphyton improves the growth and survival of milkfish during nursery rearing.

Evaluation of periphyton based outdoor nursery rearing of milkfish and scat in lower salinities

Milkfish is a euryhaline fish and is being cultured in varying salinities. Milkfish juveniles adapt to lower salinities also and grow well. A trial was conducted to evaluate the growth performance of milkfish (60 dph) with spotted scat fry under polyculture based nursery rearing systems. A different combination of stocking densities were adopted to optimize the stocking density ratio for nursery rearing in triplicate. The stocking density of milkfish (0.3 ± 0.06 g) was 0, 10, 20 and 30/m² in T1, T2, T3 and T4 respectively. Early fry of scat (1.1 ± 0.08) was stocked at 30, 20, 10 and 0/m² in T1, T2, T3 and T4 respectively. In all the treatment tanks, a shade net cloth of 0.5 × 0.5 m was suspended as periphyton substrate. Feeding was done twice at 5% body weight. After 90 days of rearing, it was found that biomass of periphyton was highest (5.1 ± 0.08 g) in T1 and lowest (1.2 ± 0.03 g) in T2. Milkfish (17.89 ± 0.49 g) and scat (9.03 ± 0.27 g) gained the highest body weight in T2. Lowest weight gain was observed in T1 for scat (5.12 ± 0.86 g) and in T3 for milkfish (7.72 ± 0.06 g). It was found that periphyton biomass was inversely proportional to stocking density of milkfish. Addition of periphyton substrate shows an improved growth rate of milkfish juveniles under outdoor nursery rearing systems.



Effect of periphyton substrate in outdoor nursery rearing of milkfish and scat in lower salinities on growth

Popularization of seed production technology of orange chromide among farmers of Sunderban

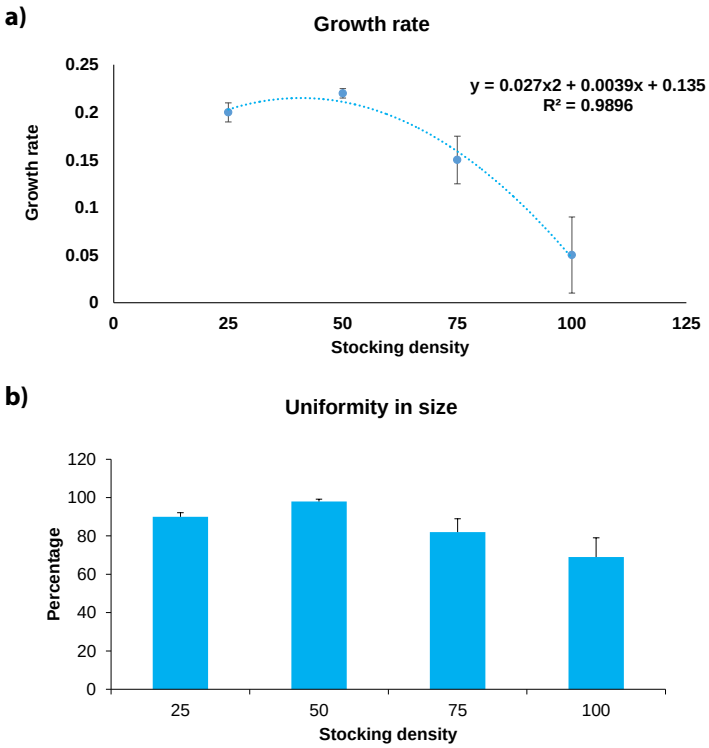
With slight modification in orange chromide seed production technology of ICAR CIBA, seeds were produced at Kakdwip research centre of CIBA and sold to progressive farmers and ornamental fish traders for its popularization. Tank (1,000 L, 1 m height) based breeding unit having provision of water recirculation and three levels of egg laying substrates (bottom, column and top) was used for breeding of orange chromide. The results showed that the orange chromide spawn more frequently at the bottom substrate (70%) than the column (30%) and top (0%) substrate.

Orange chromide seed distribution

Orange chromide fry

Growth enhancement and uniform size production in nursery phase of silver moony, *Monodactylus argenteus* by manipulating stocking density

An experiment was conducted to optimize the growth and production of uniform size silver moony in the nursery rearing phase by stocking silver moony in different densities. The fries were stocked at varying stocking densities of 25, 50, 75 and 100 numbers in 2 × 1 × 1 m hapas. The fishes stocked at a density of 50/hapa attained a higher growth rate and uniform size and the survival rate was also comparable to that in hapas with low densities. The results indicated that a stocking density of 50/hapa is optimal for nursery rearing phase of silver moony to produce higher growth and uniform size production.



a) Growth rate; b) Uniformity in size of silver moony at different densities

Livelihood support to tribal community through brackishwater ornamental fish rearing and trade

Nursery rearing of brackishwater ornamental fish silver moony was evaluated as a model for the livelihood development of tribal communities.

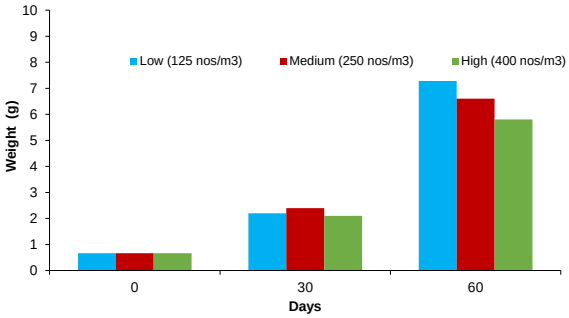
Hatchery produced silver moony fry were provided to the tribal community with formulated feed. The group reared the fry to marketable size (6 to 8 cm) in hapas in the pond system at KES of CIBA. After 60 days of rearing, a partial number was sold to the ornamental traders from Kolathur and earned substantial profit within a short period of time.

Nursery rearing activities of silver moony by the tribal community and distribution of silver moony seed reared by tribal community to ornamental fish traders by DDG (Fy), on 17th December, 2021

Nursery rearing of vermiculated spinefoot, *Siganus vermiculatus* in a hapa based system under different stocking densities.

Among Siganids, vermiculated spinefoot, *S. vermiculatus* is one of the important candidate species for brackishwater aquaculture because of its fast growth rate, herbivore feeding habit and tolerance to adverse environmental conditions. They are also suitable for polyculture systems. Based on the positive characteristics of *S. vermiculatus,* an experiment was carried out to evaluate the growth and survival of vermiculated spinefoot, in a hapa based system. Wild collected *S. vermiculatus* fry (2.5 ± 0.22 cm and 0.64 ± 0.16 g) were stocked in nylon hapas (2×1 ×1 m) at different stocking densities i.e. low (125/m^3), medium (250/m^3) and high (400/m^3). Results revealed that stocking vermiculated spine foot fry at 250/m^3 in nylon net hapa was found ideal. *S. vermiculatus* attained fingerling size (tl. 6.6 ± 0.26 cm and body weight 6.5 ± 0.59 g) in 60 days of rearing in hapa based system with 88% survival rate when provided with 32% crude protein feed.

***S. vermiculatus* fingerling at the end of 60 days of nursery rearing**



Growth performance of *Siganus vermiculatus* fry under different stocking densities

Comparative evaluation of growth performance of vermiculated spinefoot, *Siganus vermiculatus* in different production systems

A 150 day experiment was carried out to evaluate the growth performance of spinefoot *S. vermiculatus* in brackishwater pond system and cages installed in brackishwater pond. A total of 500 *S. vermiculatus* fingerlings (total length 7.86 ± 0.417 cm and mean body weight 7.50 ± 0.50 g) were stocked in 500 m^2 pond. 100 number of *S. vermiculatus* fingerlings (7.36 ± 0.202 cm and 6.60 ± 0.38 g) were stocked in floating net cages (2×2×1 m) installed in brackishwater ponds. The salinity ranged from 14 to 24 ppt during the farming period. Fishes were fed with floating pellet feed containing 32% crude protein, at 5% biomass in 2 rations. At the end of 150 days of rearing, the results revealed that growth parameters of *S. vermiculatus* showed significant difference (p<0.05) among the treatments. The highest mean total length (28 ± 1.21 cm), body weight (187.75 ± 9.02 g) and SGR (2.31 ± 0.02%/day) was observed in *S. vermiculatus* reared in the pond system as compared to cages. From the results, it is concluded that the growth performance of *S. vermiculatus* is better in ponds as compared to cage installed in ponds. *S. vermiculatus* is herbivore in nature and it grazes on aquatic vegetation and filamentous algae present in the pond.

System	Pond	Cage
Initial length (cm)	7.86 ± 0.417	7.36 ± 0.202
Initial weight (g)	7.50 ± 0.50	6.60 ± 0.38
Final length (cm)	28 ± 1.21	16.7 ± 1.73
Final body weight (g)	187.75 ± 9.02	62.710 ± 6.46
SGR	2.31 ± 0.02	1.70 ± 0.03
Survival rate (%)	92	91

Optimisation of pair density of orange chromide, in floating net cages for enhanced breeding frequency

Orange chromide, *Pseudetroplus maculatus* is considered as one of the potential ornamental fish for aquarium trade. CIBA standardized the breeding of orange chromide in floating net cages and subsequent egg collection, incubation and larval rearing in the RAS system. However, to enhance the breeding frequency of orange chromide in floating net cages, an experiment was

carried out to optimise the breeding pair density. Orange chromide brooders male (7.42 ± 0.15 cm & 7.87 ± 0.76 g) and female (7.35± 0.13 cm & 8.62 ± 0.62 g) in the ratio of 1:1 were stocked in 5 different floating net cages (2 ×1× 1 m) with 1, 5, 10 , 15 and 20 pairs. In each cage, clay pots were provided to facilitate spawning. Results revealed that a total of 35 spawnings were observed in 60 days from 10 pairs of *P. maculatus* brooders with an average fecundity of 294.07 ± 13.24. Each pair spawned 3.5 times on average in 60 days at an interval of 13 days. An enhanced breeding frequency at an interval of 13 – 15 days was observed in cages stocked with 1, 5 and 10 pairs. However, the lowest breeding frequency at an interval of 25 days was recorded in cage stocked with 20 pairs of *P. maculatus* brooders. From the overall results, it has been concluded that 10 pairs of *P. maculatus* brooders (10 males and 10 females) in 2 ×1× 1 m floating net cages is ideal for enhanced breeding frequency by curtailing parental care.

Orange chromide brooder

Fertilized eggs on clay pot substrate

Orange chromide hatchling

Cage culture of wild mangrove red snapper in creek of Mirya village, Ratnagiri, Maharashtra

An experiment was conducted on cage culture of wild collected mangrove red snapper in a creek at Mirya village of Ratnagiri, Maharashtra. In April 2021, around 500 (3-6 inch, 20-40 g) numbers of mangrove red snapper were collected from local dragnet fishermen from different creeks of Ratnagiri and stocked in GI pipe cage (4 × 4 × 2 m), fabricated by using 18 mm & 30 mm HDPE knotless nets and floated in creek with the help of barrels. During culture, the fishes were fed with 3-8% body weight with the CIBA formulated feed (45% crude protein) twice a day. The stocked fish attained 300-800 g within a period of 6 months with 80% survival. The harvest resulted in income generation of ₹55,000 to three SHG members of Mirya village, Ratnagiri. The findings revealed that wild collected mangrove red snapper easily accept formulated feed and is good candidate species for cage culture in creeks as an alternative livelihood for fisher folks.

Growth performance of pearlspot fingerlings with and without periphyton substrate

A seven month experiment was conducted to evaluate the growth performance of pearlspot fingerlings fed with formulated feed provided with and without periphyton substrate in a grow-out pond (3,000 m^2) at NGRC Farm, Navsari. For the experiment, the pond was divided into six units (each 500 m^2) by creating an internal partition in the pond with the help of HDPE garden fencing net (10 mm mesh). Pearlspot fingerlings of average size 7.74 ± 0.14 g were stocked in each unit at a density of 500/unit. The experimental setup consisted of two treatments with three replicates, T1 (30% CP feed), T2 (30% CP feed+ sugarcane bagasse substrate). Dry sugarcane bagasse (25 numbers of 1 feet long) were attached to individual pp rope for development of periphyton and eight such ropes with sugarcane bagasse were hanged in each partition of T2 at a distance of 2 m respectively. Throughout the experiment, stocked fishes were fed with formulated floating feed at 3-6% of body weight twice a day. At the end of the study, growth parameters of pearlspot in T2 were found significantly higher as compared to growth of pearlspot in T1. Hence, from the results it can be concluded that provision of periphyton substrates in grow-out pond along with feed to pearlspot fingerlings not only reduces the cost of feed but also promotes faster and higher growth of the fishes.

Growth performance of pearlspot fingerlings fed with formulated feed provided with and without periphyton substrate in grow-out pond

Particular	Treatment-1 (T1)	Treatment-2 (T2)
Treatment	Only 30% crude protein feed	30% crude protein feed + Sugar bagasse substrate for development of periphyton
Replicates	3	3
Fish Density	500/section (500 m^2)	500/section (500 m^2)
Initial weight (g)	7.74 ± 0.14 (n=60)	7.74 ± 0.14 (n=60)
Feeding (%)	3-6	3-6
Periphyton Substrate	No sugar bagasse substrate	1 feet dried Bagasse , 25 Bagasse per rope 8 bagasse rope per replicate(@ 2 m distance)
Sampling	15 days Interval (n=30)	15 days Interval (n=30)
Final weight (g)	109.6 ± 1.02	134.06 ± 0.92
Survival (%)	100	100
FCR	2.92	2.39
SGR (%)	1.26 ± 0.01	1.36 ± 0.01

Pond culture of *Mystus gulio* at different stocking densities

The growth performance of *M. gulio* was compared in two different stocking densities of 10 and 20/ m^2 in brackishwater ponds of 1,000 m^2 each. *M. gulio* fingerlings (Average weight: 0.86 g; Average length: 21 mm) were acclimatized and stocked. Fishes were fed with formulated diet (30% protein and 8% lipid) at 3% of biomass twice daily. After six months of winter rearing (August to January) fish attained an average size of 14.5 g and 12.8 g, at 10 and 20/m^2 stocking densities respectively. It is concluded that the *M. gulio* is suitable species to be farmed at higher density of 20/m^2 in tide fed brackishwater pond system with formulated feed.

Pond culture of *M. gulio*

After 250 days of culture

Nursery rearing of hilsa

Nursery ponds (30 m^2) were fertilized with three different treatments i.e., mustard oil cake at 75 ppm (T1), Plankton^{Plus} at 75 ppm (T2) and combination of both at the ratio of 1:1 (T3) six days prior to stocking of hilsa hatchling. Six days old hatchlings were stocked in rectangular nursery ponds and were fed with formulated feed (CP 36.15% and Fat 12.30%) twice a day with feeding rate of 50 g/ nursery pond for initial 2 weeks followed by 10-20% bodyweight for rest of the culture period. The phyto and zooplankton density and diversity were found to be higher in T3. Among phytoplankton population, *Chlorella* sp. and *Nannochloropsis* sp. were dominant whereas copepod, daphnia and moina were higher among zooplankton in T3 nursery ponds. After 60 days of nursery rearing, better body weight (2.39 g ± 0.24) and survival (30%) was obtained when combination of Plankton^{Plus} (75 ppm) and mustard oil cake (75 ppm) was supplemented as plankton booster.

Growth parameters of hilsa in three different treatments

Refinement of grow-out rearing protocol of hilsa

Before stocking of hilsa, pond was chlorinated to remove unwanted and predatory fish using 500 kg/ha bleaching powder. After dechlorination, Plankton^{Plus} was applied at 160 kg/ha. Post 5 days of Plankton^{Plus} application nursery reared hilsa fry (1.84 ± 0.30 g/ 5.58 ± 0.40 cm) were stocked in brackishwater pond (0.15 ha) at 14,000/ha. During culture, pond was fertilized with Plankton^{Plus} (30 kg/ha) and mustard oil cake (60 kg/ha) in alternate weeks to maintain the plankton population. Formulated slow sinking grow-out feed (Hilsa^{Plus}) was fed at 5-10% body weight. After 250 days, fry gained avg. body weight and avg. body length of 36.28 ± 2.98 g and 17.34± 0.29 cm respectively. Plankton diversity indicated that copepod, daphnia and rotifers were major zooplankton and *Chlorella* sp., filamentous algae, *Gyrosigma* sp., *Nitzschia* sp., *Nannochloropsis* sp. were predominant phytoplankton in brackishwater grow-out culture pond.

Initial Stocking

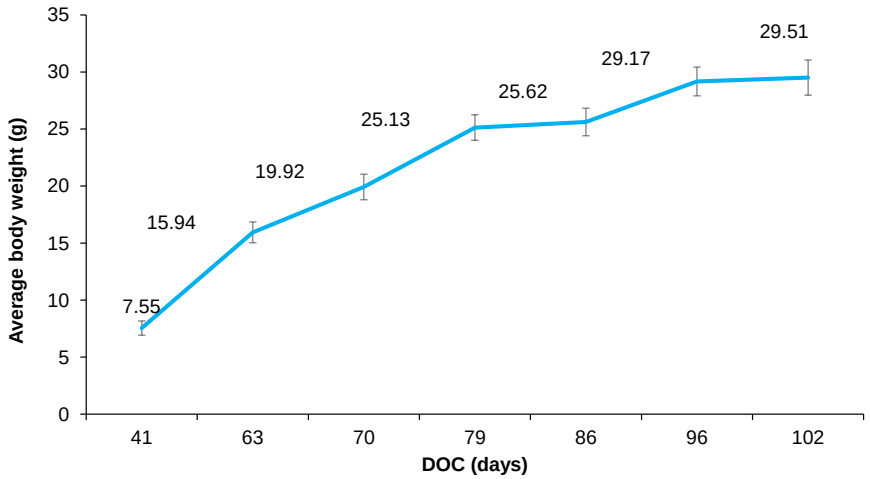
After 250 days

Images of hilsa at initial and after 250 days in growout rearing pond

Maiden harvest of SPF *Penaeus monodon* at NGRC, Navsari, Gujarat

A commercial farming trial for the newly introduced SPF tiger shrimp was carried out at the experimental station of CIBA-NGRC at Navsari, Gujarat to evaluate the production parameters and feasibility. A 0.6 ha (6,000 m^2) earthen pond at the experimental station of NGRC was stocked with SPF *P. monodon* post larvae (15/m^2) during the month of August. The shrimp were fed using a commercial tiger shrimp diet (38% CP). After 105 DOC SPF *P. monodon* attained an average body weight of 29.5 g with survival rate of 71.6% and FCR 1.40. The length-weight analysis indicated that SPF *P. monodon* demonstrated an isometric growth pattern ($W=0.008485\ L^{2.991308}$, $R^2=0.9885$, $p<0.0001$) with a relative and Fulton's condition factor of 1.002 and 0.83 respectively. The trial resulted in a total production of 1,901 kg with a net return of ₹ 2.56 lakhs and BCR ratio of 1.39, with a production cost of ₹ 342/kg and profit margin of ₹ 136/kg. Overall productivity during the trial was 3.168 tonnes/ha and total returns were pegged at ₹ 4.26 lakhs/ha/crop. The production characteristics during the trial indicates that SPF tiger shrimp has a high growth rate and adequate survival rate for economic farming.

Harvested SPF *P. monodon* after 105 DOC at NGRC, Gujarat



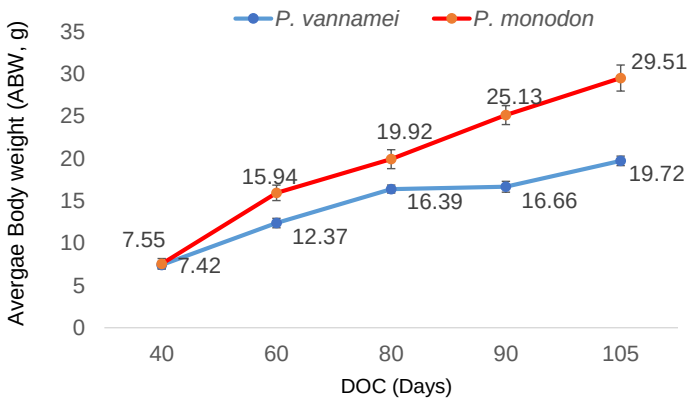
Growth performance of SPF *P. monodon*

Comparative evaluation of production and economic parameters of SPF *P. vannamei* and SPF *P. monodon* during commercial farming trials in Gujarat

The exotic whiteleg shrimp, *P. vannamei* (SPF stock) was introduced in to India during 2009 to provide necessary support to a declining shrimp industry and as an alternative to the indigenous giant tiger shrimp, *P. monodon*. Shrimp industry in India boomed after the introduction of *P. vannamei* and farmed shrimp production increased significantly with a positive annual growth rate. To reduce the over-dependence of the industry on a single species, and growing demand from the farming community for an alternative, Govt. of India permitted the introduction of SPF *P. monodon* to India during 2020. A commercial farming trial with SPF *P. monodon* and SPF *P. vannamei* was conducted at NGRC, Navsari, Gujarat to compare the production parameters. Two earthen ponds were stocked with SPF *P. monodon* (15/m^2) and SPF *P. vannamei* (30/m^2) and fed with commercial feed of 38% and 35% CP respectively. At the end of 105 DOC, *P. monodon* resulted in a higher final ABW of 29.51 g, as compared to *P. vannamei* that resulted in a final ABW of 19.72 g and a survival of 71.57% and 99.87% respectively. Tiger shrimp farming resulted in a higher net return of ₹2.52 lakhs over *P. vannamei* that resulted in a net return of ₹0.87 lakhs. Larger final ABW of *P. monodon* at harvest resulted in higher price of the material leading to greater return and revenue.

Comparative production performance of SPF *P. vannamei* and *P. monodon*

Parameters	*P. vannamei*	*P. monodon*
Length-weight relationship	$W=0.01076\ L^{2.888703}$, $R^2=0.9819$, $p<0.0001$	$W=0.008435\ L^{2.991308}$, $R^2=0.9942$, $p<0.0001$
Fulton's condition factor	0.8180	0.8320
Total production (kg)	2,422	1,901
Mean survival (%)	98.87	71.57
ABW at harvest (g)	19.72	29.51
FCR	1.4516	1.4024
WGR (weekly growth rate) (g/week)	1.32	1.967
ADG (average daily growth rate) (g/day)	0.189	0.281
Production cost/kg (₹/kg)	273.88	342.98
Profit margin/kg (₹/kg)	36.11	135.011
Net return on total cost (₹)	87,463	2,56,657
BCR on total cost	1.1318	1.3936
Rate of return (%)	13.18	39.36
Total revenue (₹/ha/crop)	2,18,657	4,26,049



Growth performance of SPF *P. monodon* and *P. vannamei* at different days of culture

Polyculture of SPF *P. vannamei* and SPF *P. monodon* in comparison with monoculture of the species under different feeding strategies

The feasibility of polyculture of *P. monodon* and *P. vannamei* is never attempted and reported in the shrimp farming sector. Polyculture of SPF *P. monodon* and *P. vannamei* (PCVT) was attempted and compared with monoculture (MCV and MCT) of the species under varying and mixed feed protein levels (35%, 38% and 35+38% CP). Shrimp PL were stocked into an earthen pond (6,000 m^2) partitioned to 10 equal units at a rate of 11/m^2 in monoculture and at 1:1 ratio in the polyculture treatments. After 108 DOC, maximum bodyweight was observed in *P. vannamei* (35.5 g) reared under monoculture system fed using 38%

CP feed followed by *P. monodon* (32.5 g) reared in monoculture system. *P. vannamei* reared in monoculture system using 38% CP feed resulted in significantly higher ($p<0.05$) average harvested biomass of 258.1 kg. The total production in polyculture system fed using 35% CP feed and mixed feed resulted in significantly higher ($p<0.05$) production of (159-182 kg) as compared to *P. vannamei* reared in monoculture system (141.5 kg). Interestingly, higher survival of *P. monodon* reared in polyculture system was noted during the experiment. Overall, the study indicates that the polyculture of SPF *P. vannamei* and SPF *P. monodon* is feasible, as the species could co-exist with minimal negative interactions resulting in higher production as compared to monoculture of a single species. Furthermore, monoculture of *P. vannamei* using higher protein feed can be employed as an option to produce larger sized shrimp within short periods.

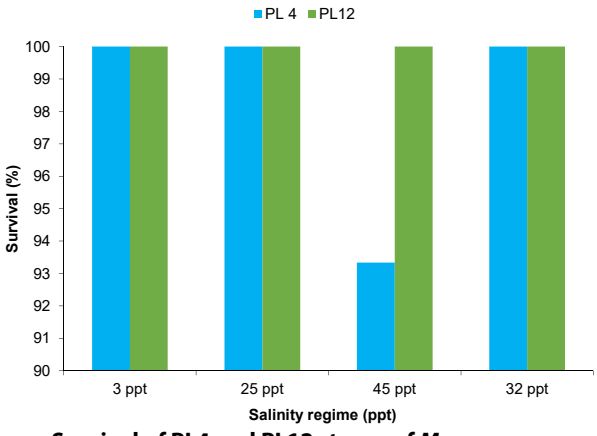
Production parameters of *P. vannamei* and *P. monodon* reared under monoculture and polyculture systems under varying feeding regimes

Treatment	Biomass (kg)	Survival (%)	FCR	Treatment	Species	Biomass (kg)	Survival (%)
MCV (35)	141.50 ± 0.92^{a}	96.7 ± 0.64^{c}	1.44 ± 0.020^{b}	PCVT (35+38)	*P. vannamei*	98.43 ± 1.54^{c}	96.99 ± 1.52^{b}
MCT (38)	176.03 ± 2.33^{c}	72.2 ± 0.96^{a}	1.48 ± 0.023^{b}	PCVT (35+38)	*P. monodon*	83.61 ± 1.73^{b}	79.99 ± 1.66^{a}
PCVT (35+38)	182.04 ± 0.54^{c}	88.5 ± 0.26^{b}	1.42 ± 0.016^{b}	PCVT (35)	*P. vannamei*	72.23 ± 1.52^{a}	97.37 ± 2.03^{b}
PCVT (35)	159.33 ± 3.59^{b}	89.6 ± 1.97^{b}	1.32 ± 0.020^{a}	PCVT (35)	*P. monodon*	87.10 ± 2.30^{b}	81.95 ± 2.17^{a}
MCV (38)	258.13 ± 3.91^{d}	96.7 ± 1.47^{c}	1.46 ± 0.008^{b}				
F statistic	285.8073	67.86	11.41	F statistic		35.68	25.4331
p value	<0.0001	<0.0001	0.0010	p value		<0.0001	0.0002

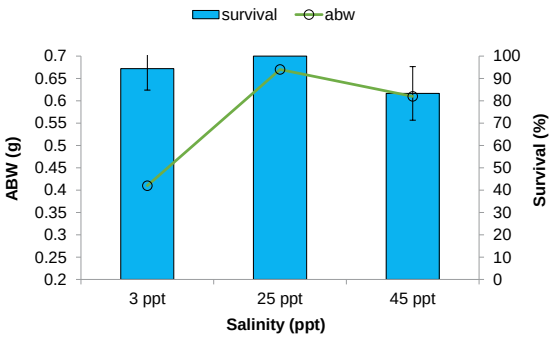
Values in the same column bearing different superscript differ significantly ($p<0.05$)

Growth and salinity tolerance of hatchery-produced *Metapenaeus monoceros*

Studies on the salinity tolerance is an important prerequisite for devising location-specific culture technology for lesser penaeids in the diverse agro-ecosystem. An experiment was conducted on the effect of different salinity on the growth and survival of the post-larval stages of *M. monoceros* to explore the salinity tolerance of the species. Comparative salinity tolerance test was conducted on post larval stages 4 and 12 at 3, 25, 32 and 45 ppt salinity. The post larvae were acclimatized to the desired salinities at 3 ppt/hr. Under the same salinities, a 45 days nursery experiment was also conducted to analyze the growth. PL4 recorded the highest ($p<0.01$) survival of 100% in 25 ppt and 3 ppt. PL12 stages recorded 100% survival irrespective of the salinity. At the end of 45 days of nursery rearing, the shrimps attained final average body weight of 0.41 ± 0.03, 0.67 ± 0.01, 0.61 ± 0.11 g, respectively. Significantly higher survival was observed in 25 and 3 ppt salinity.



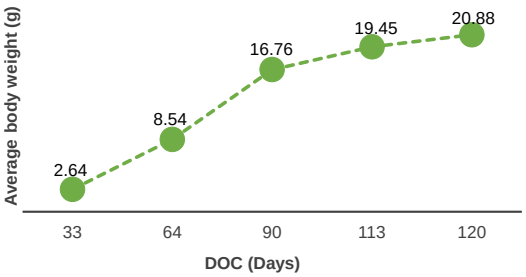
Survival of PL4 and PL12 stages of *M. monoceros* at different salinities



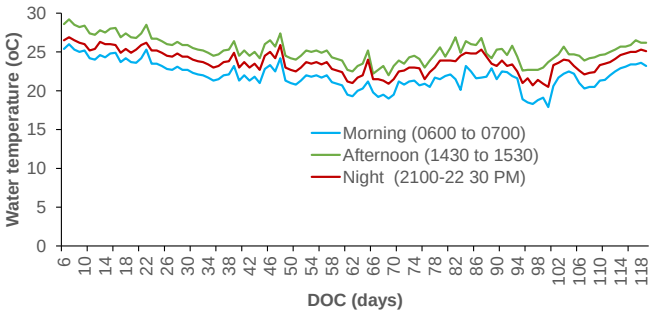
Growth and survival of *M. monoceros* at different salinity regimes

Growth, production performance and economics of commercial whiteleg shrimp, *P. vannamei* farming during winter season in south Gujarat

South Gujarat, the most intensive shrimp farming region in the Gujarat state enjoys a fair winter season from November to February wherein night temperatures drop to as low as 10-12 °C. The winter season is usually a closed period for shrimp farming and ponds remain idle due to low water temperatures under the assumption of poor shrimp growth. To evaluate the feasibility of winter farming, NGRC of ICAR-CIBA carried out a commercial farming trial at its research farm in Matwad Village, Navsari District. *P. vannamei* PL nursery reared for one week were stocked at the rate of 33/m^2 at last week of October 2020. The mean water temperatures in the early morning (0500 to 0700 h), late afternoon (1500 to 1700 h), and night (2100 to 2300) were 21.92 ± 0.23 °C, 25.37 ± 0.42 °C and 23.50 ± 0.21 °C, respectively. Shrimps were fed using ICAR-CIBA's formulated feed Vanami^{plus} four times a day and from 45 DOC, feed was supplemented using Vitamin C and a mixture of mannan oligosaccharide, β 1-3 glucan, and β 1-6 glucan at 5 g/kg feed for two feeding sessions to enhance immunity and stress tolerance. Shrimp attained a mean body weight of 20.88 g at the end of 120 days with a survival and FCR of 97% and 1.07 respectively. Growth rate of 2.01 g/week was observed during peak winter. As the growth rate and the total shrimp production were economically viable and profitable, shrimp farming regions that experience mild winter conditions, i.e., South Gujarat and parts of West Bengal, wherein a majority of the farms traditionally remain idle can be effectively used to raise farmed shrimp in the winter season.



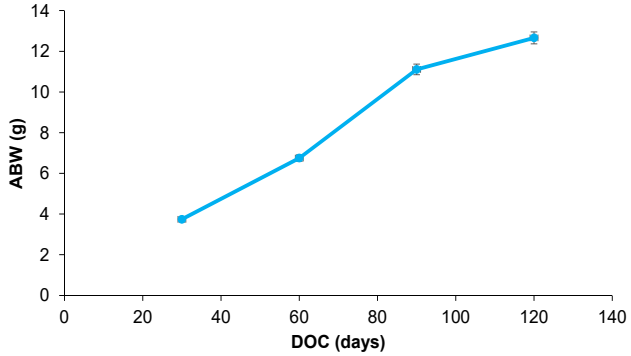
Growth of *P. vannamei* during the winter farming trial



Variation in water temprature during culture trial

Experimental growout farming of ginger shrimp, *Metapenaeus kutchensis*

Ginger shrimp, *Metapenaeus kutchensis* is a shrimp species that is abundantly caught in the Gulf of Kutch region during the post monsoon season wherein it sustains a sizeable fishery. An experimental growout trial was attempted with post larvae sourced from local stake net fishery in the Poorna river during the post monsoon season and stocked in 500 m^2 earthen pond at a density of 12/m^2. Shrimps were reared for 120 days using commercial tiger shrimp diets containing 38% crude protein. At the end of 120 days, the shrimp attained a mean body weight of 12.66 g and resulted in a total yield of 64 kg at a survival rate of 84.23%. The experimental grow out trial indicates that the species may be a slow growing shrimp, that can attain marketable size of 10 g by 80-90 DOC.

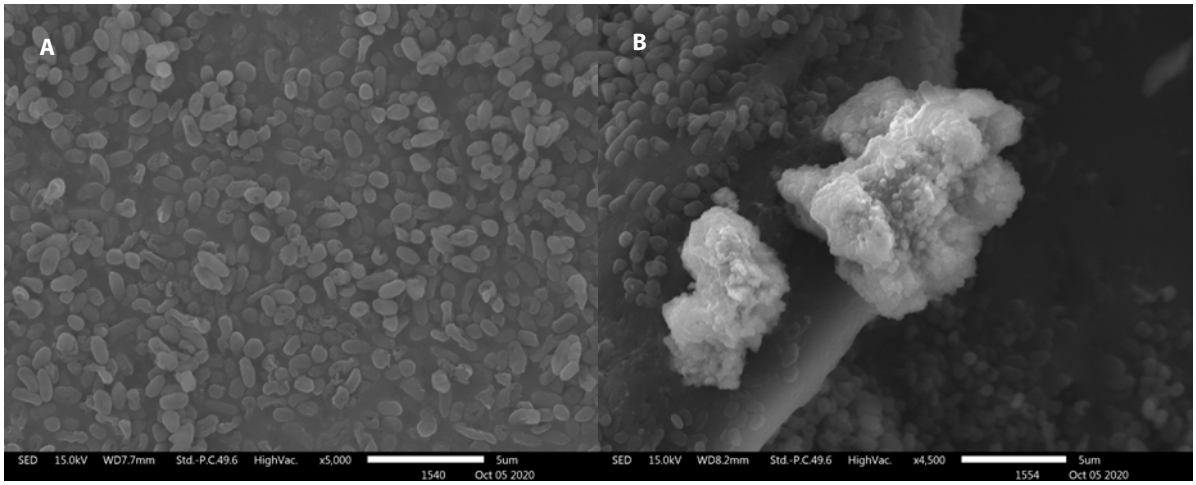


Growth of Ginger shrimp, *M. kutchensis* during farming trial

Harvested *M. kutchensis* after 120 DOC

Functional characterization and application of antimicrobial peptide from biofloc reared shrimp *Penaeus vannamei*

Antimicrobial peptides (AMPs) are naturally available antibiotics and are highly capable of being used as antimicrobial agents. AMPs are produced as a response to detrimental environmental factors to protect the host. AMPs act on microbes by increasing cytoplasmic membrane permeability. An antimicrobial peptide having prominent activity against *V. paraheamolyticus* was characterized from biofloc reared shrimp *Penaeus vannamei*. The peptide was cloned in pET-28a(+) vector and protein expression was done by using *E.coli SHuffle® T7* cells. Further, the protein was purified and antibiofilm activity was evaluated against *V. parahaemolyticus*. Real-time PCR analysis was performed and proteomic level changes were evaluated through 2D gel electrophoresis and MALDI-TOF mass spectrophotometry. Structural analysis revealed that the protein consisted of a monomer and a dimer of 11 kDa and 22 kDa respectively and had close relation to the stylicin peptide of *Penaeus stylirostris*. Minimum inhibitory concentration required for anti biofilm activity was 200 µg and morphological deformity of the *V. paraheamolyticus* cells due to stylicin was confirmed from SEM and CLSM microscopy. Genes responsible for motility, colony formation and toxin related genes were down regulated with stylicin treatment. Proteins related to the cell cycle, signal transduction, immune pathways, stress were significantly expressed in the stylicin treated group. The study proves the future potential of AMPs as a non-toxic bio therapeutic agent to treat the shrimp diseases.



SEM images of untreated *V. parahaemolyticus* cells (A) and stylicin treated *V. parahaemolyticus* cells (B)

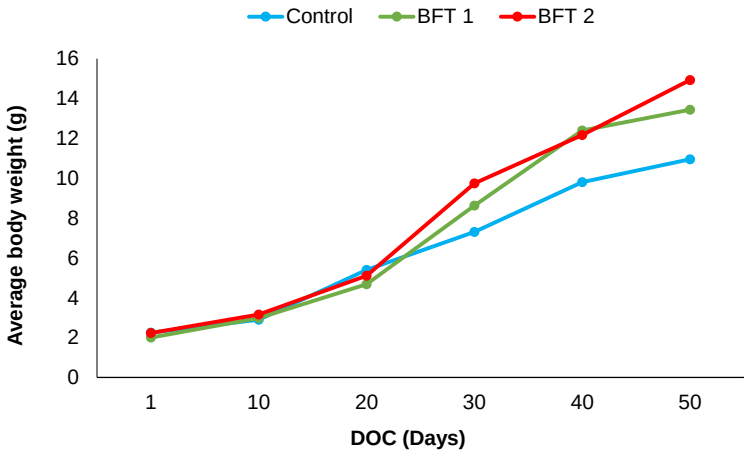
Bacteriophage therapy for reducing vibriosis in biofloc based shrimp culture system

Biofloc is a popular technology for higher production and disease resistance in shrimp aquaculture. However, the luminous bacterial disease caused by *Vibrio* sp. is a major problem faced by the shrimp industry. An experiment was conducted to evaluate the effect of the combination of bacteriophage and biofloc on shrimp culture system. The experiment analyzed the effect of different concentration of bacteriophage (Low dose phage, 75 ml/tonne and high dose phage 150 ml/tonne) on biofloc technology (BFT) systems with (BFT 1-Molasses and BFT 2-molasses with CIBAfloc bacterial consortium). Culture system without biofloc and with bacteriophage addition served as the control. Growth, water quality and vibrio count were estimated at 15 days interval. Addition of bacteriophage in the biofloc system considerably improved the growth performance and water quality and significantly reduced the *Vibrio* sp. count. Adding Phage to a biofloc system using CIBAfloc as a medium resulted in faster growth than the other treatments. The highest growth was observed in the biofloc system, which used CIBAfloc and a high dose of phage, with an average body weight of 15.3 ± 1.6 g, followed by only CIBAfloc with 14.00 ± 2.1 g and CIBAfloc with a low dose of phage with 13.82 g. Only molasses (12.93 g), and molasses with high dose phage (12.62 g) were significantly different from each other. The total *Vibrio* count was significantly high in the control tanks. Combined effect of bacteriophage and BFT system produced better results compared to the addition of bacteriophage alone.

Effect of biofloc consortium and bacteriophage on the vibrio count

	Days	Without Phage	High dose phage	Low dose phage
Control	1	7×10^{-4}	7×10^{-4}	6×10^{-4}
	15	5.8×10^{-3}	6.3×10^{-2}	5.1×10^{-3}
	30	5.3×10^{-3}	1.1×10^{-3}	6.4×10^{-3}
	45	5.3×10^{-3}	1.1×10^{-3}	5.4×10^{-3}
BFT1 (Molasses without CIBAfloc Consortium)	1	4×10^{-3}	1.1×10^{-3}	8×10^{-3}
	15	8.8×10^{-3}	7.2×10^{-3}	6.3×10^{-3}
	30	6.4×10^{-3}	7.2×10^{-3}	6.3×10^{-3}
	45	4.8×10^{-3}	1×10^{-4}	5.8×10^{-3s}
BFT2 (Molasses with CIBAfloc Consortium)	1	4.6×10^{-4}	1.3×10^{-4}	5.2×10^{-4}
	15	TLC	TLC	TLC
	30	TLC	TLC	TLC
	45	TLC	TLC	TLC

* BFT-Biofloc Technology, TLC-Too low count

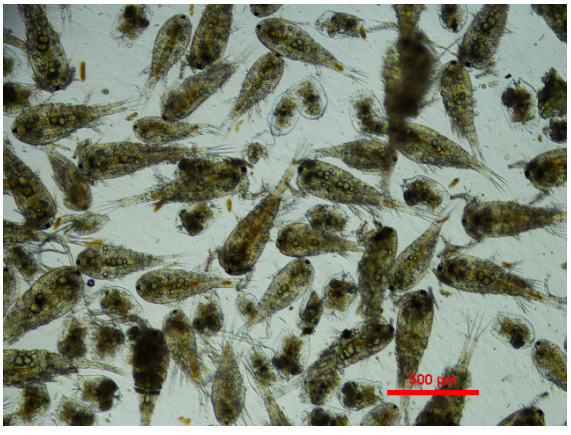


Growth of *P. vannamei* in bacteriophage treated biofloc system

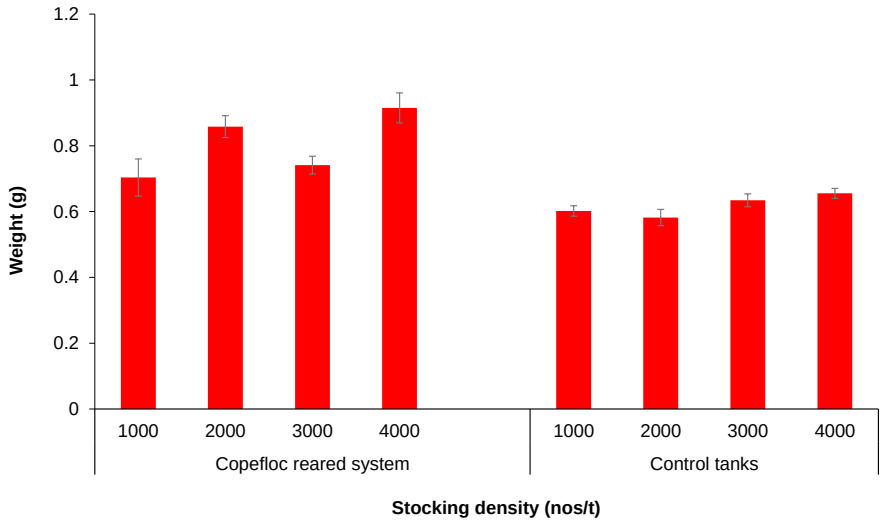
Nursery rearing of *P. vannamei* in copefloc based tank system

Copefloc is a biofloc based nursery rearing system were copepods act as major contributor to zooplankton density and as live feed for shrimp PL. Nursery rearing of *P. vannamei* was evaluated in a copepod based biofloc nursery system at different PL densities (1,000, 2,000 and 3,000/tonne) in triplicate in a tank-based system for 30 days. Three species of copepods (*Dioithona rigida*, *Pseudodiaptomus annandalei* and *Evansula pygmaea*) were inoculated into filtered fermented juice of rice bran powder, molasses and yeast to produce copefloc. Generated copefloc was introduced into the nursery rearing tanks in alternate days. Highest growth (1.2 g) and survival (96%) was observed in PL density of 2,000/tonne.

The amount of nursery feed required during the culture period was significantly less (20 ± 1.1%) in copefloc system compared to the control.



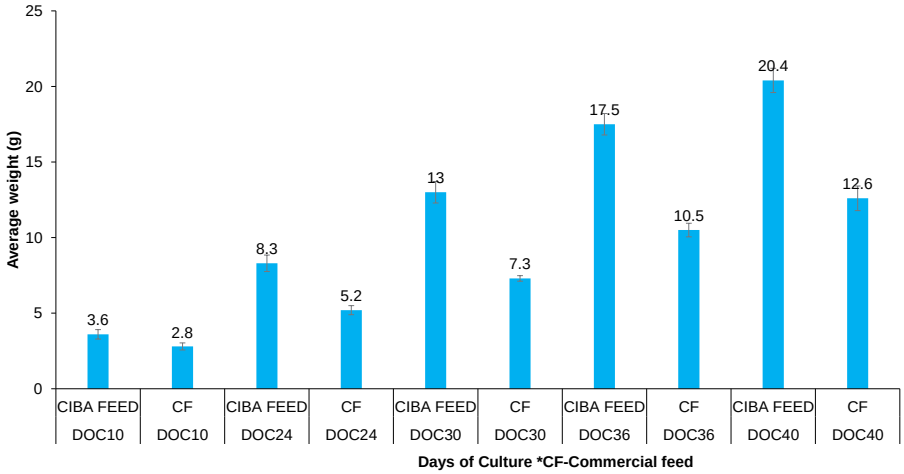
Copepods collected from copefloc medium



Growth performance of *P. vannamei* in copefloc based nursery rearing system

Growth performance of copefloc reared *P. vannamei* in grow-out culture pond fed with CIBA feed and commercial feed

P. vannamei post larvae nursery reared for 30 days in a copefloc-based system was stocked in to HDPE lined pond at a stocking density of 12/m^2. The shrimps were fed with CIBA vanami feed and commercial feed to study the comparative growth performance. Salinity and pH of the culture water was 23 ± 2 ppt and 8.1 ± 1.9 respectively throughout the culture period. After 40 days of culture, highest growth was observed in the pond fed with CIBA feed attaining an average weight of 20.4± 0.8 g whereas the commercial feed group attained a body weight of 12.6 ± 0.81 g. Food conversion ratio of 1.2 and 0.94 was recorded in the CIBA vanami feed and commercial feed respectively. Copefloc based nursery shows higher compensatory growth performance and have the potential to reduce the farming period.



Growth of copefloc nursery reared *P. vannamei* during growout

Comparison of crab fattening in low saline and high saline water

Crab fattening is a lucrative activity practiced by the fisher folk as a livelihood activity along the coastal villages. Water crabs (Post molt crab) are reared in pens and boxes for a short period to attain the hard shell, which fetches a higher price in the market. Crab fattening is usually practiced in high saline open water bodies and prospects of rearing them in low saline area is not widely explored. To study the production performance in high saline and low saline waters, water crabs (BW-500-900 g) procured from the local market were socked in to pens (55 m^2) and floating individual HDPE cages (n=30) located at two locations (Thonirevu and Kattoor village). The seawater salinity at Thonirevu and Kattoor was 32 ± 1 ppt and 3 ± 0.85 ppt respectively. At the end of 30 days rearing, average fattening days, survival and production parameters were estimated and compared between the two locations. The

average days taken for hardening and survival was not significantly different in the lower and higher salinities. Interestingly the number of crabs rejected during the export grading was significantly lower ($p<0.05$) in the crabs cultured in the low saline environment. The result shows that, crab fattening can also be practiced successfully in low saline brackishwater. However, the overall lower survival of water crabs and better grading yield in low saline waters requires further investigations.

Comparison of production parameters of crab fattening in different salinities

Culture type	Pen culture 1				Box culture 1	
Salinity	32 ppt		3 ppt		32 ppt	3 ppt
Parameters	Pen 1	Pen 2	Pen 1	Pen 2	Set 1	Set 2
Carapace width (mm)	14.98	14.90	14.95	14.72	15.14	15.21
Average Body weight (gm)	646.82	662.41	630.82	622.76	690.80	718.24
Total weight stocked (kg)	38.60	44.20	30.8	35.2	10.36	10.65
FCR	6.89 ± 0.17		6.36 ± 0.47		3.66 ± 0.24	3.79 ± 0.15
Survival (%)	60.36 ± 0.66		65.85 ± 4.09		70.78 ± 2.54	68.27 ± 1.61
Average Days for hardening	-	-	-	-	23.93 ± 1.43	24.06 ± 1
Grading Rejection (kg)	6.39 ± 1.2^{a}		0.96 ± 0.44^{b}		2.69 ± 0.48^{a}	1.15 ± 0.19^{b}
Grading rejection (%)	25.92 ± 3.28^{a}		4.58 ± 2.07^{b}		27.66 ± 3.02^{a}	12.92 ± 0.34^{b}

Values in the same row bearing different superscript differ significantly ($p<0.05$)

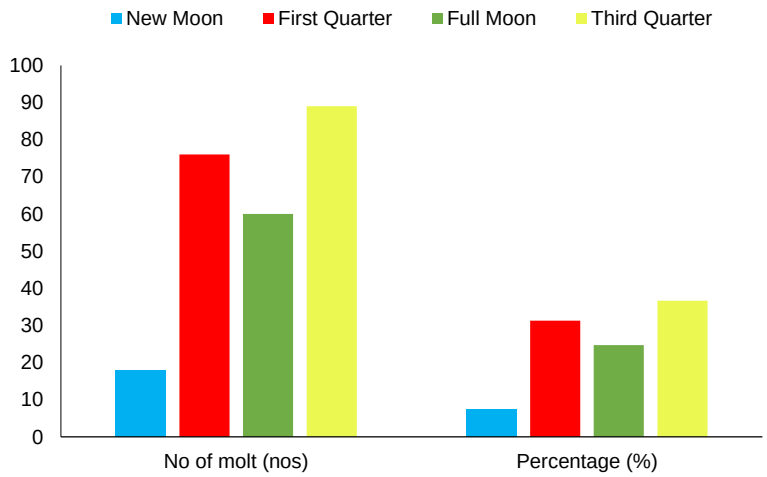
Changes in molting pattern of *Scylla serrata* due to lunar phase and different diets

Mud crab is considered as a major candidate species for brackishwater farming due to the export demand and higher price per unit. Today several innovative culture aspects like the individual box farming and vertical farming has been introduced into mud crab farming. However, issues like mortality, failure in molting and poor growth is often reported in these systems. An experiment was conducted to understand the molting pattern of baby mud crabs housed in individual containers made up of PVC and fed with different diets like, T1-Fish meat, T2- Crab meat, T3-Formulated feed and Control- Clam meat. Crabs were closely monitored individually for three consecutive moults throughout the experiment period. Individual crabs took approximately 25-32 days for completing the first molt. Time taken to complete the consecutive moults was significantly lower ($p<0.05$) in the animals fed with fish and crab meat. Feeding the crabs with fish and crab meat resulted in higher molt related death and lower survival whereas the animals fed with clam meat and formulated feed produced significantly higher survival. Significant effect of lunar phases on molting was not observed as several molt were recorded in all the moon phases.

Molting pattern of *Scylla serrata* juveniles under different diets

Treatment	Days for 1st molt	Days for 2nd molt	Days for 3rd molt	Molt death (%)	Survival (%)
T1	27.19 ± 2.07^{ab}	23.85 ± 2.05^{a}	16.36 ± 3.22^{a}	17.77 ± 4.44	51.22 ± 2.85^{a}
T2	25.71 ± 1.69^{a}	22.15 ± 1.37^{a}	17.61 ± 1.84^{a}	13.33 ± 3.22	53.35 ± 5.85^{a}
T3	34.29 ± 2.53^{c}	29 ± 1.79^{b}	34 ± 4^{b}	4.44 ± 1.22	94.55 ± 2.34^{b}
Control	32.7 ± 1.92^{bc}	23.45 ± 1.31^{a}	21.33 ± 2.66^{ab}	Nil	96.83 ± 3.84^{b}

Values in the same column bearing different superscript differ significantly ($p<0.05$)



Molting distribution of *Scylla serrata* at different lunar phases

Gut microbiota of mangrove mud crabs (*Scylla serrata* and *Scylla olivacea*)

Farming of mud crab in ponds, box and indoor vertical systems are increasing rapidly along the coasts of India. With the rapid growth in mud crab aquaculture, mortality due to microbial infections is rising, which is affecting the growth and sustainability of the crab farming industry. Application of beneficial microbes to modulate gut microbiota is widely accepted; however, limited data is available on the gut microbiota of *S. serrata* and *S. olivacea*. An attempt was made to examine the bacterial community associated with *S. serrata* and *S. olivacea* collected from Muttukkadu estuary. Though these species belong to same genus, the microbiota varied significantly. The dominant phyla in *S. serrata* were *Firmicutes* (40.29%), *Proteobacteria* (23.90%), *Fusobacteriota* (19.39%) and *Bacteroidota* (5.73%), while *Firmicutes* (27%), *Campilobacterota* (26.61%), *Fusobacteriota* (21.11%) and *Proteobacteria* (20.60%) were dominant in *S. olivacea*. At genus level, *ZOR0006* (33.21%) and *Hypnocyclicus* (13.83) were dominant in *S. serrata*, while *Helicobacter* (23.64%), *Hypnocyclicus* (21.05%), *Alphaproteobacteria* unclassified (17%) and *Candidatus bacilloplasma* (12.47%) were dominant in *S. olivacea*.

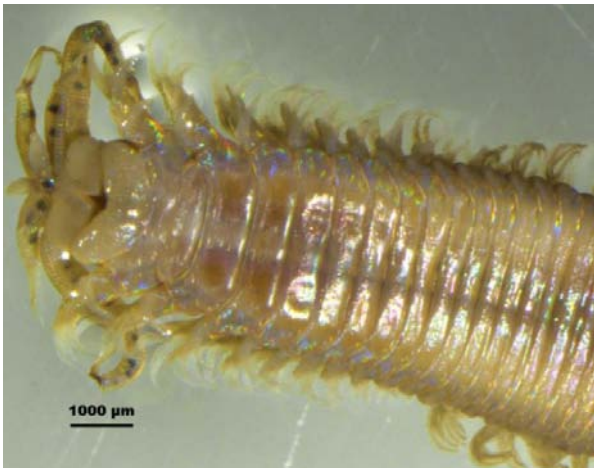
Development of culture method for sand worm, *Onuphis eremita*

Different culture trials were carried out to develop a culture technology for polychaete worm, *Onuphis eremita*. Experiments were carried out using adult and juveniles of *Onuphis eremita* collected from the beaches of Muttukkadu, Tamil Nadu. *O. eremita* adults and juveniles (n=50) were stocked in to 100 litre FRP tanks and 25 litre tubs with sand beds respectively. During the experimental period, worms were fed with CIBA shrimp larval feed. Mass culture trial with stocking 500 juveniles of *O. eremita* was also performed in a 1 tonne FRP tank as part of the study. *Chaetoceros calcitrans* (10^6 cells/ml) 20 ml/day was used as the feed for mass culture of juveniles. After 120 days of culture, adults produced 2,500 juveniles of 0.2 g body weight. Juveniles reared in the tubs attained a length of 18 cm and total biomass harvested was 33.25 g. Survival (95%) and SGR (0.41) recorded for juvenile *O. eremita* was promising. Mass rearing of the juveniles produced 400 adults with 240 g total biomass and 80% survival. Mass culture of *O. eremita* juveniles can be practiced with microalgal diets as an alternative to wild collection.

Growth and production performance of adults and juveniles of *Onuphis eremita*

Stages of worms cultured	Body weight (g)	Size in length (cm)	Feed	Survival (%)	Size at harvest	Total Biomass
Adult (n=50)	0.60 ± 0.2	14.0± 0.3	CIBA shrimp feed No: 1@ 30%	90	7.0 ± 0.1 cm	2,500 juveniles (2,500 × 0.2 g = 500 g)
Juvenile (n=50)	0.2 ± 0.01	6.1 ± 0.1	CIBA shrimp larvae feed @ 1%	95	18.10 ± 0.3 cm	47.50 (47.5× 0.70 g = 33.25 g)
Mass culture of juvenile (n=500)	0.2 ± 0.1	6.1 ± 0.2	*Chaetoceros calcitrans* (10^6 cells/ml, 20 ml/day)	80	18.0 ± 0.2 cm adult	400 numbers (400× 0.6 g = 240 g)

Adult *Onuphis eremita*



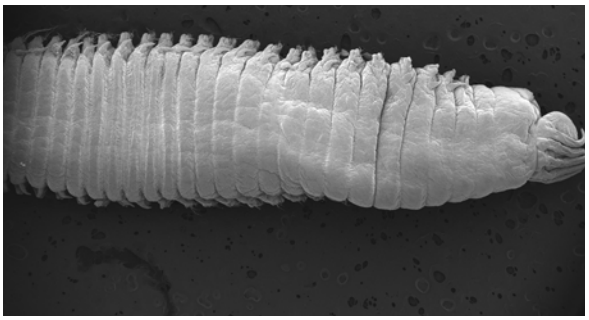
Head portion of *Onuphis eremita*

Development of grow-out technology for mass culture of muddy polychaete worm *Marphysa madrasi*

Polychaete worms are used as a major live feed commodity in the shrimp hatcheries. Studies shows that polychaetes are vectors for important shrimp diseases like White spot and EHP. Wild collected polychaete worms cannot support quality shrimp seed production. As an alternative to wild collection, culture methods were evaluated for the polychaete worm *Marphysa madrasi*. Culture of adult, juveniles and mass culture of juvenile polychaetes were done in 100, 25 and 1,000 litre FRP tanks respectively. CIBA shrimp feed was used as feed during the culture period and microalgal diet (*Chaetoceros calcitrans*-10^6 cells/ml) was specifically used for mass culture of juveniles. *Marphysa madrasi* adults and juveniles 40 and 50 numbers were stocked in to 100 litre and 25 litre tanks respectively. For analyzing the mass culture 500 juveniles of size 0.3 g were stocked in to 1,000 litre tank. Juveniles (7 ± 0.2 cm & 0.2 g ABW) were produced from the adult tanks after 120 days of culture resulting in a biomass of 403 g. On average 56 juveniles were produced from each adult in a span of 4 months. Juveniles cultured in experimental tubs reached a size of 19 cm with 95% survival. Mass culture resulted in total biomass of 280 g from 80% survival. Net weight gain of 0.5 g was recorded in juveniles.

Biomass production of juveniles and adults of *Marphysa madrasi*

Stages of worms cultured	Body weight (g)	Size in length (cm)	Feed	Survival (%)	Size at harvest	Total Biomass
Adult (n=40)	0.70 ± 0.2	16.0 ± 0.3	CIBA shrimp feed No: 1@ 30%	90	7.0 ± 0.1 cm	2,016 (2,016 × 0.2 g = 403 g Biomass)
Juvenile (n=50)	0.2 ± 0.01	7.1 ± 0.1	CIBA shrimp larvae feed @ 1%	95	19.50 ± 0.3 cm	47.50 (47.5× 0.70 g = 33.25 g, total weight)
Mass culture of juvenile (n=500)	0.3 ± 0.1	7.1 ± 0.2	*Chaetoceros calcitrans* (10^6/cells/ml, 20 ml/day)	80	19.0 ± 0.2 cm adult	400 (400× 0.7 g = 280 g total weight)

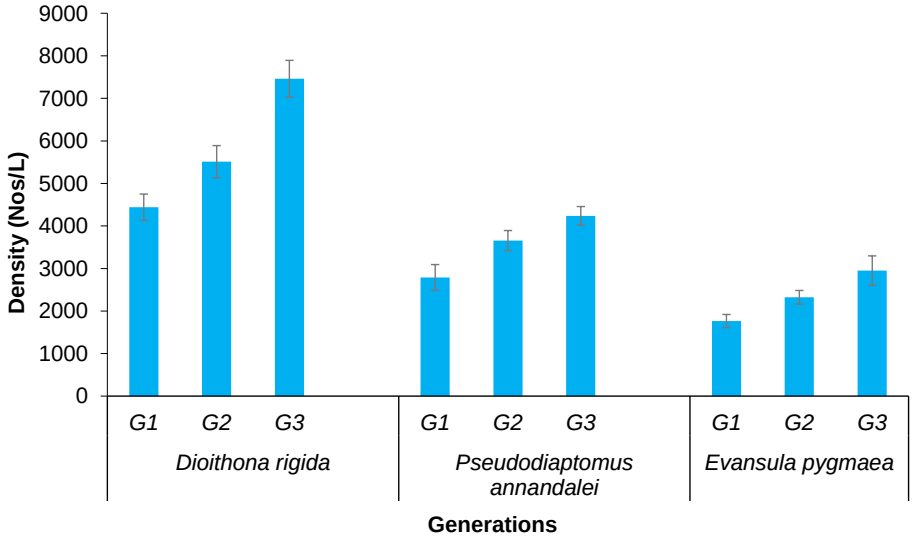


Adult *Marphysa madrasi* and SEM image of head portion

Potential of mass culture of copepods using diatom as feed

Pure isolates of three species of copepods, *Dioithona rigida*, *Pseudodiaptomus annandalei* and *Evansula pygmaea* were evaluated for potential of mass culture using *Chaetoceros* sp. with a cell density of 1-2 lakh cells/ml for three generations.

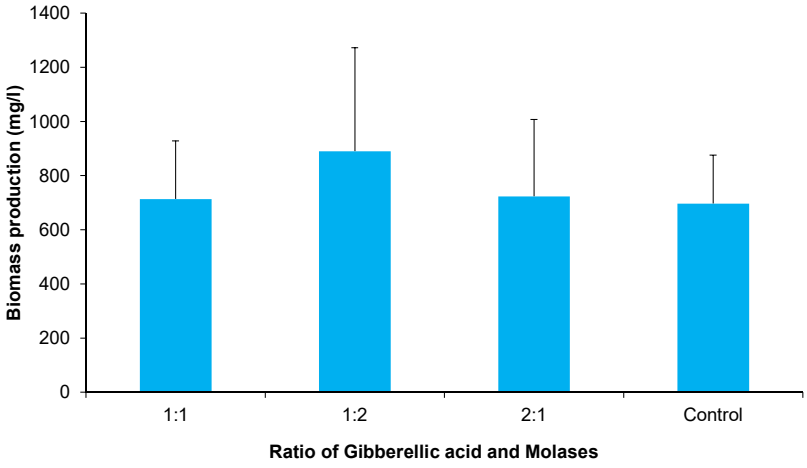
Increasing trend in copepod density was observed over the generations in all the species. Highest copepod density was obtained from the cyclopoid copepod (*Dioithona rigida*) followed by Calanoid (*Pseudodiaptomus annandalei)* and Harpacticoid (*Evansula pygmaea)* copepods. *Dioithona rigida* can be a potential live feed species for mass production using diatom as feed.



Density of copepods reared on diatoms at different generations

Modification of outdoor algal culture media for increased biomass production in *Chlorella* sp.

Microalgal production is an integral part of shrimp or fish hatchery operation and often hatcheries face issues in attaining high cell density of microalgae with conventional culture medium. Production of good quality microalgae in outdoor mass culture with high cell density could be achieved through manipulation of the culture media. With this aim, efficacy of Gibberellic acid and Molasses in different concentrations was analyzed for prodcution of *Chlorella* sp. Addition of Gibberellic acid and Molasses increased the cell density to 2.8×10^6 and 3.8×10^6 cells/ml in 72 hours at 1 gm/L concentration. Further different ratios of Gibberellic acid and Molasses (1:1, 1:2 and 2:1) was used to enrich the outdoor algal culture medium to study the efficacy. A media without enrichment served as control. Ratio of 1:2 provided the best algal production with a cell density of 4×10^6 cells/ml in 48 hours. The total biomass of algae produced at 1:2 ratio (890 mg/L) was significantly higher.

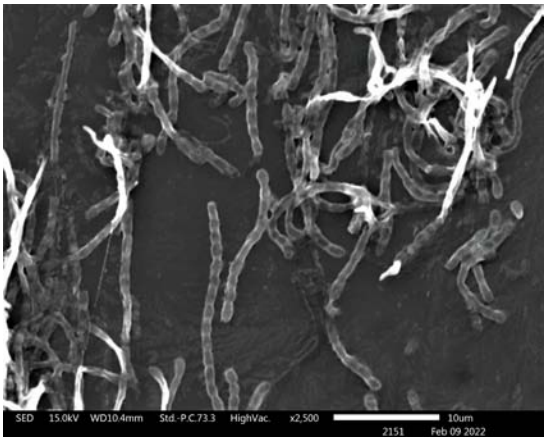


Biomass production of *Chlorella* sp. in modified algal culture media

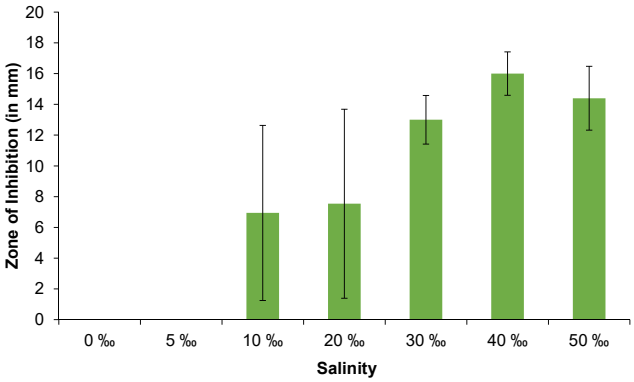
Isolation of *Streptomyces* sp. an Actinomycetes species showing antagonism to *Vibrio campbellii*

Actinomycetes are group of bacteria known to produce various anti microbial agents with huge bioactive potentials. The suitability of using actinomycetes for controlling bacterial vibriosis in shrimp hatchery was explored by isolating 11 number of actinomycetes species from Muttukkadu and Kelambakkam. The isolates were tested for antagonistic activity against *Vibrio campbellii* and further identified based on biochemical and morphological characteristics. Out of the 11 isolates, antimicrobial activity was detected in one and was identified as *Streptomyces* sp. Influence of salinity on antimicrobial production activity and efficacy in larval rearing was analyzed. Highest metabolite production activity was reported at 40 ppt salinity. Application of *Streptomyces sp* reduced the total Vibrio count in the treated test groups compared to untreated control groups.

Antagonistic activity against *V. campbelli*



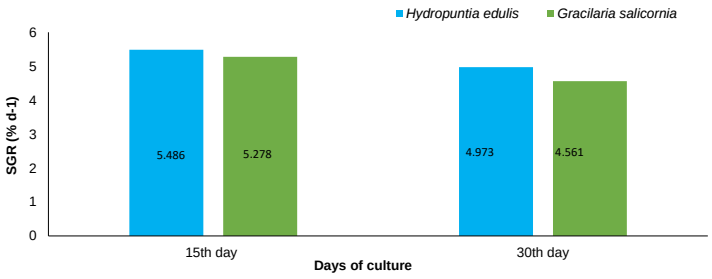
Scanning electron micrograph of *Streptomyces* sp.



Zone of inhibition of *Streptomyces* sp. in different salinities

Farming of indigenous seaweed species in brackishwater

Seaweed culture is a familiar mariculture activity among the coastal fishermen community. However, farming of seaweeds in brackishwater system is less popular and not explored in large scale. To study the farming potential of seaweeds in brackishwater, two indigenous species of red algae (*Hydropuntia edulis*, *Gracilaria salicornia*) were cultured in net bags in brackishwater ponds. Healthy branches of seaweeds collected from natural stock were reared in nursery FRP tanks for vegetative propagation. Seed stock from the nursery tanks were transferred (500 g/m^2) to net bags of size of 2 × 1 × 1 m size installed in brackishwater ponds at Kovalam Experimental station. After one month of culture, *H. edulis* and *G. salicornia* produced a total biomass of 1.25 and 1.05 kg/m^2 of seaweed respectively. Biomass gain of 2.5 and 2.1 time was achieved in *H. edulis* and *G. salicornia* respectively. Seaweed production can be achieved in a short span in brackishwater systems with low investment and maintenance.



Specific growth rate of *H. edulis* and *G. salicornia* in brackishwater system

Design and evaluation of macroalgal reactors as biofilter in recirculating aquaculture system

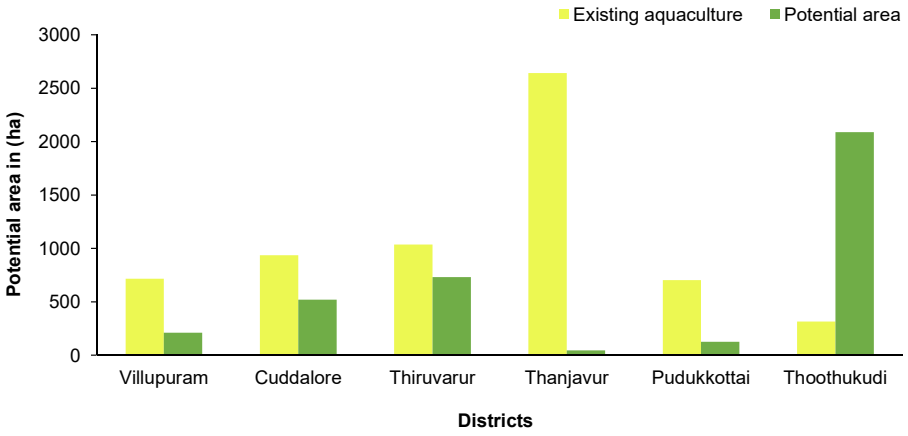
Three different models of seaweed-based bioreactor viz., A) RAS with tubing bioreactor; B) RAS with raceway type bioreactor, C) RAS with rotating wheel bioreactor were designed and the biofiltration efficiency was analysed. Red algae, *Agarophyton tenuistipitatum* was used as candidate species due to its superior proliferation and higher nutrients removal efficiency. Intensive culture tanks of *P. vannamei* was coupled with the reactors for analyzing the biofiltration efficiency. Raceway-type algal bioreactor was found very effective in managing water quality by significantly reducing

A. RAS with tubing bioreactor, B. RAS with raceway type bioreactor, C. RAS with rotating wheel bioreactor. Components: a. shrimp culture tanks, b. Sump, c. pump, d. pressure sand filter, e. seaweed bioreactor, f. collection tank, g. circulating pump

the amount of NH_4-N, NO_2-N, NO_3-N, and PO_4-P. Use of raceway type bioreactor also helped to maintain alkaline pH throughout the entire culture cycle. Macroalgal assimilation of CO_2 is an added advantage of the system as it removes the need of degasser. Seaweed based bioreactor is a sustainable model for the future development of recirculating systems.

Development of sustainable aquaculture adhering to environmental characteristics and regulatory framework in Tamil Nadu, India

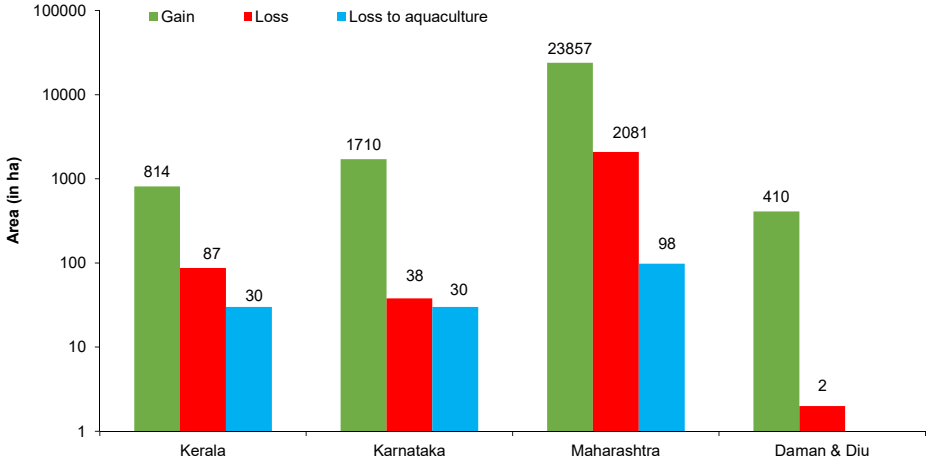
The aquaculture development has raised many environmental concerns worldwide due to its unregulated and unplanned expansion. Mapping of potential aquaculture site is important for the sustainable development. A mapping study was conducted in six coastal districts of Tamil Nadu, such as Villupuram, Pudukottai, Thanjavur, Toothukudi, Cuddalore, Thiruvarur. Land resources availability, source waterbody characteristics, unproductive land, soil quality, and infrastructure support were the indicators for selecting the suitable land for aquaculture. Water quality characteristics taken into account during the selection process included pH, temperature, dissolved oxygen, salinity, total ammonia nitrogen, nitrate, phosphate, and turbidity. Similarly, soil quality characteristics like pH, organic carbon, electrical conductivity, and texture were incorporated. The influencing factors was measured, mapped, quantified, and linked through pairwise matrix-based sensitive analysis and Geographical Information System (GIS). The spatial regulations of the Coastal Aquaculture Authority Act (2005) of India were applied to remove restricted regions such as mangroves, agricultural lands, lands used for other purposes, lands up to 200 m from high tide lines, etc.
The results showed that 3,719 ha is suitable for aquaculture in addition to the existing 6,348 ha. Combining sensitivity analysis and spatial model into resource characteristics, land availability, and aquaculture regulation laws will direct aquaculture sustainably and responsibly while protecting the other productive ecosystem characteristics.



Potential area for brackishwater aquaculture development in Tamil Nadu

Assessment of the impact of aquaculture development on the mangrove forests of India

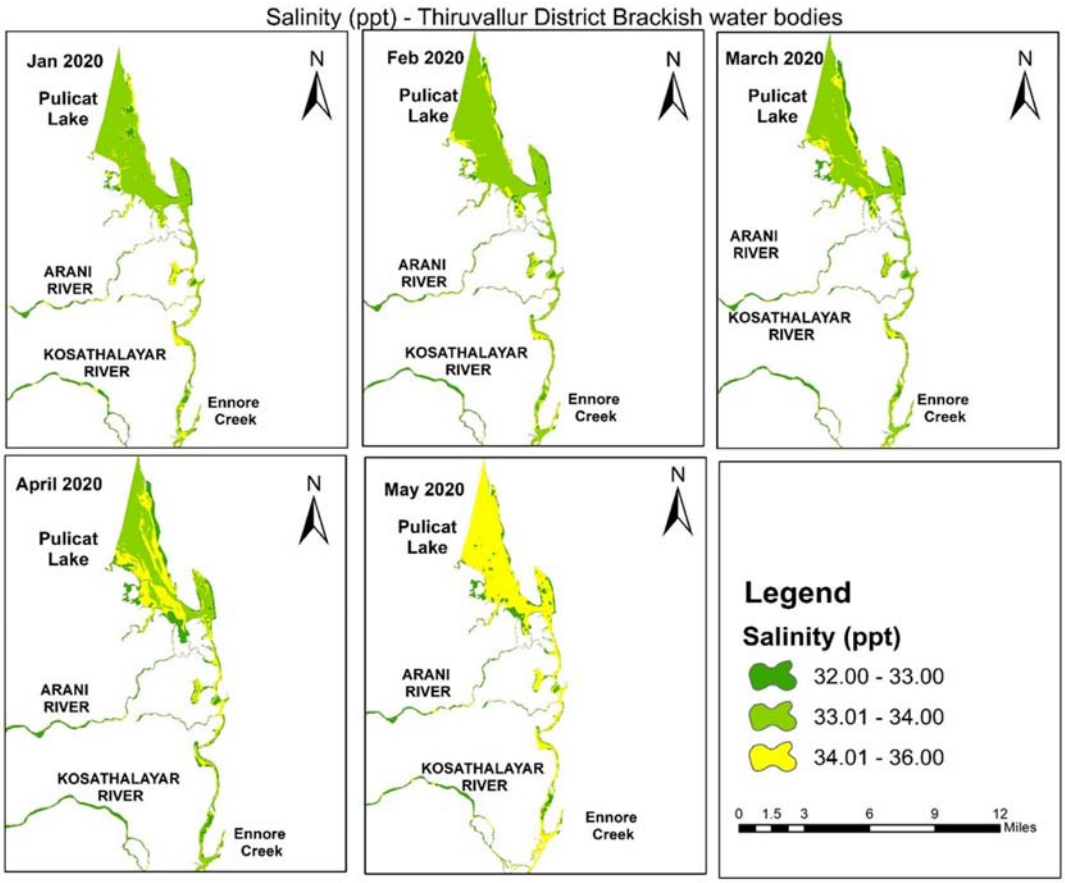
Mangroves serves as breeding ground for fishes, protect coastal regions from natural calamities and impacts of climate change. Recently, aquaculture development has been cited as the main reason for mangrove loss and degradation. However, there is no comprehensive data to prove this claim. A satellite image based time series analysis was derived for the pre aquaculture period and current years to assess the spatial spread of mangroves. Landsat TM images of 1988, Sentinel 2A images of 2018, geospatial analysis, ground truth verification, post-classification approach, and accuracy assessment were used in the study for quantification of mangrove loss. Comparing the extent of mangrove area in 1988 with 2018 revealed that the area lost to aquaculture development was meagre and extent of mangroves increased by 20.72%. The gain and loss recorded was 278% and 30% in Kerala, 859% and 19% in Karnataka, 204% and 18% in Maharashtra, and 4,100 and 20% in Daman and Diu, respectively. From the results of the study, it was evident that the shrimp aquaculture development is not a major threat to mangrove vegetation.

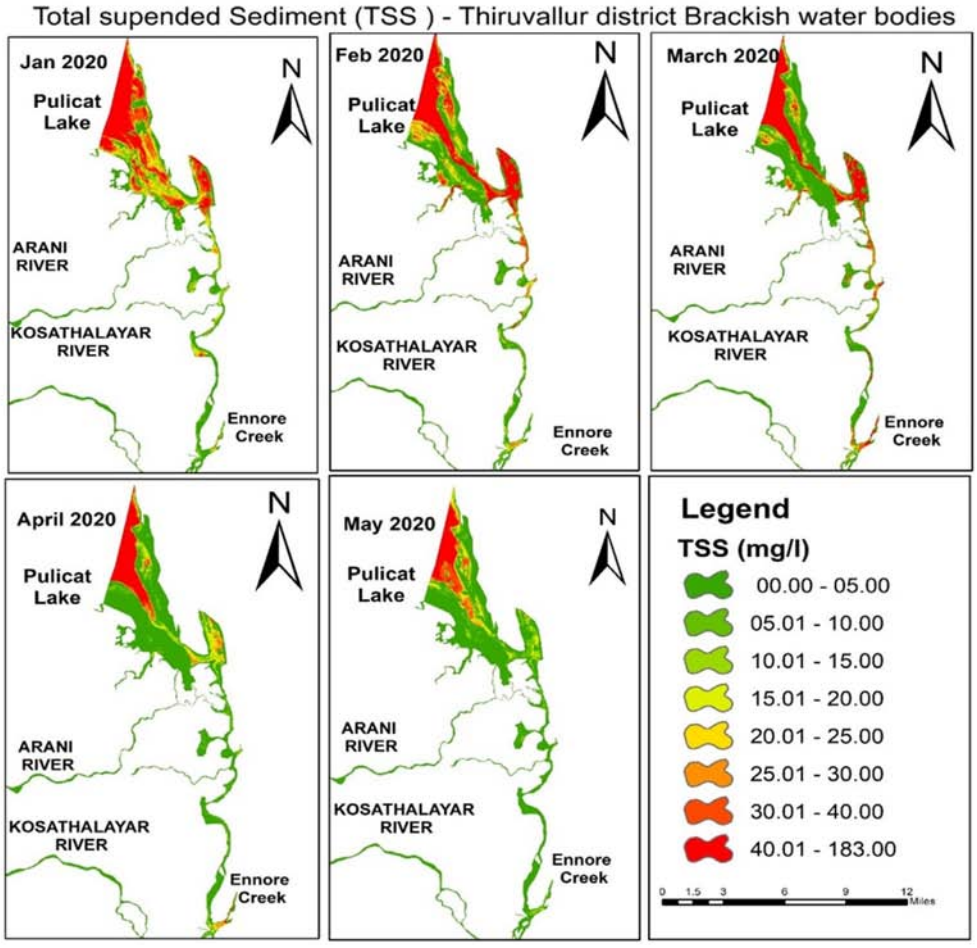


Impact of aquaculture development on mangrove forests

Water quality analysis of Pulicat lake, Tamil Nadu using remote sensing

Water quality index was developed for Pulicat lake, Thiruvallur district using pixel value and real time data correlation technique in remote sensing and GIS for three parameters salinity, chlorophyll-a and total suspended sediments. Water quality data collected from Jan 2019 - Jan 2020 was used to correlate and calibrate the prediction model. Empirical algorithm was derived from Landsat 8 OLI satellite image downloaded from https://earthexplorer.usgs.gov/. The models were tested and an R^2 value of 0.73, 0.81 and 0.71 was obtained for salinity, chlorophyll-a and total suspended sediments respectively. Salinity at Pulicat lake ranged between 32-34 ppt during Jan- March 2020 and increased to 34-36 ppt during the summer. The banks of the lake recorded higher chlorophyll-a concentration compared to the middle region due to the flow of the water. Chlorophyll-a concentration ranged from 0-3 mg/m^3 with higher values corresponding to summer season. Drastic reduction of the total suspended sediments were observed during the summer season.





Spatial distribution of salinity and total suspended solids of Pulicat lake

Reproduction, Breeding and Larval Rearing

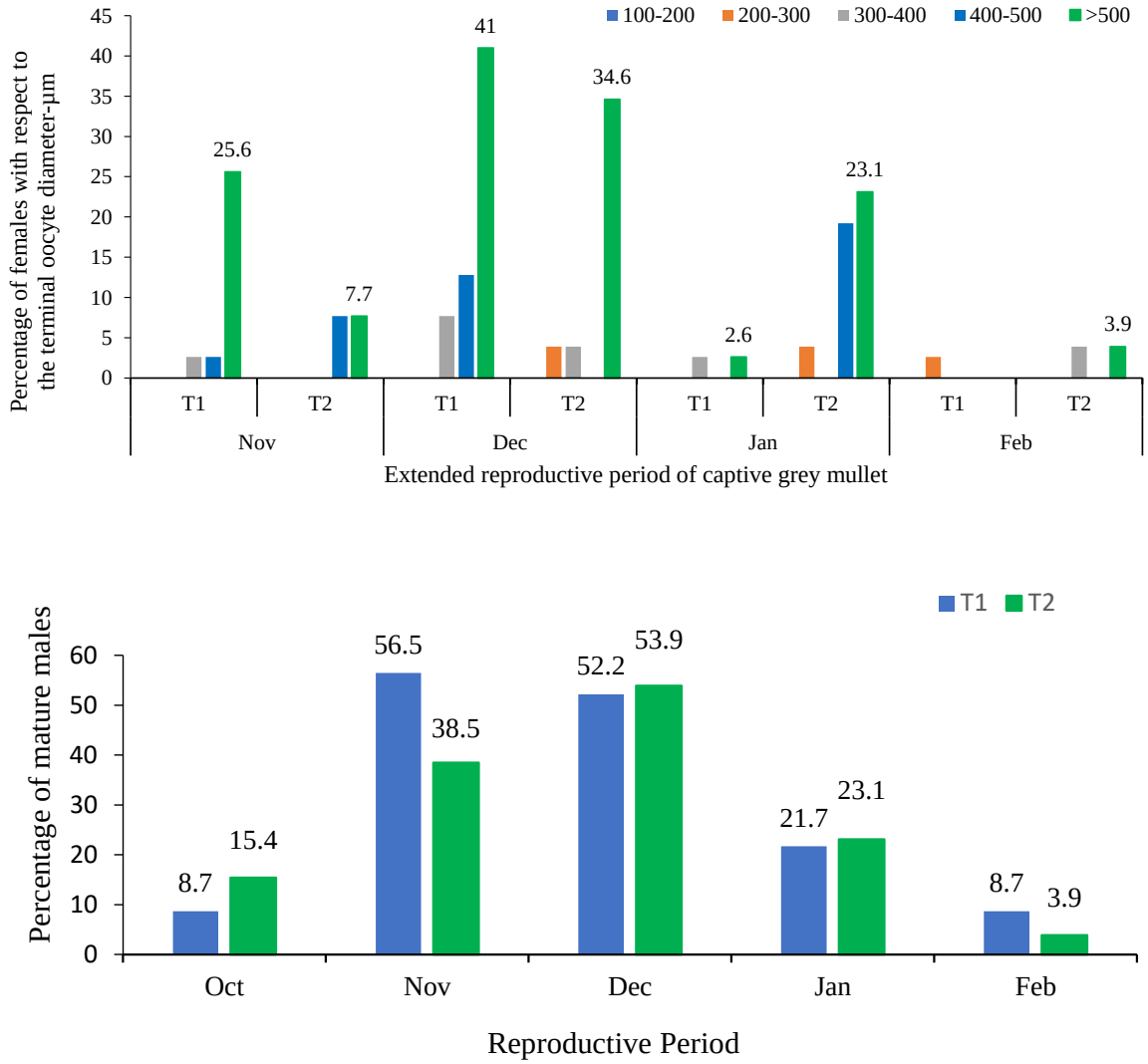
First batch of hatchery produced red snapper, *Lutjanus argentimaculatus* seeds supplied to the farmers

In a major breakthrough that would give a fillip to diversification of brackishwater aquaculture, ICAR-CIBA has succeeded in developing captive broodstock and seed production technology of another economically important brackishwater fish mangrove red snapper, *Lutjanus argentimaculatus* for the first time in India. A total of 42 broodstock fishes in the size ranging from 3.4 to 5.8 kg maintained in RCC tanks were examined on a monthly basis to assess the captive maturity. The fishes attained maximum maturity of 57% during July 2021 although mature fish were noticed from March to October 2021. Oozing males were observed predominantly (35.7%) compared to mature females (21.4%). A total of four breeding trials were conducted by selecting the females having the average oocyte diameter of above 450 µm and oozing males. These fishes were administered with hCG hormone @ 1,500 IU/ kg body weight and spontaneous spawning was observed. The larvae were reared in the hatchery and the fry reached a size of one inch in 60 days. As a first step in addition of red snapper to the brackishwater food fish basket, a total of 100 first batch hatchery produced red snapper seeds were supplied to a farmer for the grow-out culture.

Distribution of red snapper fingerlings to farmers

Extension of reproductive period of captive grey mullet by exogenous hormone therapy and production of grey mullet *Mugil cephalus* fingerlings in captivity

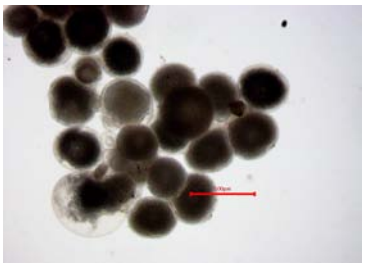
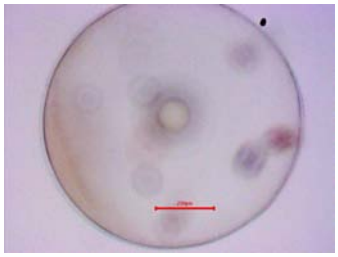
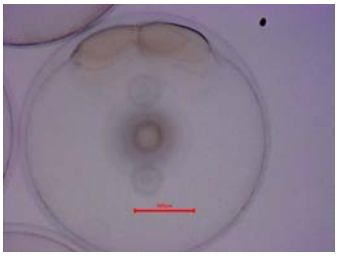
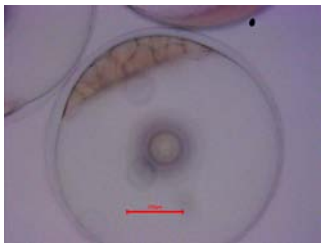
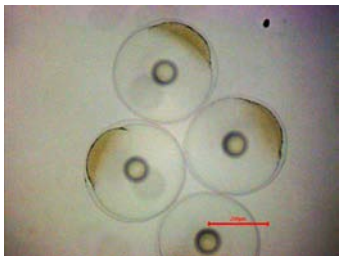
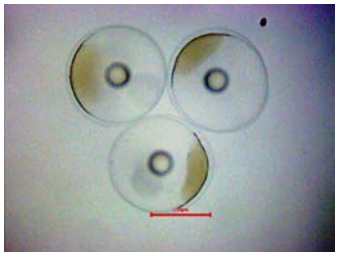
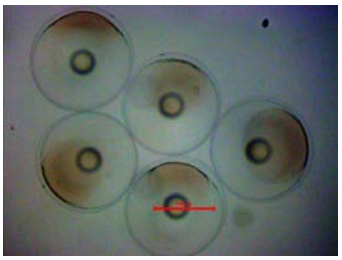
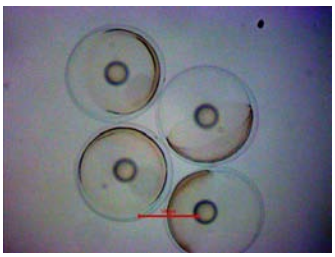
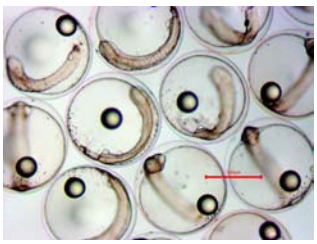
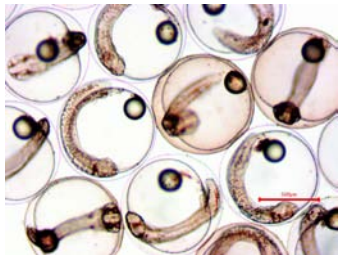
The cosmopolitan flathead grey mullet is an economically important brackishwater fish farmed mainly for its food value and also for its roe, a high value product in South East Asian countries. Despite its economic significance, the hatchery based seed production of the species is still largely on an experimental and semi-commercial scale due to the short annual reproductive period and multiple reproductive dysfunctions exhibited in captivity. Previously, ICAR-CIBA standardised the hatchery based seed production of grey mullet. Further efforts have focused on refining the existing protocols and extending its reproductive period in captivity. Optimal broodstock management, high quality broodstock feed, Cephalus^{Plus} and a hormone therapy constituting exogenous administration of cholesterol pellets of GnRHa, approx. 40 µg/ female and silastic implants of 17-alpha-methyl-testosterone, 5 mg at regular sampling intervals of about 10 days have helped to sustain an average oocyte growth rate of 8.7 ± 0.48 µm, attain an overall fish maturity % of 96.1 ± 2.3, a female functional maturity (%) of 67.3 ± 1.9 and an extended reproductive period from November to January. Variation in timing of administration of exogenous hormone therapy T1- September-15, T2- November-1 has helped functionally mature females and males to be available during November-December and December to January respectively. Four batches of larvae were produced from November to January. A total of over 5,500 fingerlings were produced which were distributed to farmers. The results are significant as it addresses the key challenge in captive reproduction of grey mullet by providing a relatively protracted reproductive period for fry production under captivity.



Percentage of milting males and functionally mature females depicting the extended reproductive period of captive grey mullet

First report on captive broodstock development and breakthrough in induced breeding of yellowfin bream, *Acanthopagrus datnia*

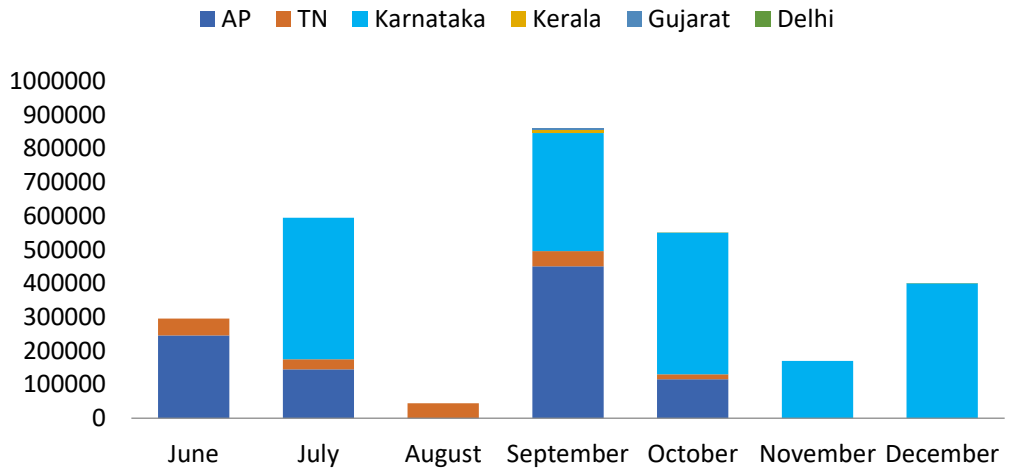
This is the first report on captive broodstock development and induced breeding of commercially important yellowfin bream, *Acanthopagrus datnia*. Sub-adult fish (70-500 g) were reared in the Recirculatory Aquaculture System (RAS) at 5-7 ppt from February to August. Two different breeding protocols were standardised. In the first breeding attempt, six immature females (oogonia stage) and twelve males were shifted to breeding RAS facility, where salinity was gradually increased to 30 ppt (@ 1.5 ppt/day) and maintained at 30 ppt from September to till final maturation and induced breeding (November-December). In the second breeding attempt, brackishwater reared brooders were collected and gradually acclimatised to 30 ppt within 48 h. In both the cases, brooders were administered with LHRHa @ 30 µg/kg body weight to females and half the dose to males. The fish spawned after a latency period of 55 h in both the salinity regime. Fertilised eggs were transparent, floating and circular (diameter, 750-830 µm). Rate of fertilisation and hatching was 90 and 70%, respectively. Embryonic development showed that the two cells, four cells, morula, blastula, gastrula, neurula and hatching at 45 min, 1 h, 2 h, 5 h, 10 h, 21 h, 26 h, respectively at 12-16°C of water temperature. Total length of newly hatched larvae was 1.75 mm. However, the larvae could not be reared beyond 2 day post hatch. At the same time, the results indicate that yellowfin bream broodstock can be developed in the brackishwater and induced to spawn with LHRHa @ 30 µg/kg at water salinity of 30 ppt.

		
Ovarian biopsy	Mature oocytes	Injection
		
Fertilized egg	Two cells stage	64 cells stage
		
Morula	Mid Morula	Advance Morula
		
Blastula	Gastrula	Advance gastrula
		
Neurula	Hatching	Hatchlings

Induced breeding and embryonic development of Yellowfin bream

New records in Asian seabass, *Lates calcarifer* hatchery seed production help to meet the seed demands of farmers, self-help groups, start-ups and in-house projects

The Asian seabass seed production and sales at fish hatchery, MES-CIBA reached new heights, achieving 11.61 lakhs of seabass seed production and ₹ 32.9 lakhs revenue generation. Asian seabass breeding trials were undertaken from the month of June 2021 to December 2021, a total of 12 induced breeding trials, 25 spawnings were observed resulting in a production of 4 million eggs with fertilisation and hatching rates of 85% and 90% respectively. A maximum survival rate of 80% (25 dph) was recorded from single spawning in June which translated into 6.0 lakhs seed sales to farmers. Protocols were standardised for airlifting of fertilised eggs involving 14 h live transport from Chennai to Kumta, Karnataka. For the first time, 21.6 lakhs fertilised eggs were supplied to the start-up hatchery, Canares Aqua LLP, Kumta and a total revenue of ₹ 32.9 lakhs was realised. Overall, a total of 11.61 lakhs of seabass seeds were produced from the fish hatchery during the year 2021, which were distributed to 42 farmers, SHG's, in- house projects and SCSP programmes.



State-wise distribution of seabass seeds

Rearing of different age-size groups of milkfish *Chano chanos* for a viable breeding program

Broodstock strengthening by maintaining different lines of broodstocks is critical for long-term success in milkfish breeding programmes globally. It is known that changes in breeding population by introduction of new brooders improve spawning performance and fertilization rate. Milkfish adults are being maintained in two different holding systems *i.e.* 100 tonne RCC tank-based system and lined pond-based system. Eight numbers of four to five years old milkfishes (body weight 1.5- 2.5 kg, tl. 62- 69 cm) were introduced from lined ponds to 100 tonne RCC tanks after PIT tagging earlier this year. Fishes reached an average of 3.5 kg body weight till December and showed initiation of maturity. Both the population of milkfish (Chennai and Kakinada) were administered with hormone implantations during January and October during 2021. A total of 17 spawning (08 Chennai population, 09 Kakinada population) was observed in two domesticated populations of milkfish during March to September resulting in 0.7 million fertilised eggs and 0.38 million larvae. Assisted hormone implantation helped to enhance relative latency period from 9 days to 75 days. On the contrary, chronic/ continuous implantation (every month) resulted in a reduced latency period of 10-15 days as observed in earlier years. A total of 98,920 hatchery produced milkfish fry were distributed among farmers from Kerala, Andhra Pradesh, West Bengal, Gujarat, Orissa, Tamil Nadu, Uttar Pradesh and a revenue of ₹ 2,73,000 was generated.

Implantation frequency and spawning performance of milkfish in 100 tonne RCC tank

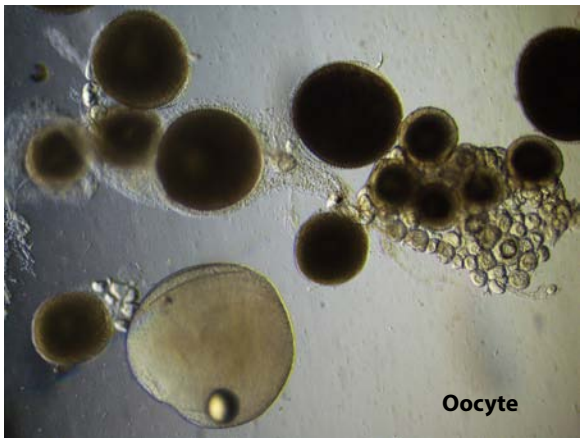
Water Temperature			27°C	30.5°C	32°C	32°C	30.8°C	30.2°C	29.5°C			
Months	J	F	M	A	M	J	J	A	S	O	N	D
IM (GnRH + 17 α - MT)	*	*		*		*		*		*		
Spawning (N=17: 9; 9-Kakinada, 9-Chennai)			2	4	1	4	0	3	3	0		
Relative Latency Period	-	-	30 d	9 d	60 d	12 d	-	10 d	75 d	-		
Fertilized egg collected			0.7 million									
Broodstock recruitment	8 milkfish of body weight 1.5 kg- 2.5 kg, tl. 62 – 69 cm [100% weight gain in 10 months]											

Pearlspot seed production in hapa set in pond and the effect of sustained GnRHa delivery on pearlspot reproduction

Decentralised seed production models of pearlspot that can be easily adopted by farmers is being promoted by ICAR-CIBA for overcoming the problems related to inadequate availability of seeds for farming. Pearlspot seed production was conducted in hapas (10 numbers) set in pond system from August- September. Hapas of 1 m^3; mesh size 3 mm were stocked with 4 numbers of pearlspot brooders (130-154 g; 150-185 mm) and provided with earthen pots set at a depth of about 30-40 cm below water surface. Brooders were selected (males: females, 1:1) based on the appearance of genital papillae. A total of 6 out of 10 hapa successfully exhibited pair formation and breeding. Eggs were deposited in the earthen pots within hapa and the larvae were collected at 1-4 dph. The number of larval batches obtained in 90 days ranged from 3-6 per hapa. The frequency at which larvae were obtained were 14.6 ± 2.2 to 36 ± 5 days. Twenty-one batches of larvae were obtained from the trail; number of larvae per batch ranged from 120-1,620. The low numbers of larvae obtained in few batches were attributed to filial cannibalism. Similar to the above hapas, an additional ten number of hapas were set and the brooders were administered cholesterol pellets of GnRHa, 40 µg/fish for sustained hormone delivery. During the period, none of the brooders exhibited any breeding response. From the pearlspot seed produced, three thousand seeds were supplied to farmers. Seeds were also used for genetic selection studies and are also being reared by scheduled caste beneficiary as a livelihood activity.

First report of captive maturation and successful spawning of goldlined seabream *Rhabdosargus sarba*

Rhabdosargus sarba (Forsskål, 1775) belongs to the family Sparidae and is commonly known as goldlined seabream. The fish is a potential candidate for aquaculture because it has high commercial value in the local market. The wild collected sub-adult and juvenile fish (47 numbers) are being maintained in the cages, flow through tank system and RAS facility at MES-CIBA. The fishes were fed with low valued fishes and specific maturation diets. In November 2021, the fishes reared in the cages matured and oozing milt stage was observed in the males. First maturity occurred in male with the size of 19.0 cm length and 320 g weight and in females with the size of 24.0 cm length and 420 g weight. Subsequently the fish (female with 635 g in weight, 30 cm length and males with 445-460 g weight, 27 cm length) with desired gonadal status (oocytes diameter, 450-488 µm) were administered with hCG at 500 IU/kg (first dose) and 250 IU (second priming dose) at an interval of 24 h and maintained in the RAS facility in the month of December 2021. Spawning was noticed between 00:30 and 1:00 h and a total of about 40,000 eggs were spawned. The average size of spawned eggs ranged between 920 and 980 µm. However the eggs did not fertilize.

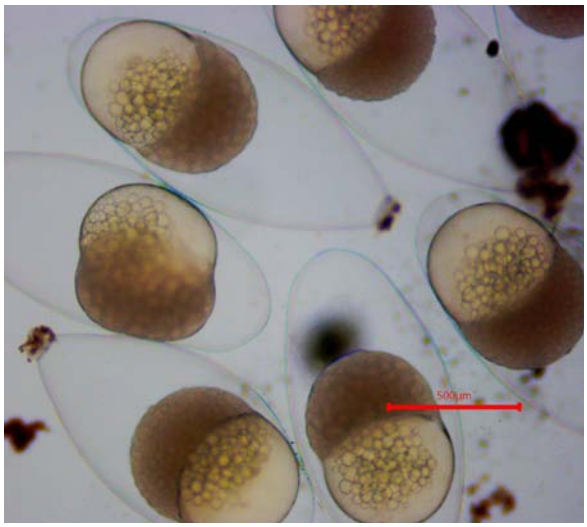


Oocytes and spawned eggs of goldlined seabream *Rhabdosargus sarba*

Breakthrough on captive breeding of estuarine goby fish, knight goby, *Stigmatogobius sadanundio*

The knight goby, *S. sadanundio* an indigenous brackishwater ornamental fish, is abundantly distributed in Sundarbans, West Bengal. This ornamental species is known for its unique grey body with black dots and distinctive beautifully marked fins. ICAR-CIBA has taken up the research activities pertaining to broodstock development and seed production in captive systems. Adults and sub adults (n = 178) of knight goby were collected and maintained in tank and cage based systems and fed with pellet feed (crude protein, 30%) for maturation in captivity. Females with bulged belly were observed after 3 months of domestication. Mature oocytes ranged from 580–670 µm.

Breeding trials were conducted using different male and female dominant sex ratios and found that 1 female: 3 male results in successful spawning. A female laid 1,000–2,000 fertilised eggs on substrate guarded by the male. The ovulated fertilised eggs are transparent and stick to the substrate with the help of fine threads. Fertilised



Fertilised eggs (1st day) under microscope

A clutch of eggs (3rd day)

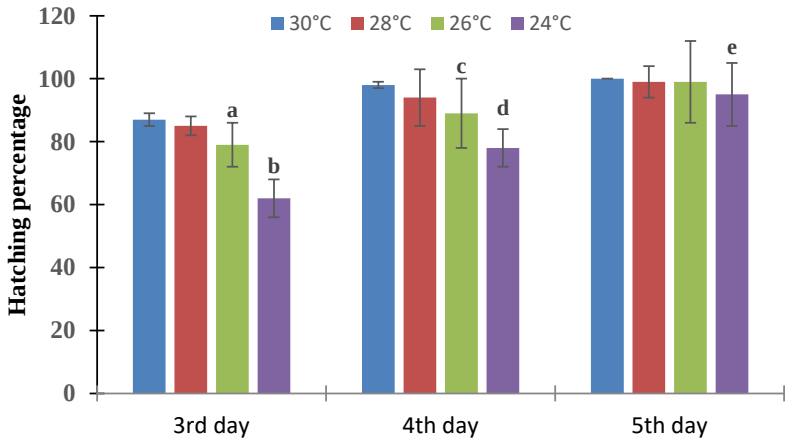
egg measures 1.2 – 1.4 mm in length and 0.59 – 0.67 mm in diameter. These eggs turn black on the 3rd day due to complete development of the embryo which can be seen with naked eyes. Hatching starts from the 3rd day and ends by the 5th day. Hatchlings are 2.4 – 2.5 mm in total length. Larvae could be reared upto 3 day post hatch. Further attempts are being made to standardize the mass scale larval rearing and seed production.

Just hatched larvae of knight goby

Optimization of incubation and hatching protocols of fertilised eggs of knight goby, *Stigmatogobius sadanundio*

Optimization of incubation and hatching protocols of fertilised eggs of knight goby, *S. sadanundio* was done for standardising hatchery production of the species. Domesticated knight goby spawn during winter months and hatching is observed from 3rd - 5th day. An experimental trial was conducted in triplicate to study the effect of different incubation temperatures on hatching. Fertilised eggs (n = 500) were incubated at water temperatures of 24ºC, 26ºC, 28ºC and 30ºC just after egg laying on substrate. Hatching was monitored from the third day onwards. It was found that 28 – 30ºC was the most favourable temperature for incubating the eggs as over 85 % hatching rate was recorded on the 3rd day. Lowest hatching (62%) was observed at 24ºC on the 3rd day. Almost all the eggs hatched out at 30ºC on 4th day. However, significantly ($p<0.05$) lower (78%) hatching was observed at 24ºC. A hatching rate of 95% could be observed at a temperature of 24ºC on 5th day. No significant difference was observed in the hatchling rate among the treatments.

Male knight goby guards and cares for the egg clutch on substrate after spawning. It was observed that in order to keep the egg clutch healthy, male eat a few eggs while caring. This may be due to fungal growth on few eggs arising from less water movement and settlement of particles on eggs. To evaluate the effect of absence of parental care and to optimise the hatching percentage four trials were designed in duplicate where breeding pairs were formed. Same pair was induced to spawn twice so that the egg clutch was first kept with parents and then without parents for hatching. It was found that hatchlings output increased significantly when eggs on substrate were separated from parents and incubated separately in hatchery conditions. These fertilised eggs were treated with 1 % methylene blue and maintained in 2 ppt salinity with aeration and water flow over the eggs to eliminate any fungal growth.



Effect of incubation temperature on hatching percentage of fertilized eggs of knight goby
Different letters represent statistical difference between treatments

First record of successful on-board breeding of hilsa, *Tenualosa ilisha* in Narmada estuary, Gulf of Khambat, Gujarat

The hilsa shad, *Tenualosa ilisha* is one of the most commercially important food fishes of India and Bangladesh. In Gujarat, the hilsa fishing season in the Narmada estuary prevails from July to September when the fish ascends for spawning migration to the Narmada estuarine river complex. The catch of hilsa is depleting in Narmada due to obstruction of spawning migration of broodfish in this region. Therefore, it is important to study the breeding biology of hilsa in this region to understand the reproductive biology and its seed production potential. To permute the aquaculture and conservation of this species, ICAR-CIBA, Navsari Gujarat Research Center has attempted first successful on board breeding of hilsa through artificial stripping method in Narmada estuary, Gulf of Khambat, Gujarat. On-board breeding trial was carried out in August by dry stripping method, where ovulating female (39.5 cm, 850 g) and oozing male (32 cm, 330 g) brooders were stripped for artificial fertilisation. A total of 60,000 hydrated eggs (2.13 ± 0.03 mm) were packed @10,000 eggs/5 L in oxygenated freshwater filled in polythene bags and transported to NGRC-CIBA research centre. Eggs were incubated for 18 h at 29 ± 0.50°C. The fertilisation and hatching rates were estimated as 70% and 65% respectively. A total of 27,300 hilsa larvae with the total length, 2.443 ± 0.02 mm were stocked at 500/m^3 in different larval rearing systems such as indoor, semi outdoor and outdoor tank systems for fry production. Hilsa larvae reared in semi-outdoor environment (tarpaulin tanks) for a period of 30 days attained fry stage (25 mm, 400 mg) with 6.6 % survival rate, whereas larvae reared in outdoor tanks attained fry size of 22.66 ± 0.88 mm with survival rate of 5.32 ± 0.09 %. Lowest survival rate of hilsa larvae were recorded in indoor tanks, 1.30 ± 0.28 %. The results of above study has indicated the potential for large scale breeding and seed production of hilsa in the Narmada estuarine region from the natural stocks and to develop the captive breeding and conservation programme.

0 day old hatchling of hilsa

30 day old hilsa fry

On-board breeding of hilsa, (*Tenualosa ilisha)* in Hoogly river

Artificial breeding of hilsa was conducted using wild collected broodstock (female, 650-754 g / 34.3 - 38.4 cm and male, 210-250 g / 23.8 - 29.46 cm) from Hooghly estuary at Godakhali, South 24 parganas (22°39'N, 88°14'E), West Bengal through dry stripping method. The successful fertilisation was recorded in the month of March, 2021 and a fertilisation of 92-96 % was obtained. Larvae produced from the trial were stocked in earthen pond for further rearing.

Artificial breeding of hilsa

Broodstock development and gonadal maturation of hilsa, *Tenualosa ilisha*

Wild collected hilsa sub-adults (158.84± 12.50 g/ 22.85± 0.72 cm) were stocked in 0.15 ha brackishwater pond. Pond was fertilised with Plankton ^{Plus} (30 kg/ha) and mustard oil cake (60 kg/ha) in alternate weeks to maintain the plankton population. The plankton abundance and diversity in broodstock ponds revealed that *Nannochloropsis*

sp., *Chlorella* sp., *Nitzschia* sp., were the major species, whereas, copepod, daphnia and rotifers were the prevalent zooplankton. Formulated feed with 39 % crude protein and 15% fat was fed at 3-5 % body weight. After 250 days, fish attained an average body weight/ length of 304.92± 32.91 g/ 29.62± 1.54 cm.

Pond reared male & female hilsa broodstock

Gonadal maturation of pond reared hilsa broodstock

To monitor the maturation status of captive hilsa, brooders were tagged with tiny coloured nylon thread (0.05 mm) at base of dorsal fin. Comparative gonadal maturation study of captive and wild broodstock revealed that female collected from both captive (265.67 ±3.48 g) and river (831 ± 21.22 g) were in stage II (with GSI 13.68 ± 0.04 in river and 13.05 ± 0.14 in captive broodstock) maturation, while the captive male (122.33 ± 3.38 g) showed advanced maturation (stage III; with GSI 2.24 ± 0.025) compared to wild male (238.67 ± 4.67 g) with stage II maturing phase (GSI 0.768 ± 0.002). About 80% of the captive brood fish were found to be in different stages of maturity.

Captive broodstock

Ovary **Testis**

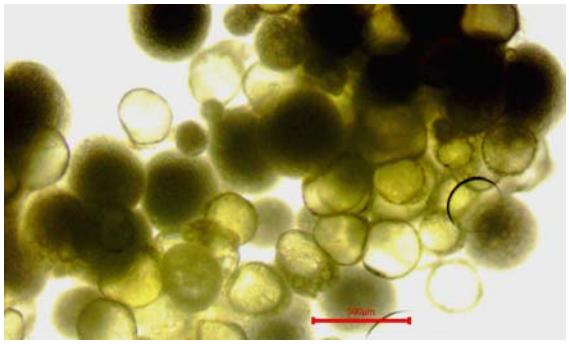
Wild broodstock

Ovary **Testis**

Gonads of captive and wild broodstock

Captive broodstock development, salinity tolerance and maturation study of four band tiger fish, *Datnioides polota*

Four band tiger fish, *Datnioides polota* is one of the high-value commercial ornamental fish of Sunderban delta which has both domestic and international markets. Development of a captive stock, understanding of the reproductive biology, spawning season and salinity tolerance of the species was considered fundamental for initiating a captive breeding program for the species. To develop the captive broodstock of *D. polota,* sub-adult fish (90-170 g) and fry (1.8-2.0 g) were collected from the mangrove area (salinity 3-5 ppt) and reared in the recirculatory aquaculture system (RAS). Ovarian biopsy of fish collected from the wild showed mature oocytes (oocyte diameter, 300.81 ±72.39 µm) indicating that fish mature and spawn during the monsoon months (May-August). Salinity tolerance study showed no fish mortality in the range of 0-15 ppt, however, at 20 ppt, 50% of fish mortality was observed . Over 40 adult and 400 numbers of fingerlings of *D. polota* are being maintained as broodstock for the captive seed production programme.

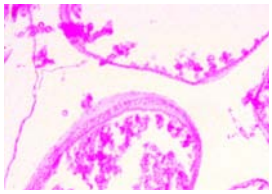


***Datnioides polota* Oocytes**

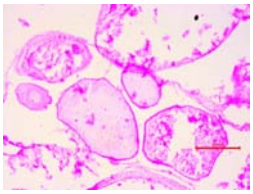
Fingerlings of *Datnioides polota*

Effect of salinity on maturation of orange chromide, *Pseudetroplus maculatus*

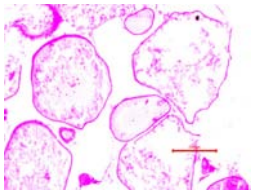
One hundred and twenty sub-adult of orange chromide, *P. maculatus* (average size: 1.82 g; 22 mm) received from CIBA headquarters were equally distributed in four different salinities viz. 0, 5, 10, 15 ppt in triplicates and reared for 45 days (June-July, 2021) to understand the gonad development in different salinities at KRC. Result of the study showed that the fish attained the final maturation in three different salinities of 0, 5 and 10 ppt however, failed to attain final maturation at higher salinity of 15 ppt. Gonadosomatic index (GSI %) of 9.524, 8.796, 5.882 and 5.535 was recorded at 0, 5, 10 and 15 ppt, respectively. Gradual reduction in oocyte size was noticed with increase in salinity. Oocyte size (L × D in µm) of 1,477.34 × 960.42, 1,598.94 × 834.16, 1,006.69 × 711.72, 950 × 612.5 was recorded at 0, 5, 10 and 15 ppt salinities, respectively. Study concludes that the orange chromide oocytes could attain final sexual maturity in salinity range from 0-10 ppt.



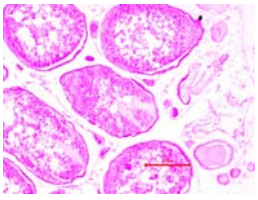
0 ppt



5 ppt



10 ppt

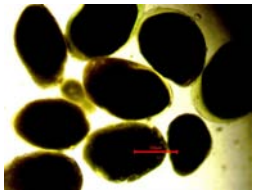


15 ppt

0 ppt

5 ppt

10 ppt

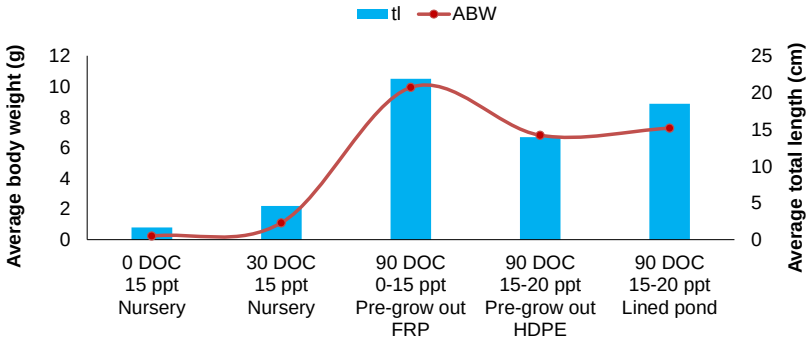


15 ppt

Broodstock development of saline tolerant red tilapia, Thai-Chitralada strain

The saline tolerant tilapia can contribute to species diversification in brackishwater aquaculture, due to their rapid growth, productivity and fillet quality. In this connection red tilapia fry (tl., 0.8 cm, abw, 0.5 g) belonging to Thai-Chitralada strain (Hybrid of *Oreochromis aureus*, *O. niloticus* (Egypt), and O. *mossambicus*) were procured from a licensed private hatchery, Andhra Pradesh for red tilapia seed production. During nursery rearing in FRP

tanks, fish grew to 2.3 g/ 2.2 tl. in 30 DOC when maintained at 15 ppt. For stock development fishes were distributed in FRP tanks (0 ppt), HDPE tanks (25-30 ppt) and lined ponds (25-30 ppt) to prevent escape into open waters. Fishes were fed with 800 µm larval feed (crude protein, 46 %, crude lipid, 8%). Although, red tilapia fingerlings survived the saline environment, the maximum growth was recorded in freshwater stocks (abw 20.7 g , tl. 10.5 cm) followed by saline stocks in lined pond (abw 15.17 g , tl. 8.87 cm). Upon attaining maturity, breeding trials will be conducted in modular breeding units for seed production and culture demonstrations in biofloc, polyculture and urban aquaponics models.



Hybrid red tilapia growth pattern in different salinity and system

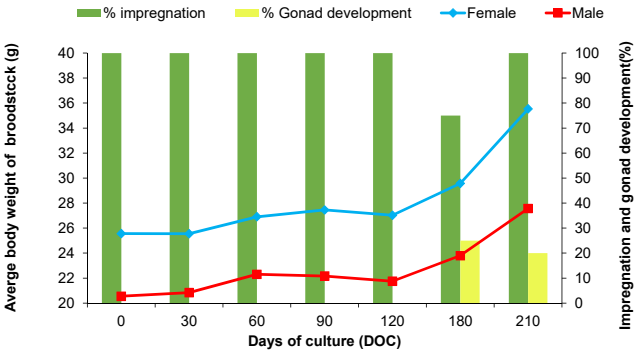
Captive broodstock development of Indian white shrimp and reproductive performance of pond reared broodstock G3 lines.

Closing the life cycle of the penaeid shrimp in captivity is most critical for the selective breeding. In continuation of the earlier works, efforts were carried out to record the breeding efficacy of captive-reared broodstock of *P. indicus* G3 line. The average size of male and female broodstock (G3) lines contributed in spawning was 42.05 ± 5.17 g and 33.04 g respectively. Out of the total population of females, 62.5% recorded advanced gonadal development and 25% responded to successful mating. Total 14 batches of breeding trials were conducted using the captive-reared broodstock of 2nd generation (G2), and 3rd generation (G3) with 50 successful spawning in 2021. The pond reared G3 lines recorded 100% impregnation, with 60% of male broodstock having milky white sperm pack. Fecundity range and average eggs per gram body weight were 56,000-90,000 and 1,357 egg/g, respectively. 2.79 million active nauplii produced form the breeding trials were further reared for the production of fourth generation lines.

Maturing stage of female *P. indicus* broodstock G3 line

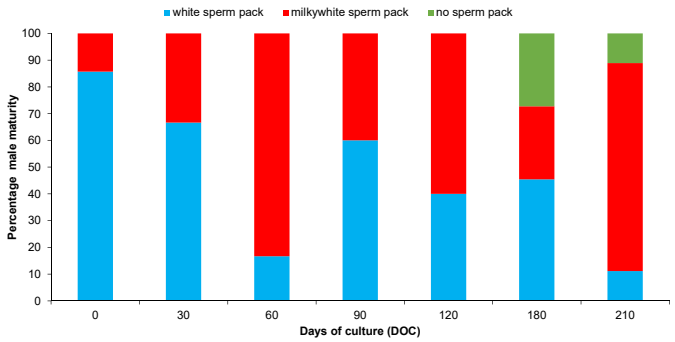
Effect of environmental cues on mating efficiency and gonad development of captive reared *Penaeus indicus*

Reproductive dysfunction in closed thelycum penaeids always poses hurdles for selective breeding programmes. Factors like water quality, temperature, etc. are known to modulate the breeding and maturation of shrimps. A comparative study was conducted on the captive reared broodstock of *P. indicus* in indoor and outdoor maturation tank system. Maturation tanks of 5 tonne capacity were stocked with female (25.74 ± 2.23 g) and male (20.47± 1.95 g) broodstock at the rate of 5-7/m^2. The average natural photoperiod varied from 12.45 L: 11.53 D to 11.28 L: 12.73 D in outdoor tanks, whereas in indoor units, it was controlled at 12 L:12 D. The light intensity in the outdoor and indoor rearing system varied between 77 to 72,000, and 25 To 1,999 lux, respectively. During the experimental period broodstock were fed with pelleted maturation diet formulated by ICAR-CIBA.



Percentage mating and gonad development of captive reared *P. indicus*

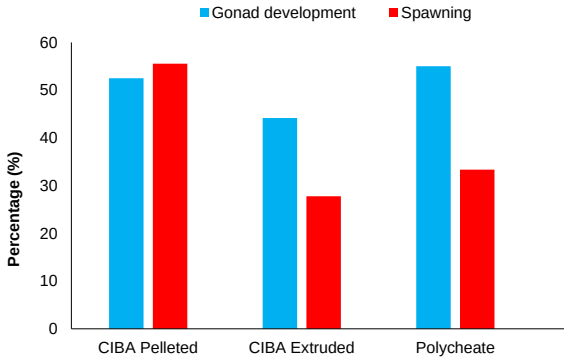
100 % impregnation was recorded in the outdoor tank system whereas it was nil in the indoor units. The total sperm count was highest in outdoor tank system and 25% of the females recorded gonadal development without eyestalk ablation. Indoor rearing system resulted in poor mating and gonadal development in *P. indicus*. Developing confined bio secure outdoor maturation systems can tackle issues in breeding and reproduction.



Spermatophore production status in captive reared male *P. indicus*

Effect of maturation diet on reproductive performance of captive-reared *P. indicus*

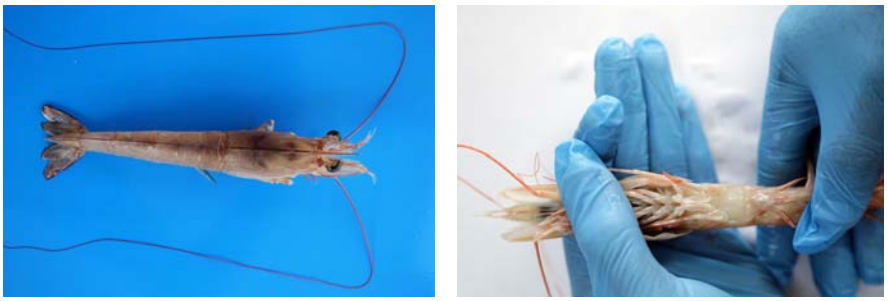
Broodstock nutrition plays a significant role in the quality of larvae produced in hatcheries. Shrimp hatcheries generally prefer live feeds to formulated feeds for maturation. However, issues related to contamination and water quality often arises with the use of live feeds. In this background, indigenous broodstock maturation diets, pelleted and extruded forms were prepared at the feed mill of MES, ICAR-CIBA, Muttukkadu. A comparative evaluation between the prepared feeds and live feed (Polychaete) was conducted with captive reared *P. indicus* (28-35 g) in maturation units for 21 days. Feeding the pelleted feed resulted in similar gonadal development (52.5%) compared to Polychaete (55%). The highest number of spawning (55.5%) was recorded in the pellet feed fed group (55.56%), followed by the polychaete worm fed group (38.33%). The extruded feed produced significantly lower gonadal development and number of spawning. Using formulated feed as an alternative to live feed resulted in better water quality in terms of TAN, Nitrite-N, and lower microbial load.



Effect of maturation diet on gonad development and spawning of *P. indicus*

Reproductive performance and seed production of lesser known penaeid shrimp, *Metapenaeus monoceros*

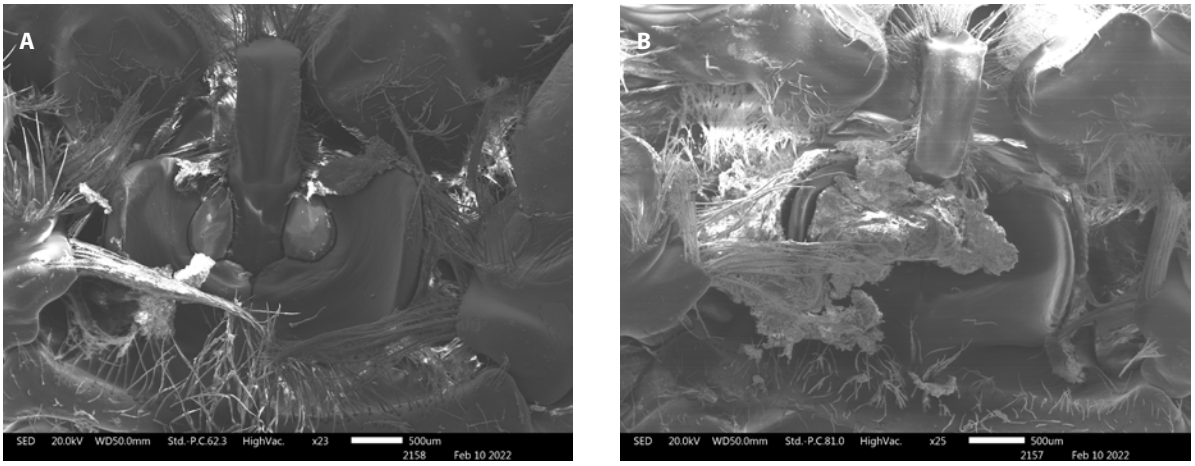
Speckled shrimp, *Metapenaeus monoceros* is a native penaeid in India, and one of the least explored species for its aquaculture potential, although this species is a part of the traditional farming systems in India. Several attributes of this species are proved to be its potential for developing as a commercial aquaculture species. Mass seed production and larval rearing of this species at commercial scale have not been addressed so far. Broodstock of *M. monoceros* (30 nos) were obtained from the artisanal fisheries of Southeast coast of India to evaluate the various aspects of hatchery production. Broodstock were transported to the experimental shrimp hatchery of MES-CIBA, Muttukkadu and gravid females were spawned to record the reproductive parameters. The average size of male and female broodstock were 40.58 ±11.03 (23.38 - 59.6 g) and 20.10 ± 3.43 (14.23 - 26.27 g) respectively. The gonadosomatic index ranged between 1.39 for spent and 12.9 for staged broodstock. The length-weight analysis of the broodstock recorded a negatively allometric growth rate with regression equation, $Y=0.009 X^2$. The average fecundity and eggs per gram body weight of wild spawner were 99,000 ± 61,595 and 3,204 ± 1,593 eggs/g, respectively. Fresh spawned eggs and nauplius recorded an average size of 283.8 and 403.64 microns respectively.



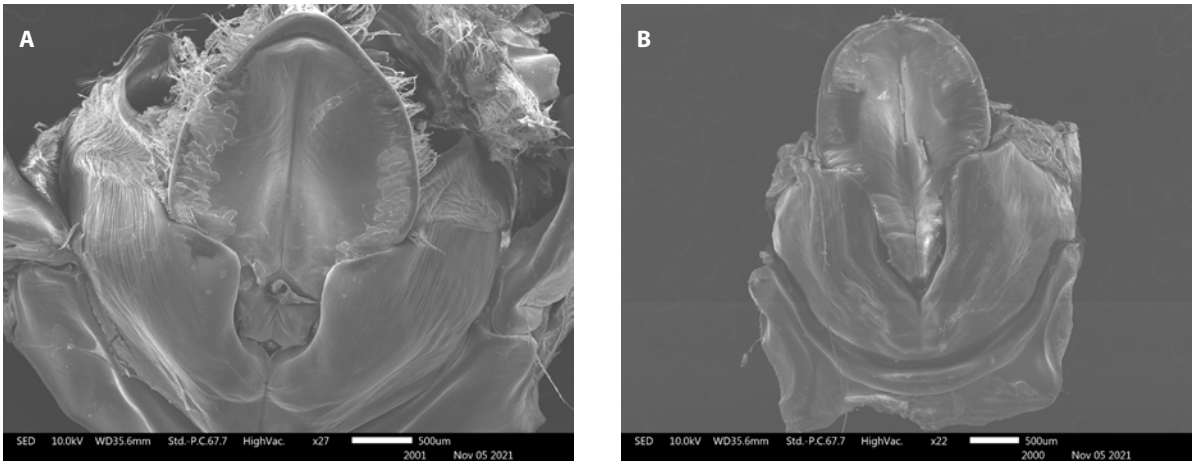
Female and male broodstock of *M. monoceros*

Ultrastructure of thelycum of *Metapenaeus monoceros* and *Metapenaeus dobsoni*

Anatomy of the female genital organ (Thelycum) plays an important role in the reproductive biology of shrimps. The thelycum of female shrimps facilitate spermatophore transfer and serves as an organ for spermatophore storage under spawning. The structure of the thelycum, either closed or open type, have large implications in their mating and reproduction. Captive maturation and breeding is often hard in the closed thelycum species due to mating issues. In this context, the ultrastructure of thelycum of *M. monoceros* and *M. dobsoni* was compared under scanning electron microscopy. Spermatophore impregnated and empty thelycum were analysed to study the structure. The thelycum in open-thelycum species are modified to form numerous protuberances and ridges. The ultrastructure of thelycum of *M. monoceros* under scanning electron microscopy revealed a concave structure formed with a median plate and two lateral plates. The ridges of the lateral plates are steep which forms an oval structure inside the thelycum, which forms an open structure. The lateral sides and the anterior part of the median plate is covered with setae. The spermatophore was seen attached to the concave portion of the thelycum in the impregnated thelycum. The morphological observations and inferences points that *M. monoceros* thelycum is open type. Thelycum of *M. dobsoni* was closed in nature with a long, grooved anterior plate resembling a tongue like shape. The posterior portion was covered with elongated lateral plates, which forms a horse shoe like shape. The tip of the lateral plates are narrower and reaches half portion of the median plate. The impregnated thelycum of *M. dobsoni* exhibited a protrusion at the median of the median plate. The median plate exhibited protrusions and ridges externally confirming to the structure of the spermatophore inside.



Electron micrograph of empty (a) and impregnated thelycum of *M. monoceros* (b)

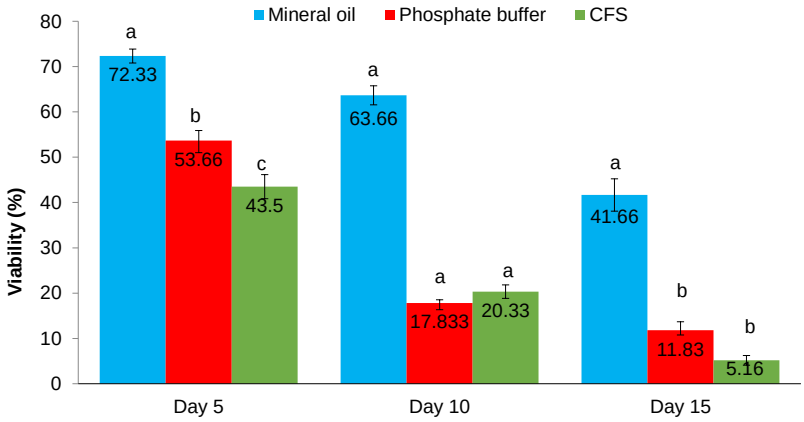


Electron micrograph of empty (a) and impregnated thelycum of *M. dobsoni* (b)

Chilled storage of spermatophores of *P. indicus* using different extenders

Preservation of spermatophores is an important step for the controlled breeding of the closed thelycum penaeids in captivity. Non cryogenic methods were explored for the preservation of spermatophores of *P. indicus* in our previous experiments and viability was conserved up to five days in chilled storage. In the present experiment,

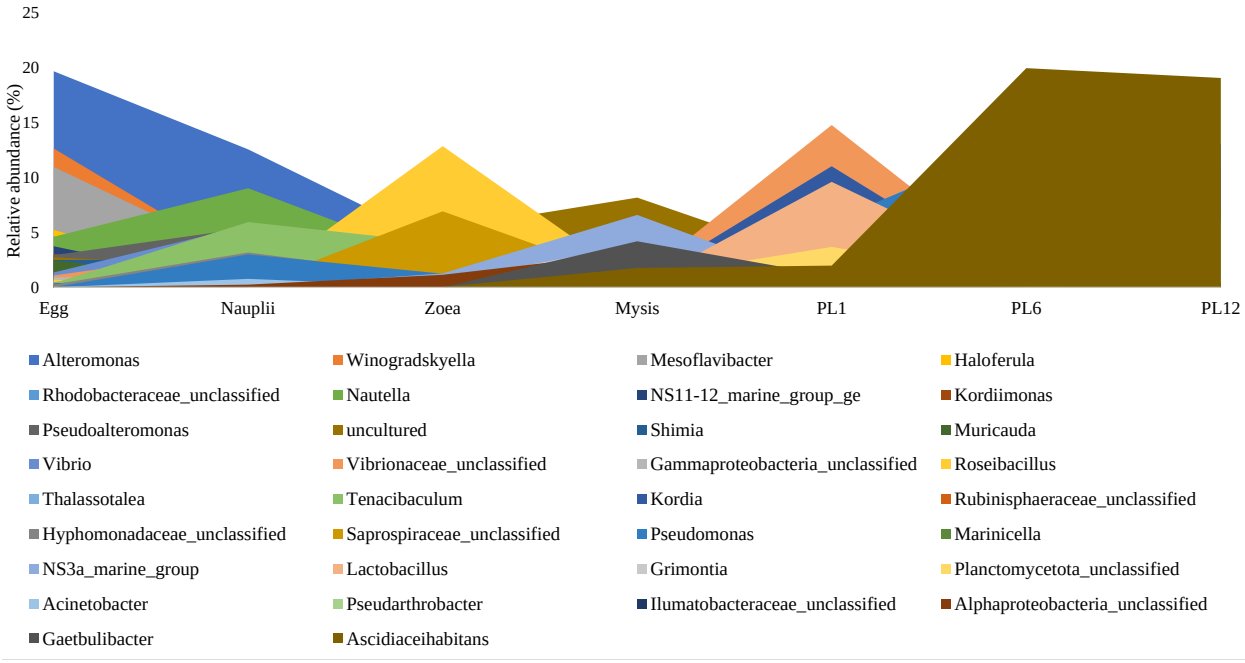
different extenders viz, mineral oil, phosphate buffer and calcium free saline where evaluated for extending the duration of sperm viability. Spermatophores (n=30) collected from *P. indicus* males were stored in prepared extenders and stored in 4°C until opened. Sperm viability (%) and Induced acrosome reaction (%) was analysed in the stored sperms after 5, 10 and 15 days. The sperm viability was significantly (p<0.05) higher in mineral oil preserved spermatophores (72.33, 63.66, 41.66%) after 5, 10 and 15 days compared to the other treatments. However, reducing trend in sperm viability was observed in all the treatments as the days of storage increased. Storing the spermatophores in mineral oil significantly (p<0.05) preserved the acrosome reaction capability. Poor acrosome response and higher cell degradation was observed in Calcium free saline and Phosphate buffer. Further optimization of the extenders can extend the preservation time.



Percentage of viability of spermatophores of *P. indicus* during chilled storage
Different alphabets over the bar denotes significant difference between treatments

Microbiota associated with the early developmental stages of the Indian white shrimp *(Penaeus indicus)*

Colonization of gut microbes is an essential and crucial process in the early developmental stages of an animal. The establishment of healthy microbiota will determine the health status of the host in later stages. Microbiota associated with the early life stages of *P. monodon* and *P. vannamei* is well documented. The bacterial community associated with egg, nauplii, zoea, mysis, PL1, PL6 and PL12 stages of *P. indicus* was examined through a metagenomics study. The bacterial profiles varied significantly in each stage, however *Proteobacteria, Bacteroidota, Firmicutes, Actinibacterota* and *Verrucomicrobiota* were the top 5 bacterial phyla associated with all the stages in different proportions. The bacterial composition became relatively stable from post larvae (PL6), indicating the establishment of a matured microbiota. This study indicates that the shrimp gut microbiota could be shaped as desired through dietary interventions during the early life stages.

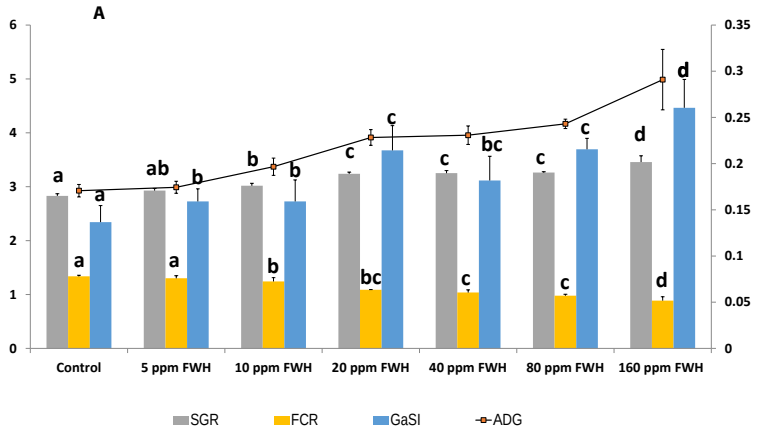


Microbial dynamics in various developmental stages of *P. indicus*

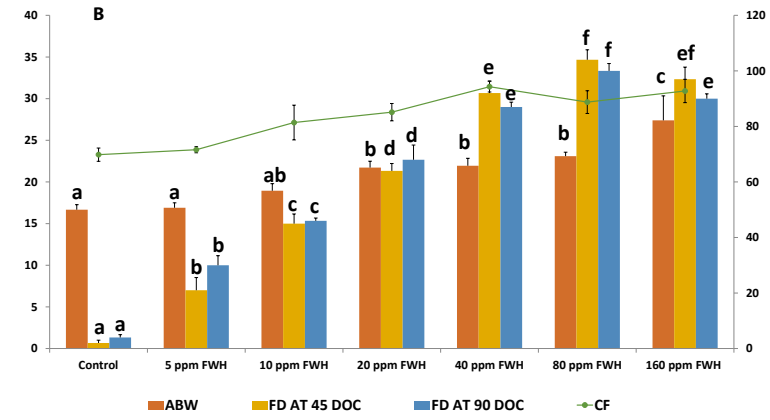
Nutrition and Feed Technology

Growth enhancement of *Etroplus suratensis* with supplementation of fish waste hydrolysate (FWH)

One of the major problems faced by the *E. suratensis* (pearlspot) farmers is the slow growth rate of the species. Since pearlspot is an omnivore, a 90 days experiment was conducted to evaluate the effect of fish waste hydrolysate (FWH) as plankton booster in outdoor tank systems. Juvenile fish (1.22 ± 0.01 g) were stocked in outdoor FRP tanks and supplemented with different doses of FWH (0, 5, 10, 20, 40, 80 and 160 ppm). 40% of the FWH doses were administered as basal dose and remaining quantity were given as equal weekly dose. The results showed that specific growth rate (SGR), percentage weight gain, average daily gain (ADG) and FCR of *E. suratensis* grown in FWH (@ 20 ppm and above) supplemented treatments were significantly improved (p<0.01) than control and lower doses of FWH @ 5 and 10 ppm. The highest growth parameters were observed in treatment supplemented with 160 ppm FWH and the parameters like SGR, percentage weight gain and ADG were significantly higher (p<0.01) than the other treatments including control. The growth enhancement is in correlation with significantly higher floc densities in FWH supplemented treatments compared to control. Moreover, the abundance of the phytoplankton and zooplankton were significantly higher in FWH supplemented treatments. Higher abundance of microalgae and zooplankton might have contributed positively to floc formation and improved growth of *E. suratensis* in the culture system. Hence it can be concluded that the FWH application could significantly enhance the growth and productivity of pearlspot.



***E. suratensis* supplemented with FWH in outdoor tank system**



(A) Growth parameters and (B) Floc density, ABW and condition factor of *E. suratensis* supplemented with FWH. Mean ± SD (n = 3) values with different superscript differ significantly (p < 0.05)

Evaluation of fish waste hydrolysate as plankton booster in nursery rearing of *Penaeus vannamei*

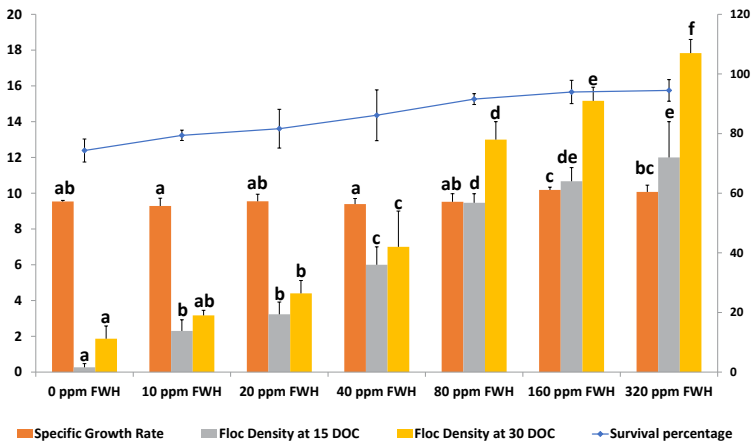
Due to the specific advantage of nursery rearing in grow-out culture most of the shrimp farmers started nursery rearing. In this context, to evaluate the effect of fish waste hydrolysate (FWH) in enhancing the growth and survival as well as to understand the effect of FWH in different stocking densities, two outdoor experiments were conducted for 30 days. PL 18 of *P. vannamei* was used in two stocking densities (1,000 numbers/m^3 and 4,000 numbers/m^3) and supplemented with different doses of FWH (0, 10, 20, 40, 80, 160 and 320 ppm). 40% of the FWH doses were administered as basal dose and remaining quantity were given as equal weekly dose.

Nursery reared *P. vannamei* with FWH

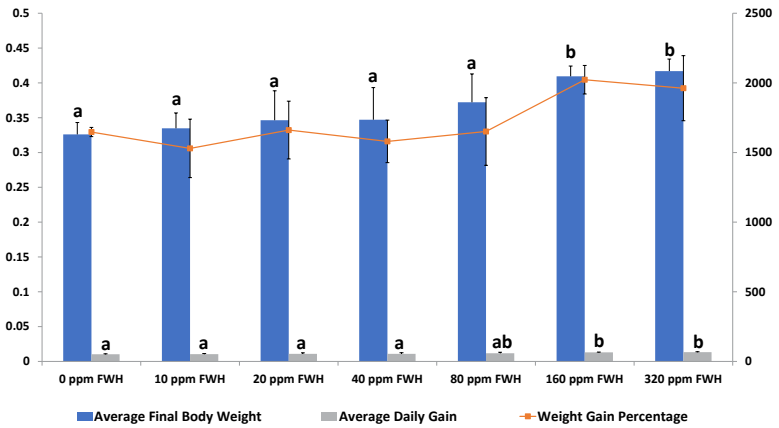
Experiment 1 (4000/m^3):

The result showed that the growth parameters, weight gain percentage, SGR, ADG and average final body weight (AFBW) were significantly (p<0.01) higher in treatments supplemented with 160 and 320 ppm FWH compared to control without FWH. The survival of treatments with FWH supplementation of 80 ppm and above are significantly (p<0.01) higher than the control without FWH supplementation. Interestingly, the higher FWH supplementation supports the formation of flocs in the system and the floc density increases with the increase in the FWH supplementation. Highest abundance was observed in treatments supplemented with 160 and 320 ppm FWH. The floc generated and plankton abundance would have positively contributed to higher growth and survival of *P. vannamei*.

A



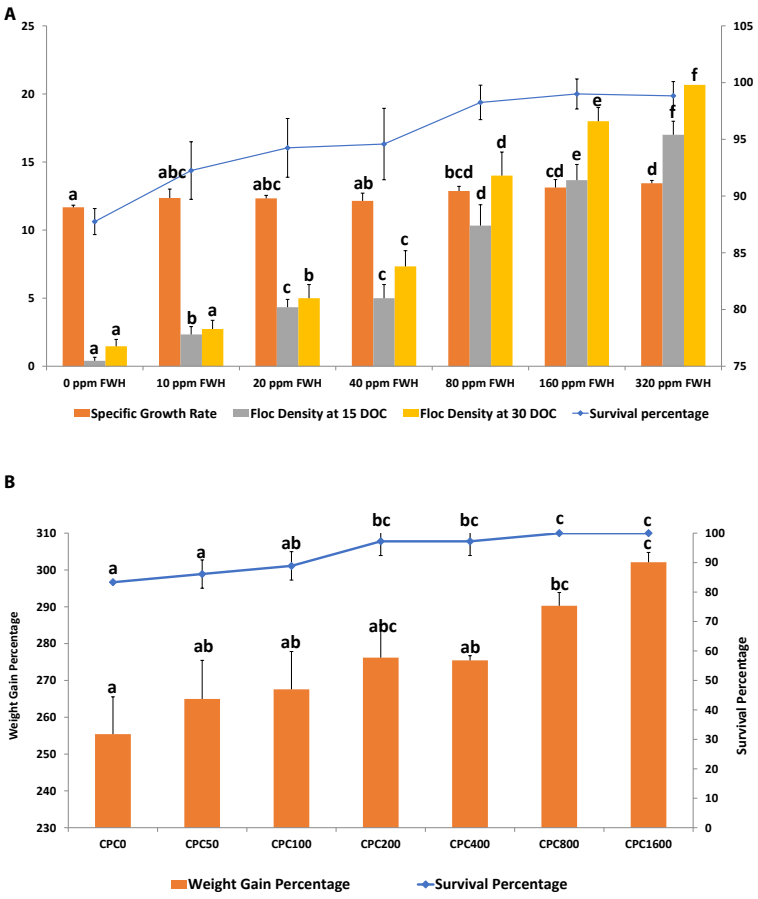
B



(A) SGR, survival and floc densities and (B) Growth parameters of *P. vannamei* in FWH supplemented nursery rearing
Mean ± SD (n = 3) values with different superscript differ significantly (p < 0.05)

Experiment 2 (1000/m³):

The result showed a similar trend in growth parameters with that of higher stocking density. Weight gain percentage, SGR, ADG, survival and AFBW were significantly (p<0.01) higher in treatments supplemented with 160 and 320 ppm FWH compared to control without FWH. The FWH supplementation positively enhanced the floc generation in the system and it would have supplemented the nutrition of the shrimp. The higher abundance of phytoplankton and zooplankton in FWH supplemented tanks would have contributed to the higher growth and survival of *P. vannamei*.



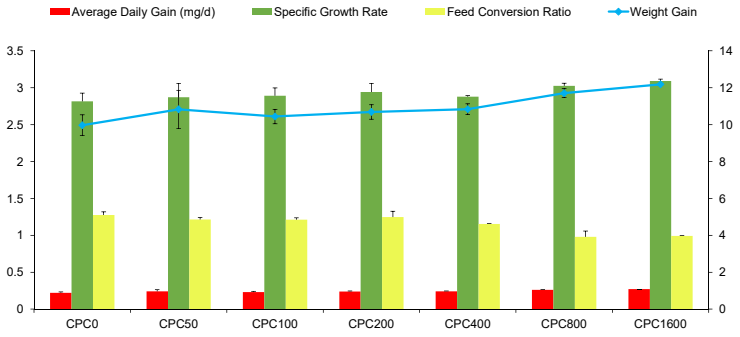
(A) SGR, survival and floc densities and (B) Growth parameters of *P. vannamei* in FWH supplemented nursery rearing
Mean ± SD (n = 3) values with different superscript differ significantly (p < 0.05)

Effect of dietary C-Phycocyanin extracted from locally isolated *Arthrospira maxima* in growth of *Penaeus vannamei*

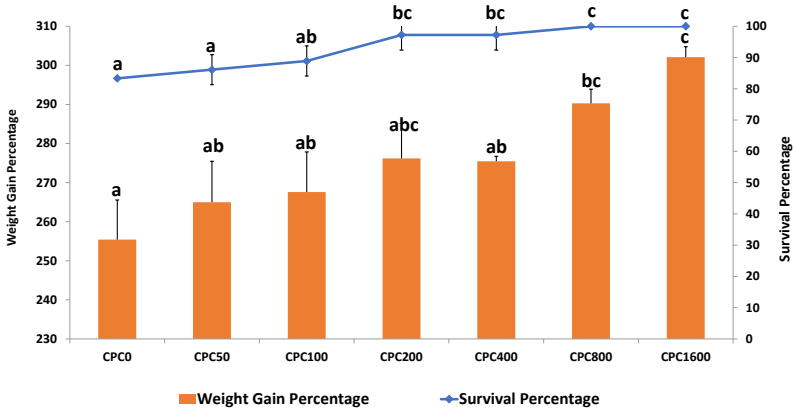
Utilization of C-Phycocyanin extracted from *Arthrospira maxima* in shrimp nutrition

An intense blue pigment, C-Phycocyanin (CPC) was extracted from a locally isolated cyanobacterium, *Arthrospira maxima*. A 45 day feeding experiment was conducted to unravel the effect of dietary CPC in *P. vannamei*. Juvenile *P. vannamei* (ABW: 3.99 ± 0.11 g) were randomly distributed into 21 FRP tanks (100 l water each) in a recirculatory aquaculture system (RAS) at 12 animals per tank. Seven iso-nitrogenous and iso-energetic experimental diets were prepared with varying

levels of CPC supplementation at 0 (control CPC_0), 50 (CPC_{50}), 100(CPC_{100}), 400 (CPC_{400}), 800 (CPC_{800}) and 1,600 (CPC_{1600}) mg of CPC/kg diet. The results revealed that the *P. vannamei* fed with dietary supplementation at 800 mg/kg (CPC_{800}) and1,600 mg/kg (CPC_{1600}) of CPC showed significantly higher ($p < 0.05$) weight gain percentage and survival compared to control. Similarly, ADG, SGR and FCR were significantly enhanced in *P. vannamei* fed with dietary supplementation at 800 and1,600 mg/kg of CPC compared to control.



Growth performances of *P. vannamei* fed with CPC

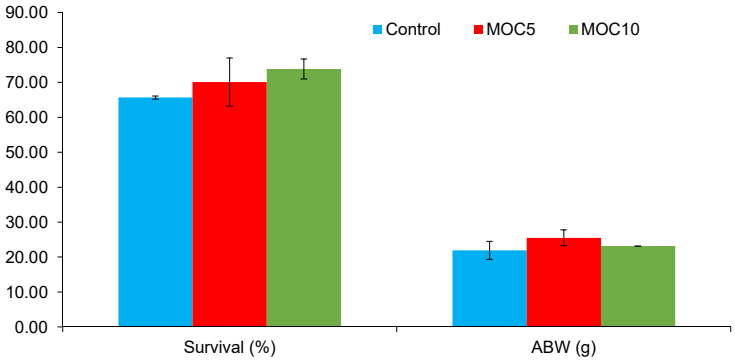


Weight gain percentage and survival percentage of *P. vannamei* fed with CPC

Mean ± SD (n = 3) values with different superscript differ significantly ($p < 0.05$)

Optimization of dietary inclusion level of mustard cake in practical diet of *P. vannamei*

To determine optimum inclusion level of mustard cake (MOC) in diet of *P. vannamei* feed was prepared with three different levels i.e., 0, 5 & 10% of MOC. All the feed were isoproteinous (CP-35%) and isolipidic (EE-6%). Experiment was conducted with three different treatments, i.e., control (feed without MOC), T1 (feed with 5% MOC) and T2 (feed with 10% MOC) in brackishwater ponds (0.15 ha) in replicates. Plankton ^{Plus} was used at 30 ppm in each pond and shrimps were stocked @ 30 pcs/m^2. At the end of 120 days culture, ABW was 21.94 ± 2.57, 25.50 ± 2.27 and 23.15 ± 0.05 g with a productivity of 4.33 ± 0.54, 5.16 ± 0.51 and 5.43 ± 0.21 t/ha in control, T1 and T2, respectively. FCR was significantly ($p<0.05$) lower in all MOC supplemented groups. Phytoplankton and zooplankton population in all the ponds were similar. From the experiment it is concluded that mustard cake can be included at 10% level in diet for *P. vannamei* culture without affecting the production performance.

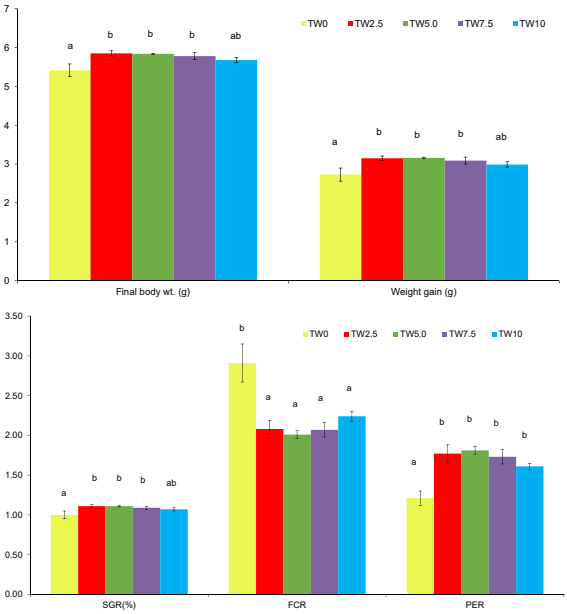


Growth performance and survival of *P. vannamei* fed with MOC

Optimising the inclusion levels of temple waste flowers in the diet of *E. suratensis*

Temple waste

To determine potential use of temple waste (TW) in diet of pearlspot feed was prepared with five different levels i.e., 0, 2.5, 5, 7.5 and 10% of temple waste on dry basis replacing soybean meal. All the feed were isoproteinous (CP-30%) and isolipidic (EE-6%). *E. suratensis* fry (ABW 2.69 ± 0.09 g) were randomly distributed in 15 tanks (500 l water each) at the rate of 25/tank and the feeding trial was carried out in triplicate. Fish of group TW_0, $TW_{2.5}$, TW_5, $TW_{7.5}$ and TW_{10} were offered feed with 0, 2.5, 5, 7.5 & 10% of temple waste, respectively, at satiety level twice (10 am & 5 pm) daily. After 10 weeks of experiment it was found that average daily gain and SGR were higher (p<0.05) in groups $TW_{2.5}$, TW_5, and $TW_{7.5}$ compared to control. Protein efficiency ratio (PER) and FCR significantly (p<0.05) improved when temple waste was included in fish diet with no significant difference between temple waste fed groups. Nutrient digestibility was higher in groups fed upto 5% temple waste compared to control. Therefore it can be concluded that temple waste can be incorporated up to 5% level in diet of *E. suratensis* and have potential to replace 5% soybean meal in diet of *E. suratensis.*



Growth performance of *E. suratensis* fed with temple waste

Mean ± SD (n = 3) values with different superscript differ significantly (p < 0.05)

Nutrient digestibility of *E. suratensis* fed different level of TW in diet

Digestibility (%)	TW 0%	TW 2.5%	TW 5%	TW 7.5%	TW 10%
DM	78.47 ± 1.79	80.10 ± 0.36	83.62 ± 1.25	79.07 ± 1.26	78.79 ± 0.34
OM	81.06 ± 1.57	82.54 ± 0.32	85.61 ± 1.09	81.70 ± 1.10	81.57 ± 0.29
CP*	91.04 ± 0.74^{a}	92.15 ± 0.14^{ab}	93.56 ± 0.49^{b}	91.87 ± 0.49^{a}	91.38 ± 0.14^{a}
EE*	92.36 ± 0.63^{a}	92.61 ± 0.13^{a}	94.41 ± 0.43^{b}	92.77 ± 0.43^{a}	92.52 ± 0.12^{a}
CF*	69.39 ± 2.54^{a}	71.04 ± 0.52^{a}	78.46 ± 1.64^{b}	69.84 ± 1.82^{a}	70.10 ± 0.48^{a}
NFE	69.52 ± 2.53^{a}	71.71 ± 0.51^{ab}	76.30 ± 1.81^{b}	70.09 ± 1.80^{a}	70.35 ± 0.47^{a}

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

Optimising the inclusion level of potato waste meal in the diet of milkfish

Potato is grown almost in all states of India and it is fourth major vegetable food crop after rice, wheat and maize. Significant portion of potato is thrown as wastage during post-harvest or processing of potato as French fries and potato chips. This can be converted as potato waste meal which contains significant amounts of nutrient (crude protein- 12.63 ± 0.03%, lipid- 1.61 ±0.13%) and can be utilized in fish feed replacing conventional energy rich ingredients.

The inclusion level of potato waste meal (PWM) was studied in milkfish fry (ABW 1.22 g) in FRP tanks (500 l) for a duration of 90 days. Five isoproteinous (CP-30%) and isolipidic (EE 4.2%) experimental diets were prepared with inclusion of 0 (control), 9 (T1), 18 (T2), 27 (T3) and 36 (T4) percent of PWM replacing conventional wheat and rice flour @ 0, 25, 50, 75 and 100% and fed to

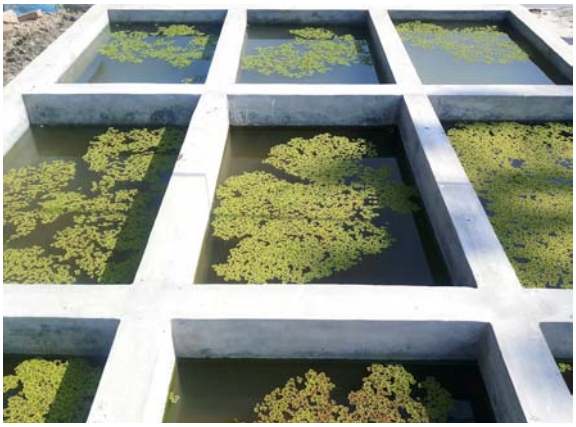
five experimental groups in triplicate containing 20 milkfish in each. It was found that weight gain was significantly (p<0.01) decreased and FCR was increased beyond 18% level of inclusion. It was concluded that PWM can be used upto 18% level with the replacement of 50% of wheat/rice flour in total in milkfish fry.

Performance of milkfish fed diet with different level of inclusion of potato waste meal

Parameters	0% PWM	9% PWM	18% PWM	27% PWM	36% PWM
Initial body wt (g)	1.22 ± 0.002	1.23 ± 0.001	1.22 ± 0.003	1.22 ± 0.002	1.23 ± 0.002
Final body wt. (g)**	4.02 ± 0.02^{c}	3.91 ± 0.05^{c}	3.93 ± 0.07^{c}	3.43 ± 0.03^{b}	3.26 ± 0.03^{a}
Wt. gain%**	229.33 ± 1.27^{c}	218.89 ± 3.34^{c}	222.12 ± 5.08^{c}	181.65 ± 2.71^{b}	165.49 ± 2.76^{a}
FCR**	3.53 ± 0.07^{a}	3.76 ± 0.06^{a}	3.58 ± 0.12^{a}	4.34 ± 0.24^{b}	4.51 ± 0.12^{b}
Survival%	85.00 ± 2.89	85.00 ± 2.89	86.67 ± 1.67	83.33 ± 3.33	85.00 ± 0.00

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

Optimising the inclusion level of Azolla meal in the diet of milkfish



Azolla culture unit

The high price rise of conventional plant protein soybean meal necessitates to explore the utilization of alternative plant protein sources to reduce feed cost in finfish diet. Milkfish is known to utilize lablab and other aquatic vegetation to a considerable extent and in this context, azolla meal which is found to contain 18.17± 0.09% crude protein, 4.23± 0.02% lipid, 14.34 ± 0.01% fibre and 18.04 ± 0.09% ash was evaluated in tank system for its inclusion in milkfish diet. Five isoproteinous and isolipidic experimental diets were prepared with inclusion of 0 (control), 7 (T1), 14(T2), 21 (T3) and 28 (T4) percent of azolla meal replacing 0, 1.35, 3.32, 4.05 and 5.4% soyaprotein and fed to milkfish juveniles (15 in each tank) in triplicate for 42 days.

It was found that there was no significant difference (p<0.05) in weight gain percent upto 21% inclusion of azolla leaf meal in respect to control diet and beyond which weight percent decreased significantly (p<0.01). The feed conversion ratio increased significantly (p<0.05) at 28% level of inclusion of azolla in the diet. Body composition did not differ between the experimental groups. Hence it was concluded that azolla meal can be included upto 21% level in milkfish diet without compromising production performance.

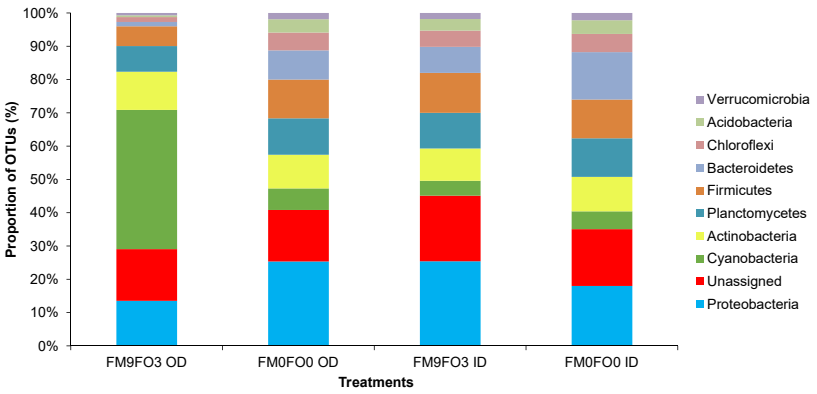
Performance of milkfish fed diet with different level of inclusion of azolla meal

Parameters	Azolla meal (0%)	Azolla meal (7%)	Azolla meal (14%)	Azolla meal (21%)	Azolla meal (28%)
Initial body wt (g)	3.62 ± 0.01	3.63 ± 0.00	3.63 ± 0.01	3.63 ± 0.01	3.63 ± 0.01
Final body wt. (g)**	6.66 ± 0.13^{b}	6.48 ± 0.02^{b}	6.44 ± 0.17^{b}	6.36 ± 0.05^{b}	5.65 ± 0.17^{a}
Wt. gain%**	84.16 ± 3.83^{b}	78.58 ± 5.46^{b}	77.68 ± 4.81^{b}	75.35 ± 1.29^{b}	55.52 ± 4.93^{a}
FCR*	2.80 ± 0.13^{b}	2.98 ± 0.24^{b}	2.87 ± 0.24^{b}	3.00 ± 0.06^{b}	3.96 ± 0.29^{a}
Survival%	93.33 ± 3.85	91.11 ± 4.44	88.89+±5.88	91.11 ± 4.44	86.67 ± 3.85

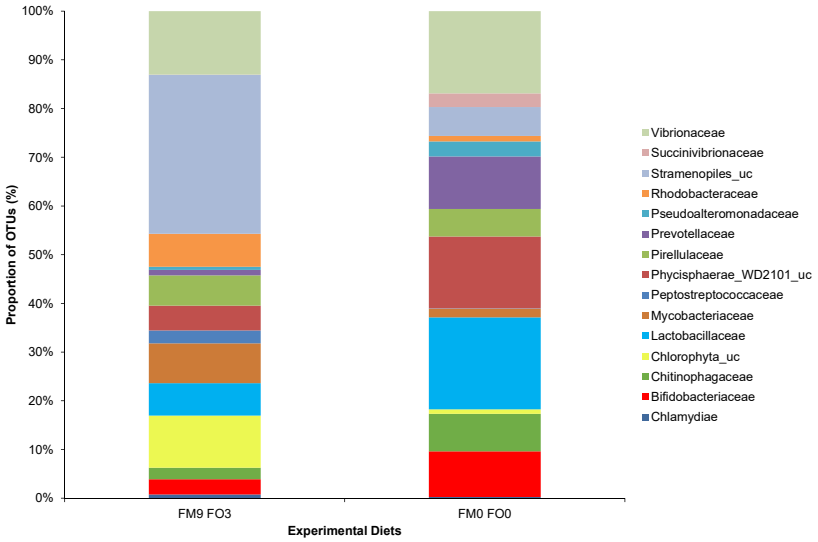
* p<0.05, ** p<0.01, values bearing different superscript in a row differ significantly

Metagenomic profiling of milkfish gut fed on zero fishmeal and fish oil based diet reared in an out-door microcosm and in-door systems

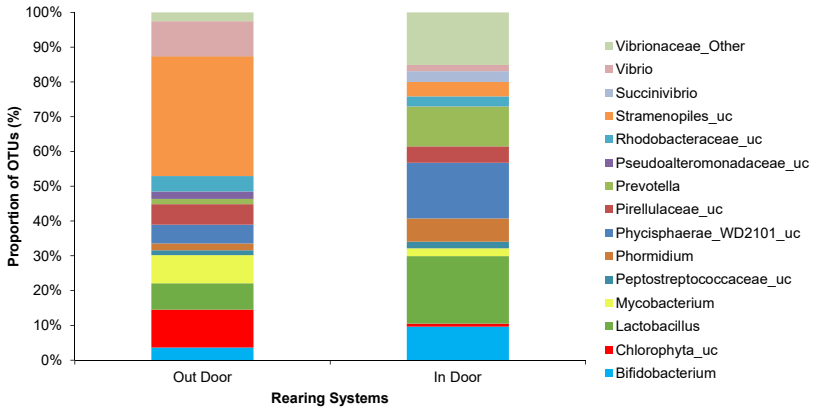
Aquaculture is mainly relying on two marine sources viz., fish meal and fish oil as protein and lipid sources, respectively for its feed preparation. Any further expansion of this sector depends on the resilience of use of alternate plant based sustainable resources. In the present study, an experimental feed is prepared by completely replacing both fish meal and fish oil and tested in herbivorous fish milkfish, *Chanos chanos*. Feeding experiment was conducted for 60 days using the hatchery produced juveniles of milkfish and reared in outdoor microcosm and indoor systems. The metagenomic DNA was isolated from the fish gut samples, 16 s metagenomic sequencing library was prepared and bioinformatics analysis was carried out. The presence of significant amounts of bacteria belonging to the family Phyla Acidobacteria in milkfish fed on zero fishmeal and fish oil diets could contribute in digestion of plant based polysaccharides due to the presence of cellulases and other fibrinolytic enzymes. The milkfish reared in out-door system are having high number of bacteria belonging to the genus Chlorophyta, Stramenopiles and Rhabdobacteriaceae indicates the high photosynthetic activity in this system.



Highly abundant phyla in milkfish gut microbiome fed with different diets reared in out-door and in-door systems



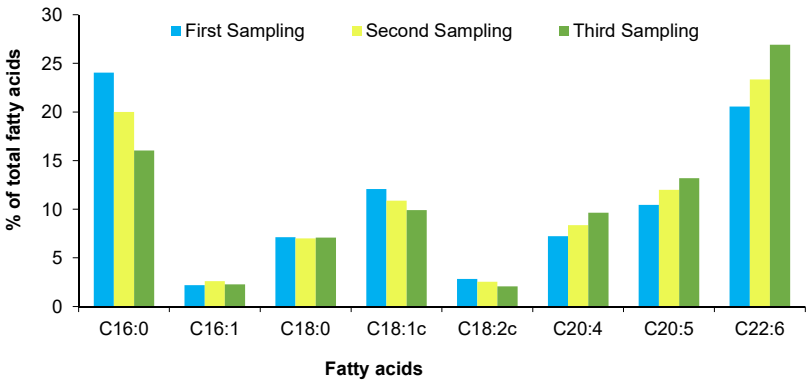
Highly abundant families in milkfish gut microbiome fed with different diets irrespective of rearing system



Highly abundant genera in milkfish gut microbiome reared in out-door and in-door systems irrespective of diets

Nutrient profiling of milt from mangrove red snapper, *Lutjanus argentimaculatus* collected at different time intervals

Sperm cells are the most unique and diverse cell type on Earth, they differ not only with their cell morphology and also have taxa-specific physiological properties associated with their diverse lipid composition. The fatty acids like DHA, ARA and EPA had an effect on the total volume of extractable milt and sperm motility. The objective of this study is to understand the chemical composition in terms of fatty acid, amino acids and mineral profiles on fertilizing ability of sperm which can be used in evaluating the milt quality in order to develop appropriate broodstock feed for red snapper. Milt samples were collected in 45 days interval. Three sampling milt were analysed



Fatty acid composition (% of total fatty acids) of red snapper milt collected at different time intervals

for its nutrient profiling. The important fatty acids like arachidonic, eicosapentaenoic and docosahexaenoic acids (% of total fatty acids) which are very crucial for milt volume and fertility increased ($p<0.05$) from 7.23 to 9.64; 10.45 to 13.19 and 20.56 to 26.91 from first milt oozing to third sampling. Except lysine all other amino acids were not significantly different in the milt samples analysed.

Effect of salt supplementation in the nursery diet of seabass on survival and growth

The seabass nursery^{Plus} feed was supplemented with 2% salt and the effect of additional supplementation of salt in the diet of seabass fry was evaluated in the nursery rearing of seabass fry reared in low saline water. Total 6,000 seabass fry was stocked in six hapas (2 × 1 × 1 M) @ 500 per hapa. Three hapas were fed with the standard diet and the three haps were fed with the 2% additional salt supplemented diet. The results revealed that salt supplementation improved the survival and decreased the shooters percentage. The results revealed that salt supplementation is beneficial in the nursery rearing of seabass under low saline conditions.

A preliminary assessment of protein and energy requirement in the diet of giant trevally *Caranx ignobilis*

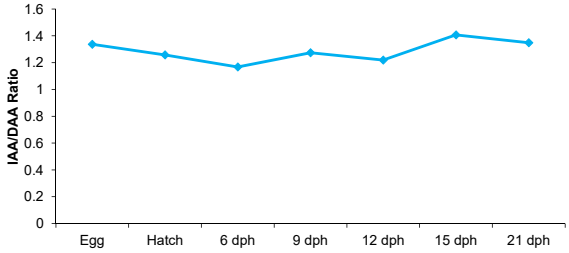
A 40-day feeding trial assessed the dietary protein and energy: protein ratio requirements for optimum growth performance of juvenile giant trevally, *Caranx ignobilis*. Practical diets were formulated to contain 35, 40 and 45% crude protein and either 8 or 12% lipid. Diets containing 35 and 40% protein, either at 8 or 12% lipid resulted in reduced growth performance and feed consumption. Results suggest that optimum growth and feeding response of juvenile giant trevally can be attained at a dietary protein level of 45% with 12% lipid.

Amino acid and fatty acid compositions of various stages of *C. chanos* larvae: Implications for early life feed formulation

The indispensable amino acids (IAA) and fatty acid profile of larval tissue has been commonly used as a good indicator of larval amino acids and fatty acid requirements. Amino acid (AA) and fatty acid composition of the whole larvae of milkfish, *C. chanos* was determined for the fertilized egg and larval ages of 0, 3, 6, 9, 12, 15 and 21 days of post hatching (dph). The total IAA contributed to 55.62% of the total AA in the egg, and reduced to 52.54% on 6 dph. Glutamic acid, valine, leucine, lysine, aspartic acid, isoleucine and arginine had accounted for more than 50% of the total AA in the egg, while glutamic acid was predominant among the dispensable AA (DAA). The reduction of fatty acids (FAs) is very high in newly hatched larvae (NHL), especially DHA (51%), ARA (26%) and EPA (24%), indicates the significance of these FAs during the embryogenesis of milkfish egg. The trend observed in different stages of AAs and FAs content indicates their requirement during the larval period and those values are to be considered while formulate feeds for larval stages of milkfish. The prepared diets with the required nutrient content would be adequate.

Nutritional potency of silk worm pupae (SWP) in the diet of *P. vannamei*

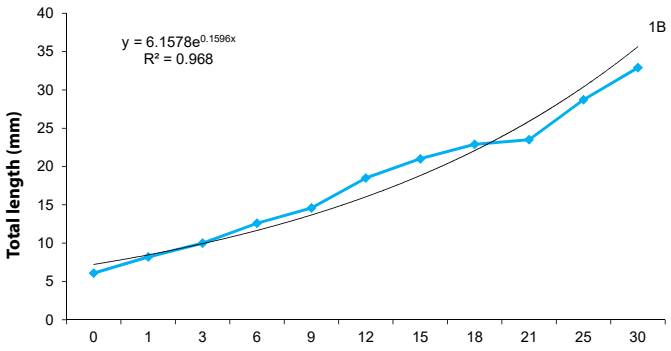
In order to ascertain the nutritional potency of the SWP, a feeding experiment was conducted by replacing fish meal with SWP meal at 0, 2.5,5 and 10% (w/w). The feeding experiment was conducted for eight weeks in the juvenile *P. vannamei* with an ABW of 1.00 ± 0.03 g with three replicates for each treatment. There was no problem in palatability of the test feeds containing varying levels of SWP meal and the test diets had been consumed without any problem. The results at the end of the experiment revealed that it can be included upto 10% in the diet of *P. vannamei*. This also revealed that SWP is a sustainable and viable alternative to fishmeal.



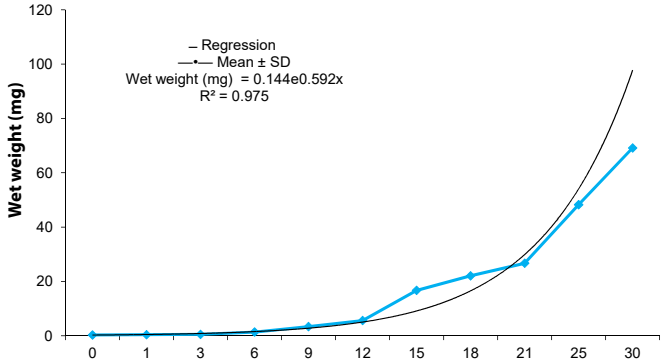
IAA/DAA ratio changes during larval development of *C. chanos*

Digestive enzyme activities during the early ontogeny of milkfish (*C. chanos*)

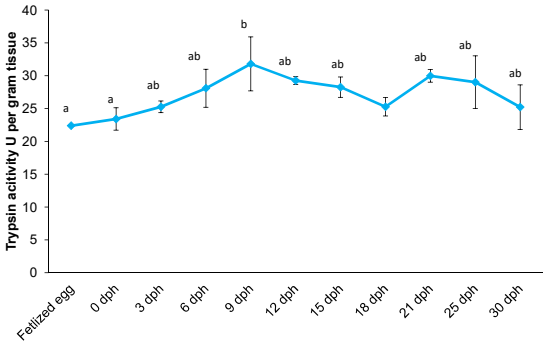
Larviculture requires full knowledge about the digestive system and nutrition; therefore, this study was intended to assess the digestive enzyme changes at different ages during the early ontogeny. The ontogenetic development of the digestive enzymes amylase, lipase, trypsin, chymotrypsin, leucine aminopeptidase and alkaline phosphatase in milkfish *C. chanos* larvae were studied. The activities of these enzymes were detected prior to exogenous feeding, but their developmental patterns differed remarkably. The growth of milkfish larvae was determined by increase in total length (TL), wet weight and SGR during initial ontogeny. TL of larvae measured to 21 dph as well as 30 dph with 23.5 ± 1.63 mm and 3.96 ± 2.11 mm length respectively. Increase in wet weight was moderate during the first 12 days (0.37 to 5.6 mg), and then growth was emphasized, obtaining a final wet weight of 69.12 mg. After 21 day of rearing specific growth rate of larvae also followed the similar trend SGR was recorded in 21 dph as well as 30 dph with 3.34 ± 0.7 and 4.27 ± 0.66% per day, respectively. Survival of milkfish larvae gradually decreased from 5 dph to 30 dph and survival was achieved in 30 dph with 48 ± 4.63%. It was evident that in early larval rearing significant reduction in survival during 6 dph to 12 dph. Survival during 20 dph –30 dph was stable. Total trypsin enzyme activity was increasing up to 9th dph and then decreasing till 18th dph again sharp increasing trend at 21st dph. After 25th dph trypsin activity was very low. These essential scientific information can be used in the design of feeding and culture protocols, provide artificial diets according to the digestive physiology.



Milkfish larvae at different dph



Milkfish larvae at different dph

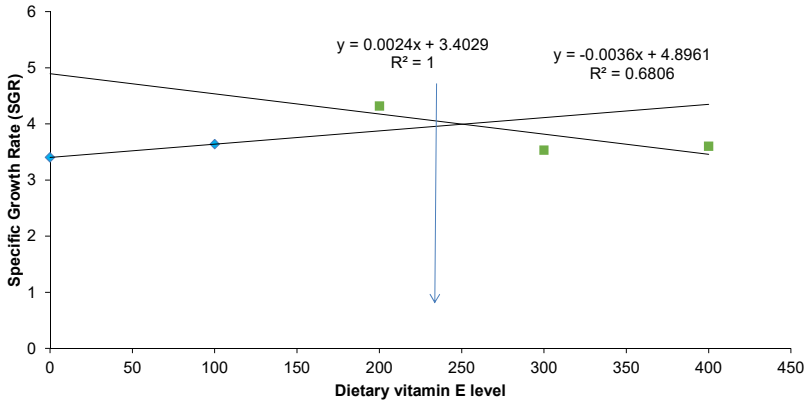


Milkfish larvae at different dph

Dietary alpha tocopherol requirement of milkfish, *C. chanos* larvae

A forty five-day study was conducted to examine the effect of dietary vitamin E (alpha tocopherol) supplementation on growth, survival and immunity of milkfish larvae. Vitamin E has become one of the most important vitamins in aquatic animal breeding and larval development. Five iso-nitrogenous and iso-energetic (580 g protein /kg and 120 g lipid /kg) experimental diets were prepared with varying levels of vitamin E supplementation at 0 (control E_0), 100 (E_{100}), 200 (E_{200}), 300 (E_{300}) and 400 (E_{400}) mg of α-tocopherol acetate per kg and fed to milkfish larvae in triplicates following a completely randomized design. Milkfish larvae fed with dietary supplementation at 200 mg /kg (E_{200}) of α-tocopherol showed enhanced ($p < 0.05$) growth performance, in terms of final body weight (371.7 ± 12.80 mg), weight gain (320.5 ± 11.18 g) and specific growth rate (4.31 ± 0.80) as compared to control diet, E_0 ($p < 0.05$). There were significant differences in the feed efficiency ratio (FER), and protein efficiency ratio (PER) among the dietary treatments. Significantly better PER was obtained in E_{200} diet (0.52 ± 0.08) followed by E_{100} (0.44 ± 0.01) while, the control (E_0) recorded lowest PER (0.40 ± 0.01). Similar trends were observed in body indices too. Alpha tocopherol content

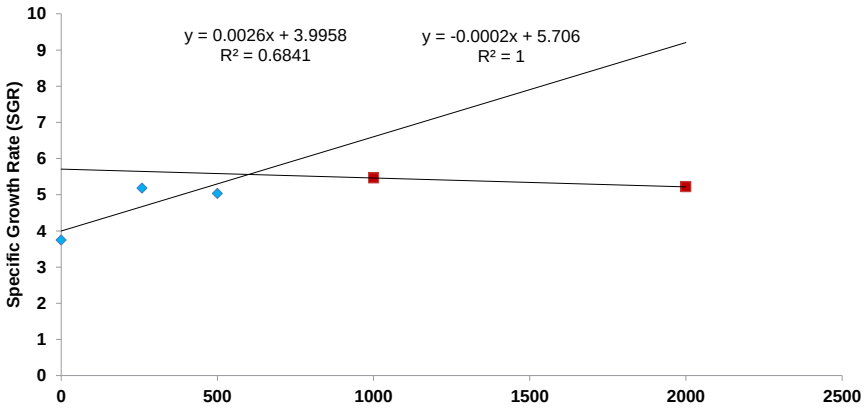
of whole larvae was linearly correlated with the dietary α-tocopherol inclusion levels. Fatty acid composition and lipid content of whole larvae were linearly increasing with respect to dietary α-tocopherol up to 300 mg/kg feed. The group fed with E_{200} showed increased RBC ($p<0.05$) and WBC ($p<0.01$) counts as compared to that of other groups. Statistically ($p<0.01$) decreasing trend was observed in both MCV and MCH among the α-tocopherol fed groups when compared to control. Total lymphocyte count showed increasing trend up to E_{300} but got reduced at E_{400} ($p<0.05$). Whereas, the myelocyte count was less among the E_{200} and E_{300} groups compared to that of other groups ($p<0.01$) The broken line regression analysis clearly revealed that the dietary vitamin E requirement for optimal growth of *C. chanos* larvae was 248.8 mg α-tocopherol acetate/kg feed. The results of the present study provide the baseline scientific information in formulation of cost-effective α-tocopherol acetate incorporated diets for milkfish, *C. chanos* larvae.



Broken-line regression analysis of SGR in milkfish larvae fed with graded levels of dietary α-tocopherol

Dietary ascorbic acid requirement of milkfish, *C. chanos* larvae

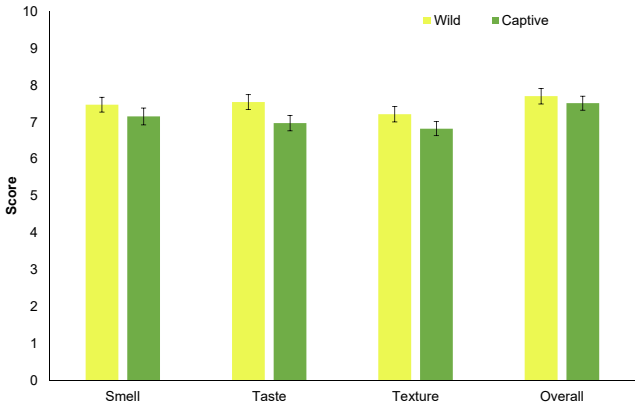
Vitamin C is a critical nutrient for the growth and development of fish larvae. A 45 days feeding experiment was conducted to examine the effect of dietary ascorbic acid (AA) supplementation on the growth of milkfish, *C. chanos* larvae. Five iso-nitrogenous and iso-lipidic (580 g protein/kg and 120 g lipid/kg) experimental diets were prepared with varying level of ascorbic acid supplementation at 0 (AA_0), 250 (AA_{250}), 500 (AA_{500}), 1,000 (AA_{1000}) and 2,000 (AA_{2000}) mg ascorbic acid (L-ascorbyl-2-polyphosphate) equivalent/kg diet. Milkfish larvae with average body weight of 25.18 ± 3.23 mg were stocked @ 1 larva/l in triplicate following a completely randomized design. The results at the end of the experiment of 45 days revealed that milkfish fed with 500 and 1,000 mg vitamin C/kg feed showed significantly better ($p < 0.05$) performance in terms of final body weight, weight gain, SGR and survival rate. The group fed without vitamin C supplementation (L_0) showed poor growth performance and lower survival compared to other treatments. Broken-line regression analysis revealed that the dietary vitamin C requirement for the growth of *C. chanos* larvae is 855.58 mg AA/kg. The results will be helpful for the formulation of cost-effective ascorbic acid incorporated diets for milkfish larvae.



Broken-line regression analysis of SGR in milkfish larvae fed with graded levels of dietary ascorbic acid

Comparative sensory evaluation of pond reared and wild stock of hilsa (*Tenualosa ilisha*)

The sensory evaluation test was carried out using nine-point hedonic scale for comparing taste, aroma and texture of muscle between captive stock and wild stock of hilsa. A panel of 50 evaluators were assigned for this test. Two types of cooked items, i.e., steamed hilsa and hilsa curry of the fish samples were prepared. It was observed that there was no significant difference in smell, taste and texture of muscle between captive and wild stock of hilsa.



Sensory evaluation data showing the comparison between wild and captive hilsa

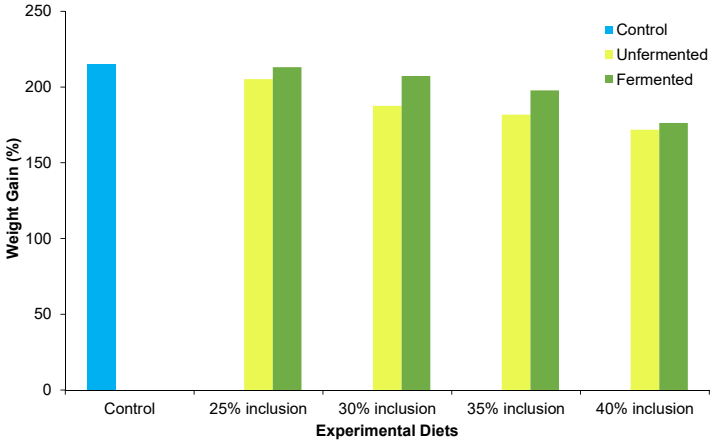
Development of grow-out and broodstock feed for hilsa

Formulated feed for grow-out (CP- 35% and EE- 12%) and broodstock (CP- 39.5% and EE- 15%) rearing of hilsa have been developed and shared with partner institutes for testing in pond culture. Both the feeds showed promising result in pond culture.

Hilsa grow-out feed shared with partner institute, ICAR-CIFRI

Solid state fermentation of soybean meal with yeast, *Saccharomyces cerevisiae* on growth and nutrient utilization in *P. vannamei*

Commercial solvent extracted soybean meal (SBM) was fermented with yeast, *S. cerevisiae* at 60-65% moisture for three days and was evaluated as a fishmeal alternative in the diet of *P. vannamei*. A 45-days' feeding trail was performed using nine iso-nitrogenous and iso-lipidic diets in 500 l fiber reinforced tanks. Nine iso-nitrogenous diets were formulated for each ingredient by replacing fishmeal (w/w) using untreated/fermented SBM (200, 250, 300, 350 and 400 g/kg). Each diet was randomly allotted to three tanks with 20 shrimp per tank. Results revealed that the inclusion of fermented SBM up to 350 g/kg had no significant difference in growth compared to control, whereas, the inclusion was limited to 250 g/kg for the unfermented SBM. The feed efficiency measures were better with fermented ingredients compared to the respective level of untreated ingredients. The results indicate that the fungal fermented ingredients could be used as a potential protein sources rather than untreated materials in the diet of *P. vannamei*.

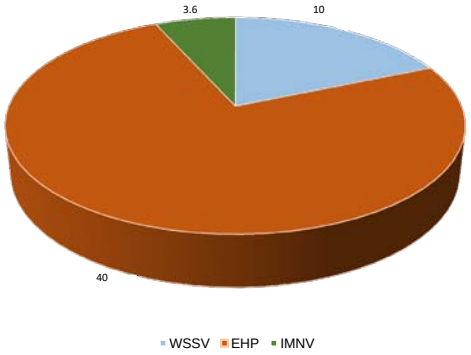


Performance of *P. vannamei* with fermented SBM

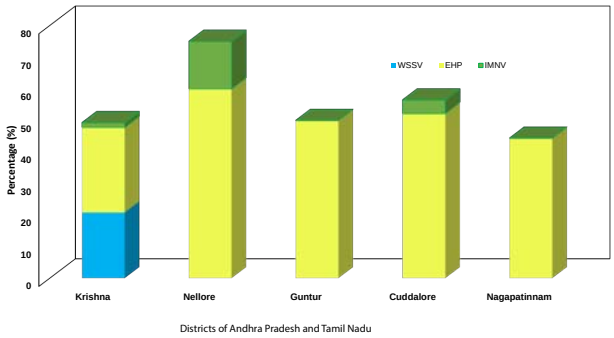
Aquatic Animal Health

Disease surveillance of brackishwater shellfish and finfish

Disease surveillance is an important component in any disease control programme. It is an important activity that provides the elementary information about the disease spread in the country and helps to chart an effective control programme and paving the way for eradication of the disease. During the year 2021-2022, disease surveillance was carried out in about 140 *Penaeus vannamei* shrimp farms in the approved districts of Tamil Nadu and Andhra Pradesh. Three diseases i.e. Hepatic microsporidiosis (EHP), White spot syndrome (WSSV) and Infectious Myonecrosis disease (IMNV) were prevalent more in shrimp during the year 2021. Of the three diseases, EHP prevalence was found to be 40% and followed by WSSV where in 10% farms were affected and IMNV prevalence was found to be 3.6%. All the districts (Krishna, Guntur and Nellore in Andhra Pradesh; Nagapattinam and Cuddalore in Tamil Nadu) reported EHP, Nellore had highest prevalence while Krishna district had least prevalence of EHP. Three diseases have been reported from Krishna district. Expect Nagapattinam and Guntur, IMNV has been reported from all the districts. All the exotic pathogens like AHPND, NHPB, TSV and YHV were not detected in any of these farms. One *vannamei* farm and tiger shrimp farm (*Penaeus monodon*) at Tamil Nadu reported mortality due to unknown reason as the samples were not positive for any of the known pathogens. One finfish farm culturing seabass at Tamil Nadu found positive for viral nervous necrosis. An emerging pathogen, Mud Crab Reovirus (MCRV) was reported from a mud crab farm at Tamil Nadu. Samples received from farmers of Gujarat, Haryana and Kerala reported positive for diseases IMNV, EHP and WSSV.



Overall disease prevalence (%) in Tamil Nadu and Andhra Pradesh



Disease prevalence in various districts of Tamil Nadu and Andhra Pradesh

Comparative effect of different sanitizers on shrimp white spot syndrome virus (WSSV) inactivation in experimental and simulated field conditions

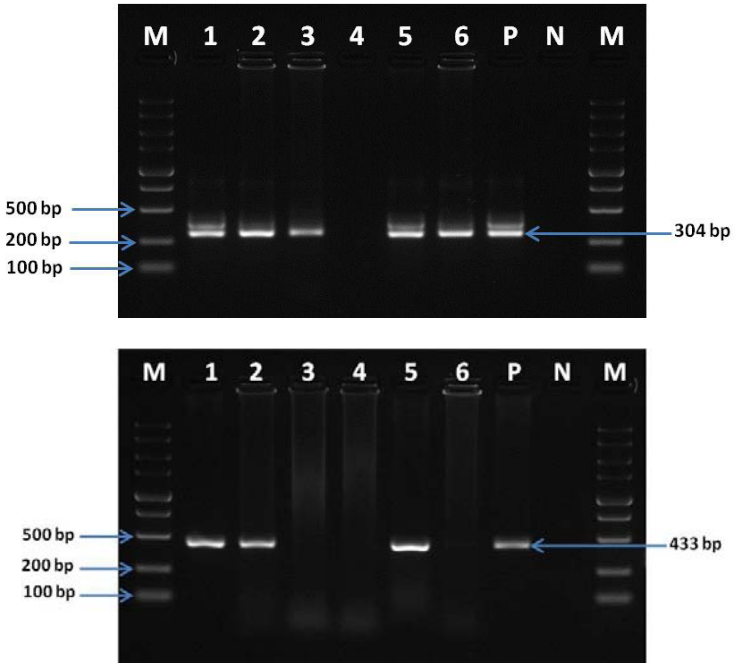
Effective concentrations of different sanitizers were evaluated for total prevention of WSSV. It was demonstrated how the concentrations can vary based on different laboratory or field conditions and also based on the pathogen availablity in the environment. In this way, the right concentrations can be used to eradicate the pathogen and at the same time without putting much pressure on the aquatic environment (soil or water). This was done by various methods, (1) *In vitro* method wherein sanitizer at desired concentration added with equal volume of WSSV filtered particle (1:1) and incubated for 1 h at RT, then it was injected to live virus free animals and mortality was observed. (2) Viral particles in sea water, in which WSSV filtered particles were added to filtered sea water (~10^7/ml) and sanitizers were added. Kept for 48 h and then animals were released to the treated water. Mortality was observed thereafter. (3) WSSV infected cut shrimp pieces in sea water, this was done similar to the above where in infected animal remnants were directly used. (4) WSSV particle in soil based, thereafter virus particle and sanitizers were added and left for 48 h in a tub containing soil base and sea water. Then healthy shrimp were added to it and mortality was observed. (5) WSSV infected shrimp cut pieces in soil based, similar to the above, direct infected animal remnants were used for the study. The comprehensive results were given in the table which shows the ideal concentration of various sanitizer against WSSV infection. Further, these concentrations can prolong the survival rate of the shrimp. Among all the sanitizer studied BKC found to be more effective against WSSV infection.

Effective concentration of various sanitizer against WSSV infection

S.No	Name of sanitizers	Effective concentration (ppm)				
		In vitro	WSSV particles in sea water	WSSV infected shrimp cut pieces in water	WSSV particle in soil based	WSSV infected shrimp cut pieces in soil based
1	Chlorine	5	5	10	15	20
2	Formalin	250	250	300	300	350
3	BKC	4	4	10	8	18
4	Iodophore	60	60	75	75	80
5	$KMnO_4$	150	150	160	160	175

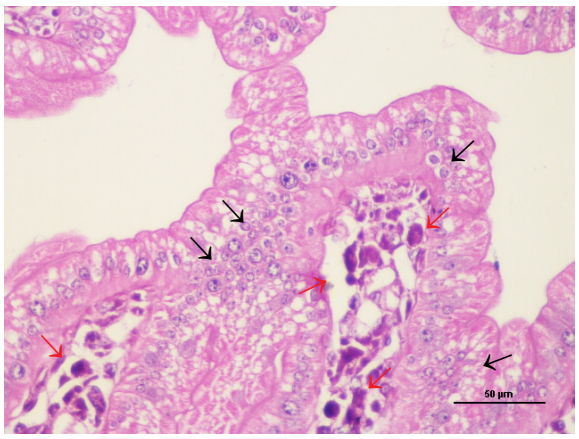
Mud Crab Reovirus (MCRV) detected from *Scylla serrata* farm from Tamil Nadu

Scylla serrata (Forskal), commonly known as mud crab is the most prevalent species in India, has high demand and commercial value both in international and domestic markets. Mud crabs are generally considered hardy animals. Very recently mortalities due to Mud Crab Reovirus (MCRV) in wild and farmed *Scylla* species have been documented from India. The disease condition termed as "Sleeping disease (SD)", in 2004 in China caused high mortality to a tune of about 70% in cultured mud crab. The causative virus was isolated first in 2007 and is an icosahedral, non-enveloped, double-stranded RNA virus of 70 nm with 24.464 kb segmented genome. MCRV infection in *S. serrata* farm in Tamil Nadu was diagnosed recently. The animals weighed 3-5 g, at 30 – 40 days of culture period experienced 70% mass mortalities with in a fortnight period. The morbid animals found weak, off feed, a grey coloration and no response to external stimuli. Internally displayed an atrophied hepatopancreas and empty guts. On RT-PCR screening, MCRV detected in gills and hepatopancreatic tissues. Mud crab fattening and farming activities vastly depends on wild seed or water crabs' collection. Therefore, it is advisable to stock PCR negative seeds for a successful culture.

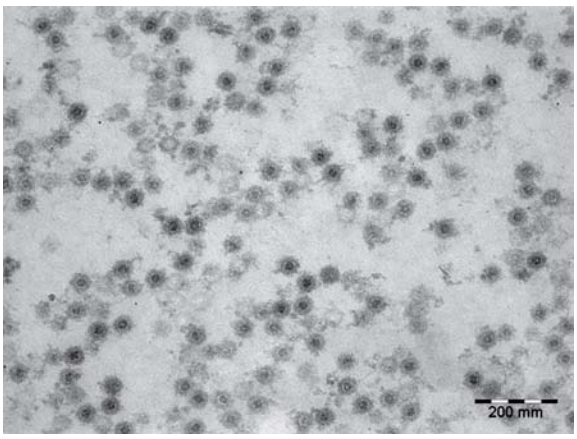


Detection of MCRV in mud crab gill, hepatopancreas tissue samples by nested RT-PCR

MCRV infected mud crab grey in colour



Hepatopancreas of MCRV infected mud crab showing inclusion bodies and necrosis of the connective tissue – H&E-40x



Electron microscopy of MCRV infected mud crab hepatopancreas showing viral particles – Lead citrate and uranyl acetate

Hepatic microsporidiosis, major pathogen of current importance in shrimp aquaculture

Risk factors associated with *Enterocytozoon hepatopenaei* (EHP) infection in *Penaeus vannamei* grow-out farms

Identifying risk factors in any disease can be instructive and assist in mitigating disease impacts in a particular farming region. It aids in formulating devise management strategies that are effective in reducing the impact of aquatic animal diseases. The risk factors associated with EHP infection in *P. vannamei* grow-out farms was investigated in samples and data collected from 115 shrimp farms [59 from Andhra Pradesh (Nellore, Guntur), 37 from Tamil Nadu (Cuddalore, Thiruvallur, Chengalpet, Nagapattinam) and 19 from Gujarat (Navsari)]. The factors such as farm location, culture period, previous culture history, seed source and health, pond preparation, water management, culture method, feed and other inputs, biosecurity measures, water quality parameters and occurrences of other diseases and syndromes were collected and analyzed. The Odd's ratio was calculated to assess the risk factors association with EHP incidences using Epi InfoTM online software. The factors such as EHP PCR tested seeds, drying + chlorination and reservoir were significantly reduced the EHP incidences in shrimp farms. Whereas, factors such as previous history of white faecal syndrome, previous history of EHP and continuous culture were significantly associated with the increase in the EHP incidences. Consequently, all other factors were not significantly associated with EHP occurrences in shrimp farms. Among major diseases, no disease is significantly associated with the incidences of EHP. Whereas, among syndromes the white feces syndrome (WFS) and stunted growth were significantly associated with increase in the EHP incidences.

Comparison of breeding efficiency in EHP-positive and EHP-negative *Penaeus vannamei* broodstock

Feed plays an important role in maintaining the SPF status of shrimp broodstock. Live polychaete diet supplemented as maturation diet could be the source of EHP infection in SPF shrimp broodstock in hatcheries. Earlier studies revealed that gonad tissues of male and female shrimp were found negative for EHP infection, while being positive in hepatopancreatic tissues. A study was conducted to assess the effect of EHP-infection in maturation of shrimp broodstock and the breeding efficiency in comparison to uninfected broodstock as control. In order to know the disease transmission through feed, and it's influence on production performance an experiment was conducted in *P. vannamei* broodstock (n=400 pairs), with male 38 g and female 43-45 g, 17-18 cm length. Biosecured feed (frozen squid, clams, oyster, artemia biomass, polychaetes and pellet feed) were fed to 200 pairs of broodstock up to ten cycles of spawning. Similarly, another 200 pairs of broodstock were fed with non-biosecured feeds (frozen squid, clams, oyster, artemia biomass, pellet feed and live polychaetes). The faecal samples of broodstock fed with non-biosecured feed gave EHP positive by sixth spawning onwards and, thereafter it remained positive till the study period i.e., up to 10th spawning cycle. Broodstock from biosecured feeding group gave more egg and nauplii production during each cycle, whereas non biosecured feed give less production. The highest nauplii production observed was 4.21 lakh in bio secured, whereas 3.36 lakh in non-bio secured feeding group. There was statistically highly significant difference observed between the biosecured and non-biosecured fed group of broodstock in average egg/shrimp,

average nauplii/shrimp production and fertility percentage. The study concludes that EHP infection occurs through ingestion of contaminated live polychaetes used in the test group. Hence it is advisable to feed frozen polychaetes to broodstock. The study also showed that the broodstock which received the biosecured feed had slight extended spawning cycle where as non-biosecured fed broodstock had short spawning cycle. However, hatching percentage and duration of spawning did not differ significantly between the two treatment groups.

Comparison of breeding efficiency in EHP-positive and EHP-negative *Penaeus vannamei* broodstock

Biosecured feed (EHP free broodstock)

No. of Cycle	Egg development (%)	Mating (%)	Average egg/ shrimp	Average nauplii/ shrimp	Fertility (%)	Hatching (%)	Duration of spawning (days)
1	18.4	14.4	2.7	2.3	83	87	7
2	21.7	16.6	3.5	2.95	84	85	6
3	21.0	14.4	3.5	3.2	85	89	8
4	20.8	15.9	3.76	3.49	86	92	6
5	20.5	16.3	3.91	3.56	85	88	6
6	22.0	17.3	3.94	3.66	87	92	6
7	21.1	18.3	4.0	3.86	90	94	5
8	19.2	15.5	4.3	4.0	87	93	7
9	20.5	17.5	4.69	4.21	89	90	6
10	21.0	18.9	4.52	3.93	88	87	5

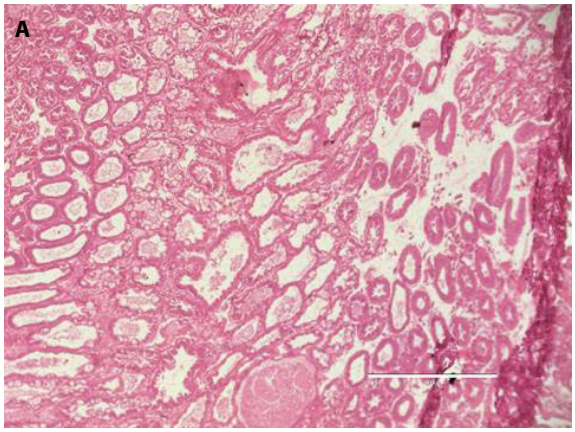
Non-Biosecured feed (EHP-positive broodstock)

No. of Cycle	Egg development (%)	Mating (%)	Average egg/ shrimp	Average nauplii/ shrimp	Fertility (%)	Hatching (%)	Duration of spawning (days)
1	15.8	13.0	2.1	1.8	79	85	8
2	21.4	18.3	2.45	2.17	81	88	6
3	19.0	18.3	2.6	2.4	83	91	5
4	17.6	17.0	2.92	2.8	84	93	6
5	21.7	20.6	3.0	2.82	85	92	5
6	19.4	19.0	3.0	2.84	85	90	5
7	19.0	18.3	3.17	3.0	87	94	5
8	19.4	18.6	3.22	3.0	86	93	5
9	20.1	19.1	3.4	3.18	87	93	5
10	20.3	19.6	3.68	3.36	87	91	6

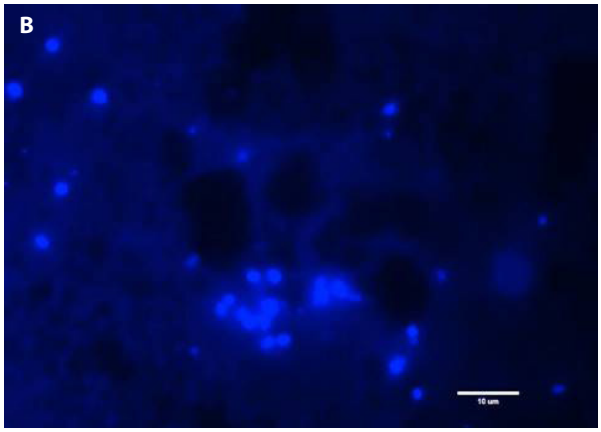
Investigation of vertical transmission of EHP in brooder shrimp

Enterocytozoon hepatopenaei emergence and epizootics are considered as a severe threat to the global shrimp aquaculture. EHP can spread the disease horizontally to the shrimp by cannibalism, oral-fecal, infected water and soil. But the vertical mode of EHP transmission is largely unknown and was studied in adult challenged *P. vannamei* 30 g shrimp, reared up to 20 days.

EHP challenged/shrimp observed with matured ovaries

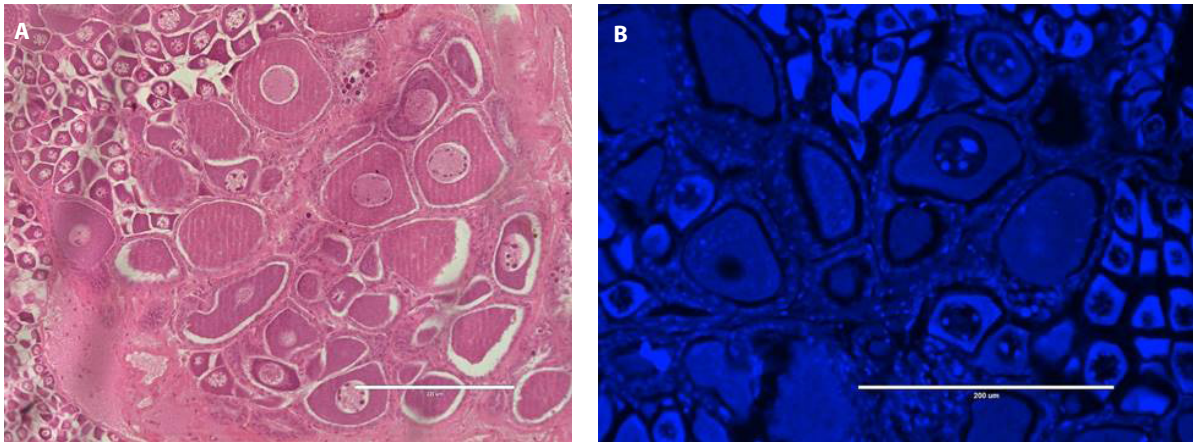


A. Affected hepatopancreas (HP) with severe necrosis in epithelilal cells and tubules and dilated HP tubules-H&E 4x



B. Histology sections stained with calcoflour white clearly show the spore clumps in epithelial cell cytoplasm

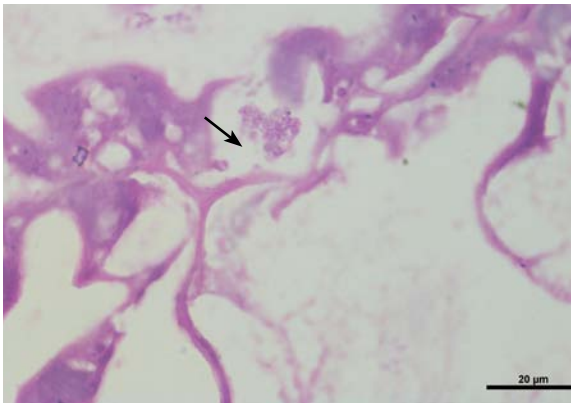
The challenged shrimp were induced maturation by eye stalk ablation and tissues such as hepatopancreas and ovaries were collected and tested for EHP by microscopy and PCR. The hepatopancreas found positive for EHP by wet mount, histology, *in-situ* hybridization and PCR. Histology sections stained with calcoflour white clearly showed the spore clumps in epithelial cell cytoplasm. Whereas, ovaries gave negative for EHP by wet mount, histology, *in-situ* hybridization and PCR. Hence, it can be concluded that the vertical transmission of EHP is unlikely in experimental conditions. Still, further detail research is warranted to arrive at a conclusion.



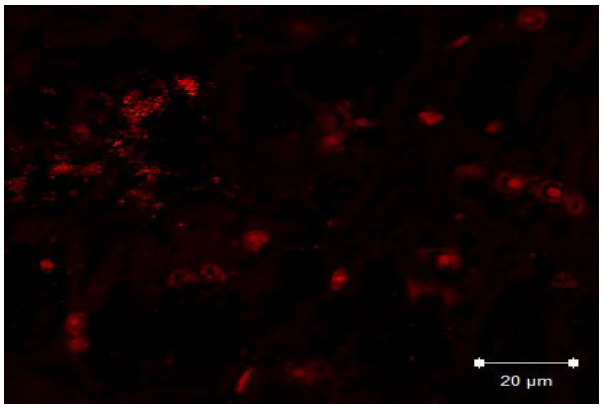
A, B- Histology section of ovaries stained with H & E and Calcoflour white

Molecular pathogenesis and pathology of microsporidian parasite *Enterocytozoon hepatopenaei* in Pacific white shrimp (*Penaeus vannamei*)

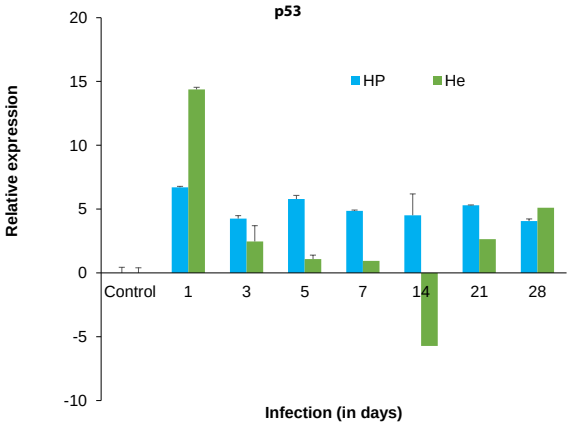
Hepatic microsporidiosis (HPM) caused by *E. hepatopenaei*, a microsporidian parasite is causing panic to shrimp farmers. It is highly essential to understand the basic pathology of this pathogen at cellular level in shrimp. To understand the sequential changes, an experiment was conducted for 28 days in *P. vannamei* shrimp (n=150) of 3-6 g to unravel the molecular pathogenesis and pathology of EHP. The shrimp were grouped into control and challenge group, which was fed with infected EHP. Sampling done at 1, 3, 5, 7, 14, 21 and 28 day of infection (DOI) and test like physio morphological studies, histopathology, PCR, expression of genes like p53, caspase and ProPO, scanning electron microscopy (SEM), transmission electron microscopy and confocal microscopy (CM) were done. The shrimp became PCR positive by 3rd DOI. Histopathological analysis revealed HP tubular epithelial damage with necrosis of tubules from 3 DOI. Posterior HP affected most than the anterior portion. Confocal microscopy showed presence of spores inside HP tubules from 3rd to14th DOI whereas 21st to 28th DOI spores seen dispersed in the lumen. SEM analysis revealed presence of spore in the tubule from14th DOI. The apoptotic gene caspase 2, 4 were expressed more in HP while caspase 3, 5 in haemolymph. p53 and ProPo were upregulated initial DOI and down regulated during the later days. The study indicated that hepatopancreas is the main target organ for this infection and HP rejuvenating drugs if given during early stage of infection can facilitate HP to regain its normal architecture and thereby the animal health.



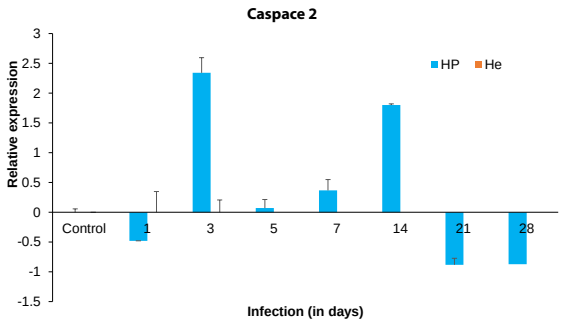
EHP spores in foregut of the HP on 28 DOI– H&E 100x



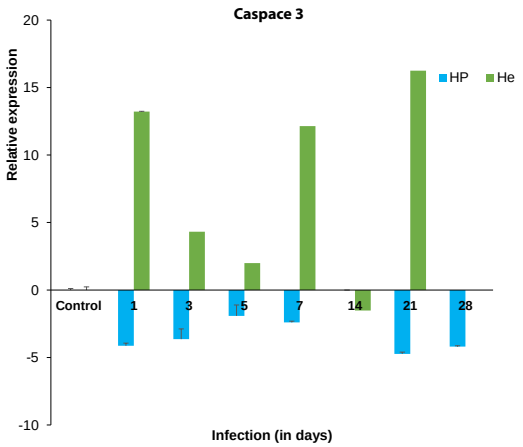
EHP spores in foregut of the HP on 28 DOI– PI 100x



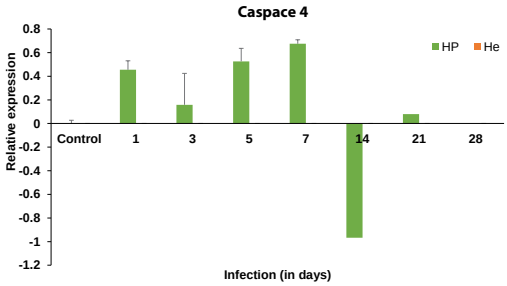
Expression of p53 genes in HP and HE



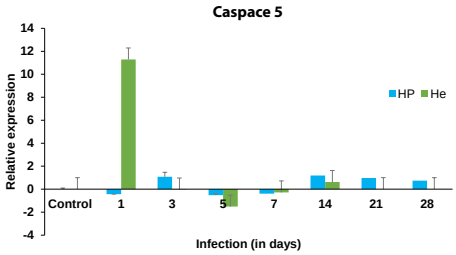
Expression of Caspase 2 genes in HP and HE



Expression of Caspase 3 genes in HP and HE



Expression of Caspase 4 genes in HP and HE

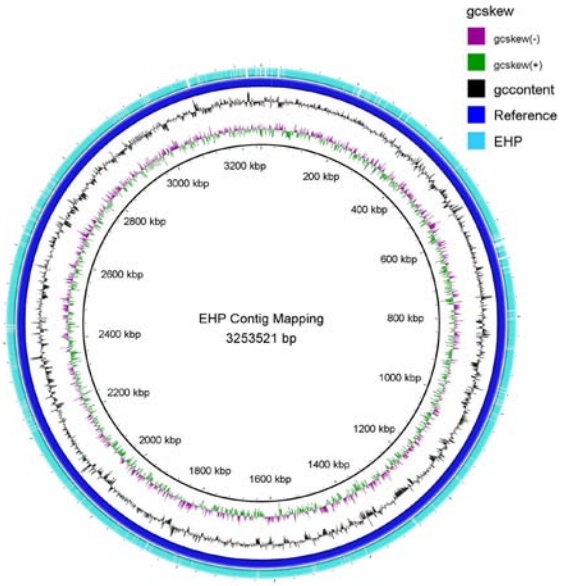


Expression of Caspase 5 genes in HP and HE

Whole genome sequencing of *Enterocytozoon hepatopenaei*

Most outbreak management protocols of EHP, often fail to distinguish closely related outbreak strains or detect virulence/resistance features. This is largely due to the limited genomic resolution of conventional molecular methods and the target-specific nature of outbreak analysis approaches, to overcome these caveats of conventional outbreak management, novel technologies that provide full genetic information of the entire pathogen genome are needed. With this aspect the study on whole genome of EHP was made and was sequenced.

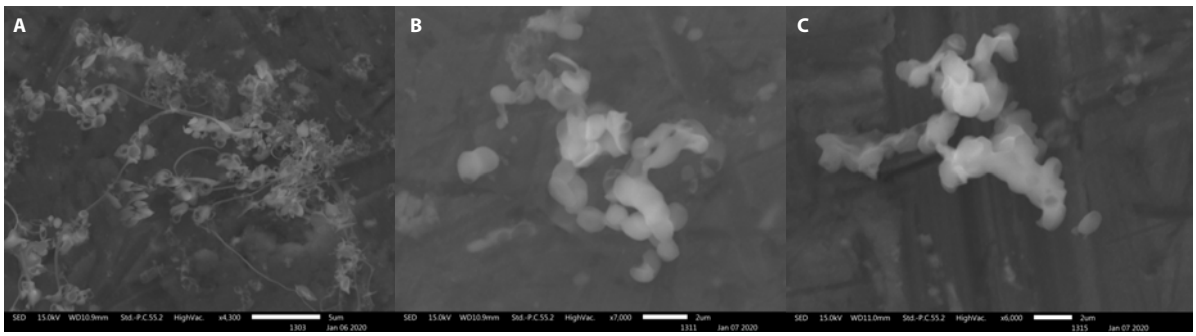
The whole genome sequencing of EHP was completed with illumina platform. The paired-end library was prepared using Truseq Nano DNA Library Prep Kit and the sequencing on illumina Nextseq 500 platform using 2 × 150 bp PE chemistry. Five million paired end reads were used to assemble the genome using SPAdes genome assembler with default parameters and resulted in the longest scaffold of 118181 bp length the scaffold N50 was 18395 with a total length of 3.92 mega-bases. In preliminary assembling, the scaffolds were further filtered based on a minimum length of 1750 bps, resulting in 354 scaffolds with a total length of 3.25 mega-bases and an N50 of 26934. Thus, the genome similarity with earlier reported scaffold level assembly of EHP genome revealed 99.8% similarity.



Draft whole genome of *Enterocytozoon hepatopenaei*

Development of therapeutics for EHP control

Prophylactic and therapeutic protocols for treatment and control of EHP are very limited currently and the present study was made to develop prophylactic strategies for the treatment of EHP. Spore germination/extrusion is an osmotic event through which the infective material polar tubule pierces the host cell and makes entry into cytoplasm.



Control spores observed with sporulation (A), Spores treated with nifedipine (B), metronidazole (C) observed with no sporulation

Different chemical and biological biocide drugs were evaluated for anti-EHP spore extrusion activity. The biological drug biocide such as Tricholin- LF (*Trichoderma viridae*) and chemical drugs such as Fenbendazole, ketoconazole, nifedipine, and metronidazole were evaluated for anti-EHP spore extrusion activity. The EHP spores 10^4/ul was incubated with different drugs and incubated for overnight. Of which, nifedipine and metronidazole completely inhibited the EHP spore germination. Further, these different drugs need to be tested *in vivo* before being used in shrimp.

National survey on chemicals, biologicals and veterinary medicinal products (VMPs) used in aquaculture

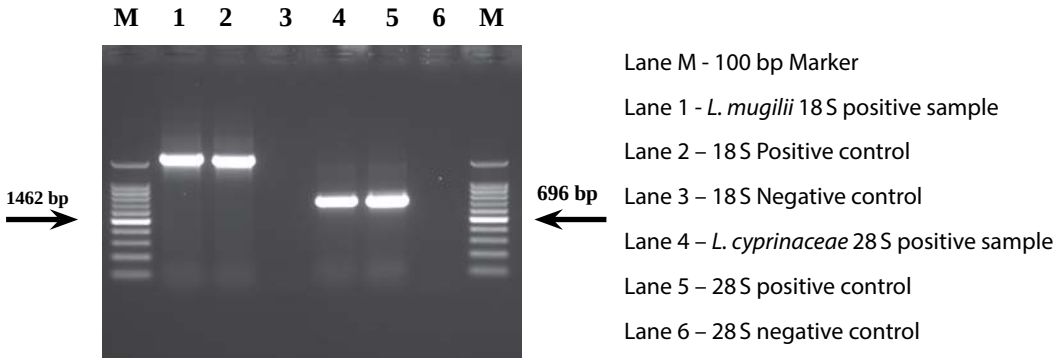
In order to get the real feedback from aqua shrimp farmers and to build confidence among the exporters a questionnaire-based nationwide survey conducted covering aquaculture farms (n=2936) producing carps, tilapia, pangasius and rainbow trout in freshwater and shrimp in brackishwater estimated the use of 52 different types of inputs which included disinfectants (597 g/t), probiotics (2.28 kg/t), environmental modifiers (22.82 kg/t), nutritional supplements (1.96 kg/t), natural anti-infective agents (293 g/t), herbicide and piscicides (844 g/t), antibiotics (2 mg PCU/t), antifungal (4 mg PCU/t), and antiparasitic (14 mg PCU/t) of production. The bulk of these inputs was used for soil and water quality improvement and had low environmental and human safety concerns. Redundancy analysis revealed a significant association between the number of products used and stocking density. Results of the study indicated greater reliance of farmers on the use of disinfectants for biosecurity, nutritional supplements for enhanced growth and environmental modifiers for maintaining soil and water quality in culture systems. The use of antimicrobial agents in Indian aquaculture was lower in comparison to reported usage in the global food animal production systems. Implementation of national regulatory guidelines in harmony with the international standards is essential for safe and effective use of chemicals and VMPs inputs for sustainable aquaculture.

Quantity of chemicals, biologicals and VMPs used in each farm group (kg/t of harvest)

Classification	IMC	IMC+	Pangasius	Rainbow trout	shrimp	Average
Disinfectants	0.967	1.223	0.291	0.184	0.320	0.597
Probiotics	1.841	0.576	2.900	0.000	6.100	2.283
Environmental modifiers	31.230	40.820	16.570	0.000	25.490	22.822
Nutritional supplements	2.793	2.480	4.170	0.000	0.350	1.959
Antibiotics	0.002	0.004	0.004	0.000	0.000	0.002
Antifungal products	0.006	0.000	0.015	0.000	0.000	0.004
Antiparasitic agents	0.024	0.006	0.041	0.000	0.000	0.014
Natural anti-infective agents	0.009	0.076	0.000	1.381	0.000	0.293
Herbicides and piscicides	0.011	4.211	0.000	0.000	0.000	0.844

Isolation and identification of parasitic infestations in brackishwater candidate fish species

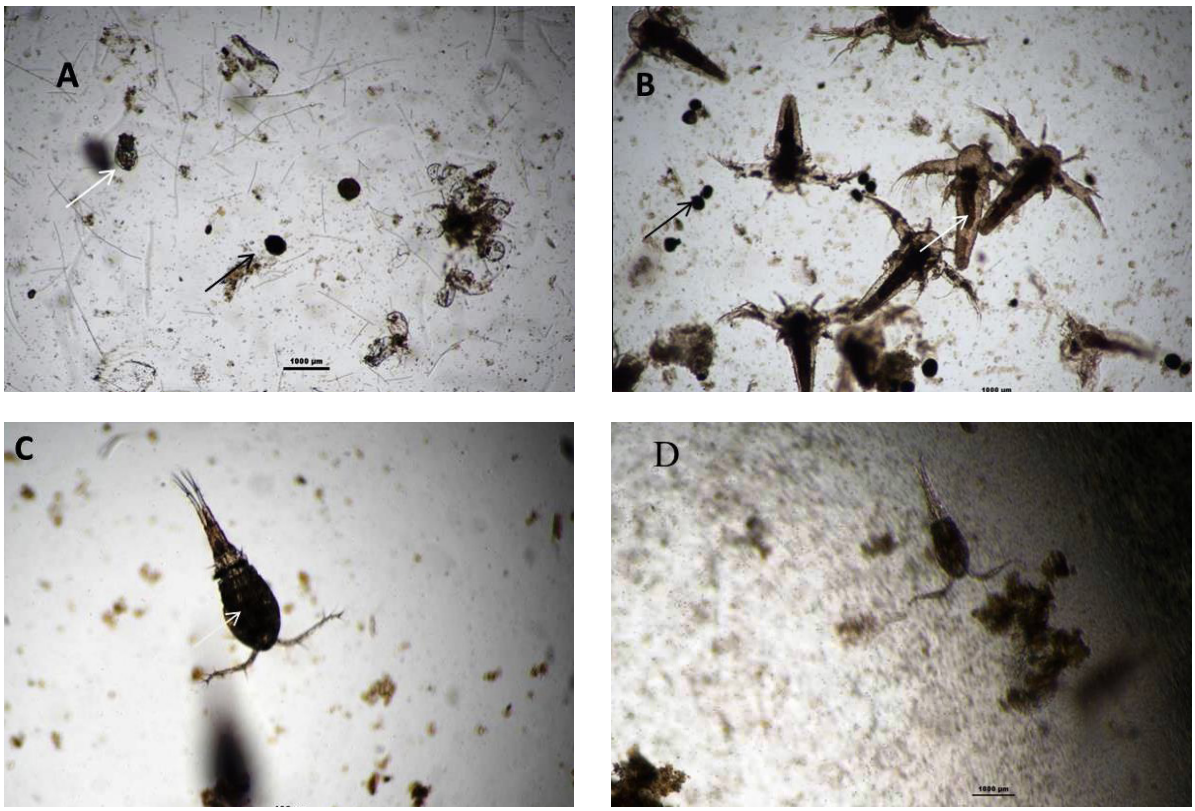
Aquaculture is the fastest growing food industry in the world. The intensification of culture has led to increase in quantum of diseases especially due to parasites thereby production and economic losses. Hence, parasitic infestations were screened among the varying sizes of farmed Finfish species from Tamil Nadu, Puducherry, Kerala, Andhra Pradesh and Maharashtra. Ten major parasitic infestations such as *Argulus* spp., *Caligus* spp., *Lernaea* spp., *Cymothoa* spp., *Lernanthropsis* spp., *Amyloodinium* spp., Ancyrocephalid, *Zeylanicobdella* spp. *Anisakis* spp. and *Octolasmis* spp. were collected from different fish species and identified morphologically, but no parasitic infection was found in *M. argenteus* and *C. chanos*. *Lernaea cyprinaceae* and *Lernanthropsis mugilii* were identified from Asian seabass, *L. calcarifer* and grey mullet, *M. cephalus* based on 28 S rDNA and 18 S rDNA fragments molecular identification, respectively.



PCR identification of parasitic infestations in brackishwater candidate fish species

Biocontrol measures for *Amyloodinium* infection in closed systems: Experimental foraging of *Amyloodinium* tomonts using live feeds

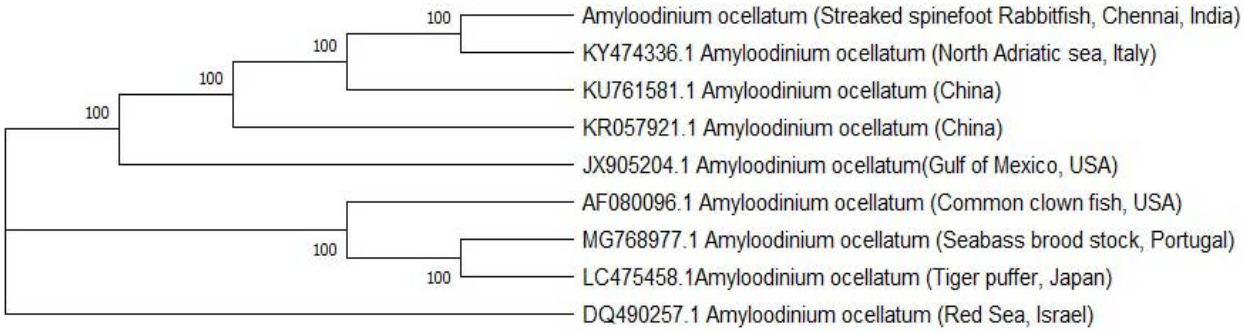
This study was undertaken to eliminate and manage the parasitic stages of *Amyloodinum* in live fishes. The foraging capacity of the various zooplankton commonly employed in larval rearing of marine larvae can be used as possible bio controllers to prey on the stages of *Amyloodinium*. Rotifers, *Artemia* naupli and copepod adults were chosen for this experiment. The gills collected from previous mortalities preserved in 1 × PBS and stored in 4°C were used. Tomonts (n=100) were distributed in Petri plates in triplicates and all the three predators (10/ml) were introduced. No other feeds were added except in control plate they were added with green algae for foraging. Plates were incubated overnight and observed under light microscope after 18 h. All live feeds foraged the tomonts, however, *Artemia* naupli found dead with full gut. The copepods and rotifers were foraging on tomonts and surviving in the medium. At the end of third day, only copepods were surviving in experiment and control. We suggest that copepods could forage, digest and survive on tomonts quite similar to its natural feeds such as green algae and can be used as an agent to biocontrol *Amyloodnium* tomonts, however their efficiency in feeding on dinospores are yet to be explored.



Microscopic observation on foraging of rotifer, *Artemia* naupli and copepod adults on *Amyloodinium* tomonts. A. Rotifers B. *Artemia* naupli C. Copepod adults D. Control copepod with green algae. Arrows in white indicates the live feed organisms feeding on cysts and arrows in black indicate the free cysts ungrazed

Amyloodinium ocellatum isolate from India has 100 percent sequence similarity to other reported isolates from the marine fish

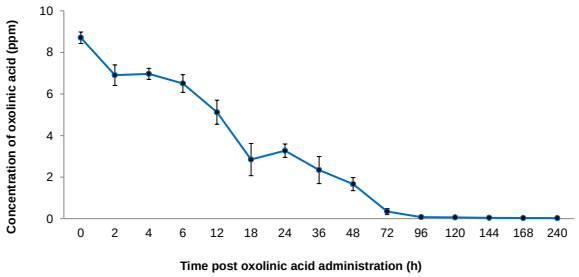
A phylogenetic tree was constructed to examine the similarity of various *Amyloodinium* isolates reported from different fish species and the locations. *Amyloodinium* sequences (n=9) were retrieved from the GenBank used for the phylogenetic anlaysis in MEGA × software. The tree revealed the Indian strains were 100% similar to the all the other *Amyloodinium* isolates reported from Italy, China, USA, Portugal, Japan, and Israel and clustered in the same node.



Phylogenetic tree for *Amyloodinum* isolates from marine and brackishwater fishes using MEGA × software

Withdrawal of Oxolinic acid in shrimp, *Penaeus vannamei* muscle tissue

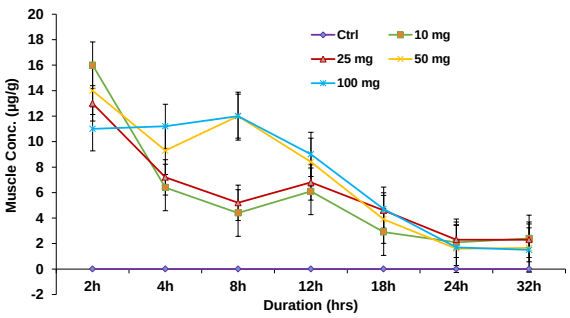
Oxolinic acid (OA) is a quinolone antibiotic, one of the few antibiotics approved for therapeutic use in aquaculture for controlling bacterial infection. Pacific whiteleg shrimp, *P. vannamei*, were administered (5% of body weight) with OA (@ 5 g/kg feed) for consecutive seven days. Muscle tissue was sampled in triplicate at 0, 2, 4, 6, 12, 18, 24, 36, 48, 72, 96, 120, 144, 168 and 240 h post drug administration and concentration of OA was determined by LCMS/MS. The drug residue level reached below 0.3 ppm, at 96 h post drug administration the maximum residual limit (MRL) set by Food Safety and Standards Authority of India (FSSAI). This indicates, the shrimp orally administered with OA (5 g/kg feed) is safe for human consumption by four days post treatment and good to harvest.



Withdrawal of Oxolinic acid in muscle of shrimp

Biosafety, withdrawal of Florfenicol and the role of immune genes in *Penaeus vannamei* shrimp during various concentrations of florfenicol treatments

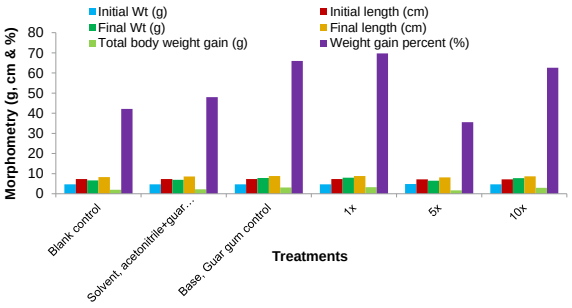
Florfenicol is a broad-spectrum antibacterial drug commonly approved and used by aqua farmers in the treatment of bacterial disease. An experiment was conducted in *P. vannamei* (n=270) shrimp, 4-6 g to elucidate the pharmacodynamic effects of florfenicol drug @10, 25, 50, 100 and 200 mg concentrations and expression of immune genes (crustin, haemocyanin, lysozyme, paenidin, peroxinectin, prophenoloxidase (ProPO), superoxidedismutase and transglutaminase) in haemolymph (HY) and hepatopancreas (HP) was studied at 2,4, 8,12, 18, 24 and 32 h intervals. The elimination of drug in muscle was analyzed using LC-MS/MS in-house method. The drug reached its maximum residual level (MRL) within 2 h of treatment and it was less than 2 µg/g of tissue by 32 h indicating, shrimp can be consumed within a day after treatment. Most of the immune genes are expressed more in HP during early hours of treatment, and HY in their later hours. This might be due to the degradation of the drug in the HP first followed by its dissemination in the HY.



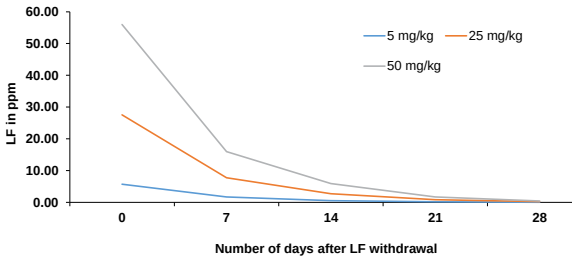
Withdrawal of Florfenicol in muscle of shrimp

Biosafety, withdrawal and efficacy of lufenuron as an anti-parasiticide in fish

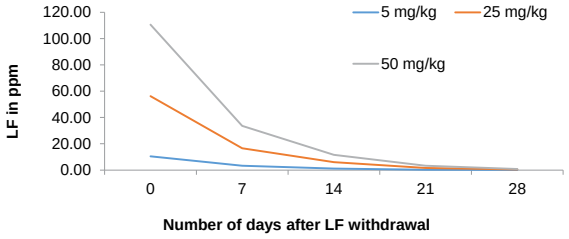
Lufenuron (LF) added in-feed treatment has shown to be effective and safe for controlling infestations of several ectoparasitic crustacean copepods and branchiurans in sea water, brackishwater and freshwater-reared fishes. The safety of LF for use in brackishwater reared Asian seabass, *L. calcarifer* has not been demonstrated. Hence, pharmacodynamic studies were conducted in triplicate to evaluate the safety of LF in Asian seabass. The drug was administered in feed @ dose of 0 (0 x), 5 (1 x), 25 (5 x) and 50 (10 x) mg of LF/ kg of fish body weight (BW) per day for 21 days. Asian seabass fingerlings (mean total length ± SE = 7.40 ± 0.02 cm; mean body weight ± SE = 4.71 ± 0.01 g) were stocked into 500 L flow-through tanks at 20 fish/tank. Fish were fed @ at 4% BW/d divided equally between three feedings. Fish behavior were characterized as normal. LF was found biologically safe up to 10 times the recommended therapeutic dose and three times the treatment duration based on the behaviour, feeding, total weight gain, weight gain percent. Further, pharmacokinetic studies were conducted in Asian seabass fingerlings (4.63 ± 0.06 g; 7.67 ± 0.13 cm) for 49 days with proposed dose of 5 mg/kg BW for seven consecutive days. QTRAP 4000 LC-MS/MS analysis showed that the level of LF in liver, kidney and muscle reached least by 28th day with the limit of quantification (LOQ) fixed at 0.01 ppm. In addition, no significant difference was observed in the rate of LF leaching with 3.52 and 5.36% in guar gum and egg albumin coated feeds, respectively after soaking the top-dressed feeds in water for 40 min.



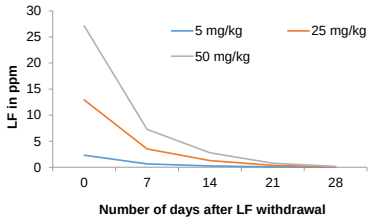
Morphometry of Asian seabass fed with different levels of lufenuron



Withdrawal of lufenuron in kidney of Asian seabass



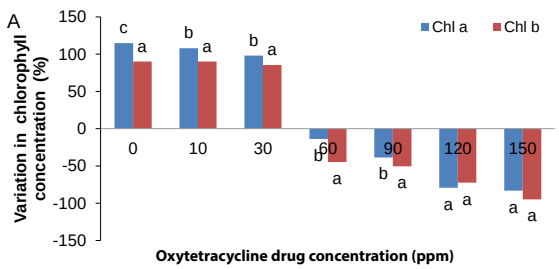
Withdrawal of lufenuron in liver of Asian seabass

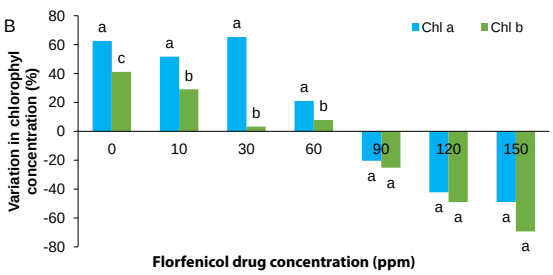


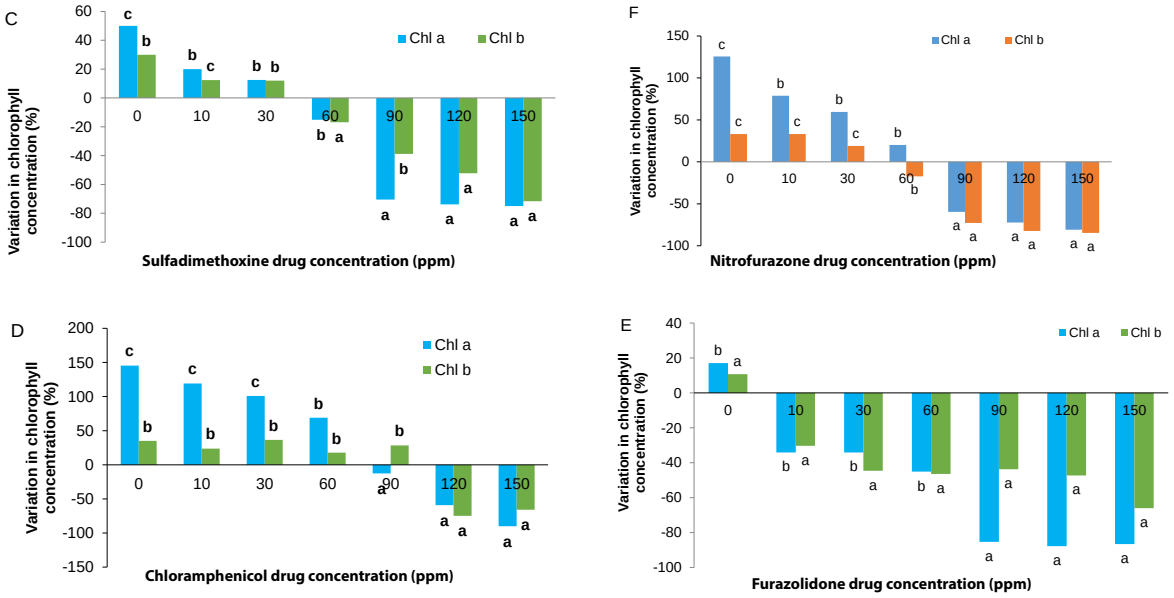
Withdrawal of lufenuron in muscle of Asian seabass

Evaluating the environmental safety of aquaculture important antibiotics through their effect on indicator organisms

Effect of aquaculture important antibiotics like oxytetracycline, sulfadimethoxine, florfenicol, chloramphenicol, furazolidone and nitrofurazone on growth, photosynthetic activity and antioxidant enzyme levels non-target organisms revealed their little adverse impact at environmentally relevant concentrations. The IC_{50} values for these antibiotics were much below their possible concentrations in the aquaculture systems following their therapeutic applications. However, need for regulated monitoring on their usage and environmental impact is emphasized.



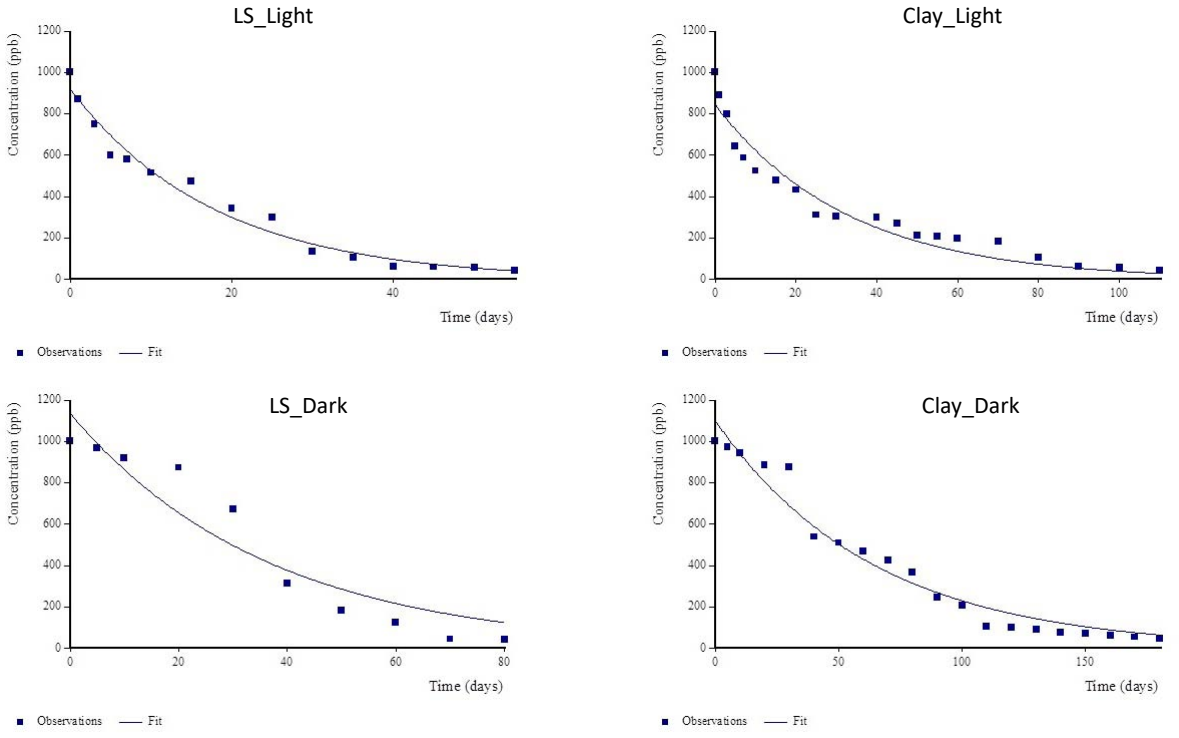




Effects of antibiotic exposure on Chlorophyl a and Chlorophyl b contents in microalgae

Degradation of *Emamectin benzoate* in aquaculture pond sediment

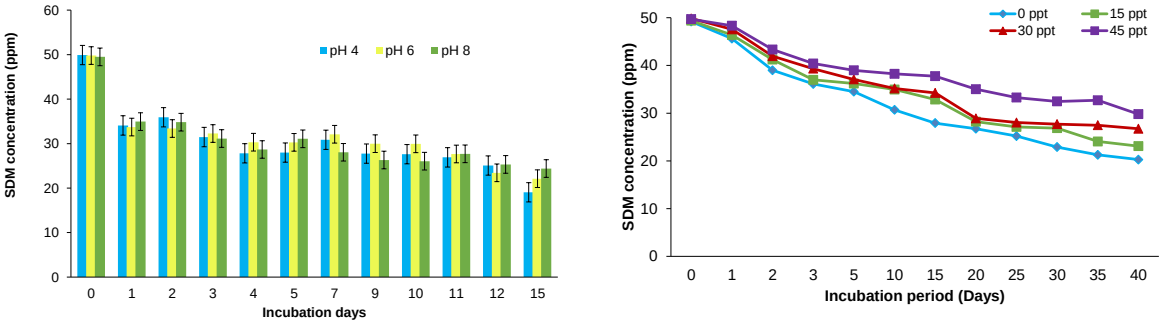
Emamectin benzoate (EMB) has been effectively used as an anti-parasitic drug against ecto-parasites. Feed based drugs can reach the environment through uneaten feed and faeces, and a significant proportion may potentially reach the pond sediment. To understand the influence of abiotic factors viz., sunlight and soil texture on EMB degradation, the drug was spiked in loamy sand (LS) and clay (C) soil textures at field capacity and exposed to dark and natural sunlight conditions. Sampling was done at periodical intervals and the results showed that EMB degradation followed the first-order kinetics in CAKE (Computer Assisted Kinetic Evaluation) with a half-life of 12.4 and 22.8 days in sand and clay soil, respectively under sunlight. The half-life period almost doubled in dark conditions, inferring that EMB degradation is faster in light-textured soil exposed to sunlight. In tropical countries like India, EMB degradation is rapid as the farms are exposed to sunlight throughout the year.



Kinetics on EMB degradation

Persistence of sulphadimethoxine under varying environmental condition

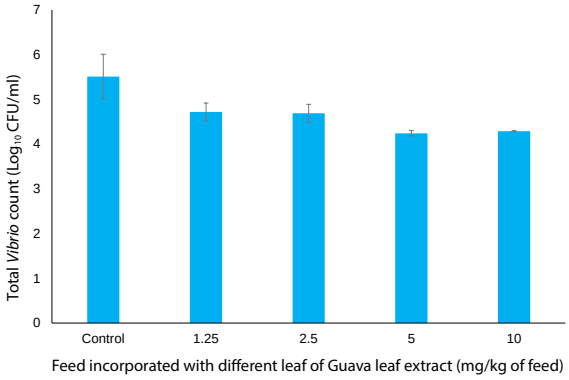
To know the persistence of sulphadimethoxine (SDM), degradation study was carried out by varying pH and salinity. Sulphadimethoxine degradation was faster under acidic condition and with increase in pH there was reduction in photolysis. After 15 days of incubation degradation percent was 62, 48 and 43 at pH 4, 6 and 8 respectively. With increase in salinity there was reduction in photodegradation of sulphadimethoxine. Percent degradation was 75, 70, 62 and 56 at 0, 15, 30 and 45 ppt, respectively after 40 days of incubation. Persistence of sulphadimethoxine was high under brackishwater system (high pH and salinity) than freshwater system.



Effect of pH and salinity on degradation of sulphadimethoxine

Effect of Guava leaf extract supplemented feed on growth and health status of *Penaeus vannamei*

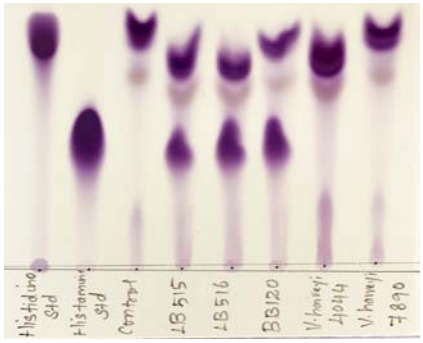
Guava leaf extract is well known for its different beneficial activities including anti-bacterial and anti-oxidant properties. In previous studies at ICAR- Kakdwip Research Centre, Guava leaf extract was found to inhibit different brackishwater aquaculture pathogens. A growth trial of 44 days duration was studied in *P. vannamei* with feed supplemented with four different levels (1.25, 2.5, 5 and 10 g/kg) of ethanolic Guava leaf extract. One group was kept as control (C), where guava leaf extract was not incorporated in the feed. The growth performance of the cultured *P. vannamei* including weight gain and specific growth rate was significantly better in guava leaf extract supplemented feed as compared to control. The total *Vibrio* level was checked in gut and hepatopancreas of shrimp in all treatment groups and it was observed that *Vibrio* level of gut and hepatopancreas was significantly lower in all treatment group than control. However, the lowest *Vibrio* load was observed in T3, where supplementation of guava leaf extract was done at the rate of 5 g/kg of feed.



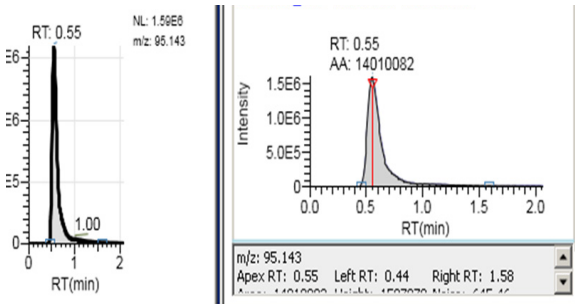
Effect of Guava leaf supplementation and *Vibrio* load

Vibrio campbellii is a prolific histamine producer

Vibrio campbellii is a major luminescent bacterial pathogen in Indian shrimp hatcheries. The pathogen possesses several pathogenic determinants such as type III secretion systems, lysogenic phages, metalloprotease, siderophore systems etc. To understand the siderophore system, the production of intermediary metabolite histamine was evaluated by thin layer chromatography (TLC) and liquid chromatography Mass spectrometry (LC-MS). The TLC study suggested that 28 out of 30 isolates of *V. campbellii* produces histamine. However, none of the isolates of phylogenetically related pathogens such as *Vibrio harveyi* or *V. owensiii* had histamine production. To further confirm the result, six samples (Three *V. campbellii* isolates, Two *V. harveyi* isolates and one *V. owensii* isolate) were analysed by LC-MS. The result suggested that *V. campbellii* is a prolific histamine producer. Apart from role as intermediary metabolites in siderophore synthesis, histamine is a major cause for food borne poisoning. However, there are no such reports for involvement of *V. campbellii* in food poisoning and any such possible involvement needs further investigation.



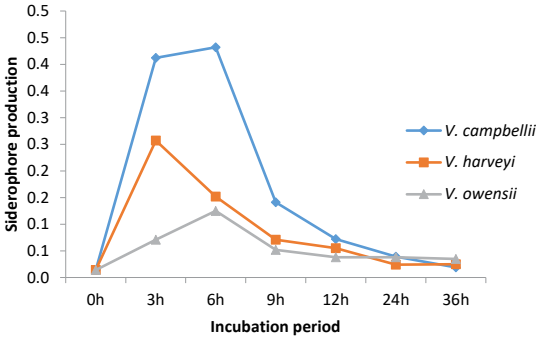
Thin layer chromatography showing the production of histamine by strains of *V. campbellii* but not by *V. harveyi*



Mass spectra showing level of histamine production in *V. campbellii* LB102

Siderophore production by *Vibrio campbellii, Vibrio harveyi* and *Vibrio owensii*

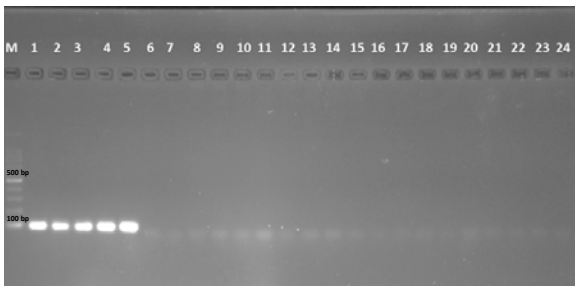
Siderophores are small, high-affinity iron-chelating compounds that are secreted by pathogenic microbes. This provides ability to bacterial pathogens to provide vital nutrients under adverse condition, hence serves as critical virulence factors. *V. campbellii, V. harveyi* and *V. owensii* are phylogenetically related pathogens and often reported in shrimp and finfish hatcheries and farms. Contrary to several reports, our earlier study suggested the predominance of *V. campbellii* in Indian shrimp hatcheries. To understand the reason for such predominance and relative pathogenicity, a comparative study on siderophore production was undertaken. For this purpose, these three pathogens were grown under varying concentration of EDTA, a metal chelating compound. The results suggested that at every concentration of EDTA, the highest level of siderophore production was observed with *V. campbellii* followed by *V. harveyi* and the least by *V. owensii*. Overall, the level of siderophore production in *V. campbellii* was 60 to 184% higher compared to *V. harveyi* and 240 to 480% higher with respect to *V. owensii*. The present result suggests that *V. campbellii* has competitive advantage over *V. harveyi* and *V. owensii* under adverse condition and could be probable reason behind its dominance within shrimp hatcheries.



Siderophore production by various *Vibrios*

Development of Real time PCR diagnostics for *Vibrio campbellii*

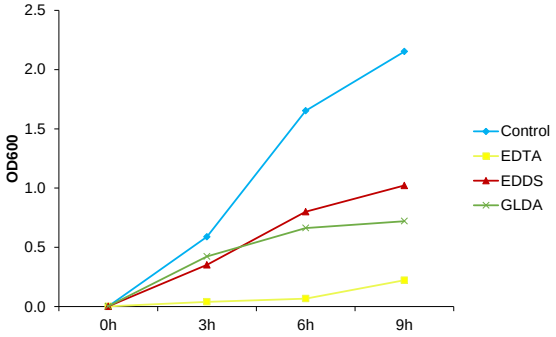
Harveyi clade species such as *V. harveyi* and *V. campbellii* are major pathogen in shrimp and finfish hatcheries. Earlier we developed differential and quantitative real time PCR for *V. harveyi, V. owensii* and *V. rotiferianus*. To further boost the diagnostics against pathogenic *Vibrios*, a quantitative real time PCR primer was designed against *V. campbellii*. For identifying a novel marker, a differential pangenome analysis was carried out, based upon the result, *hdc, fatA* and *angR* were selected for primer design. Primers targeting *fatA* genes produced 95 bp amplicon which was 100% sensitive and specific after screening 15 different species including seven closely related *Vibrio* species.



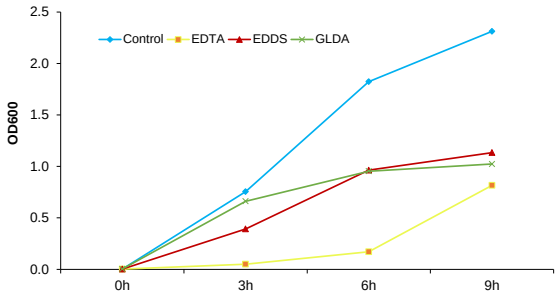
M- 100 bp ladder; 1-5 *V. campbellii*; 6-9 *V. harveyi*; 10-11 *V. owensii*; 12 *V. Rotiferianus*; 13 *V. jasicida*; 14 *V. parahaemolyticus*; 15 *V. alginolyticus*; 16 *V. fluvialis*; 17 *E. coli*; 18 *K. oxytoca*; 19 *S. Typhi*; 20 *P. fluorescens*; 21-23 Gram-positive bacteria; 24 Negative

Comparative analysis of metallic chelator compounds for growth inhibition of *Vibrio harveyi, Vibrio campbellii* and *Vibrio owensii*

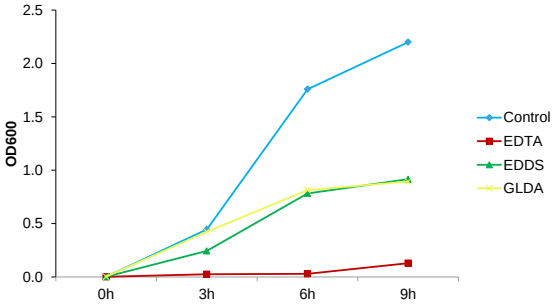
Effective therapeutic and control measures for major aquaculture bacterial pathogens like *V. harveyi, V. campbellii* and *V. owensii* in aquaculture setup is lacking. Therefore a comparative trial was conducted to evaluate the effect of metallic chelator of two different categories; non-biodegradable (EDTA) and biodegradable; GLDA (glutamic acid diacetate) and EDDS (Ethylenediamine-N,N'-disuccinic acid). The results suggested that all these three compounds are effective in controlling growth of these three pathogens, but EDTA was far more effective than biodegradable compounds GLDA and EDDS.



Growth kinetics of *V. harveyi*



Growth kinetics of *V. campbellii*



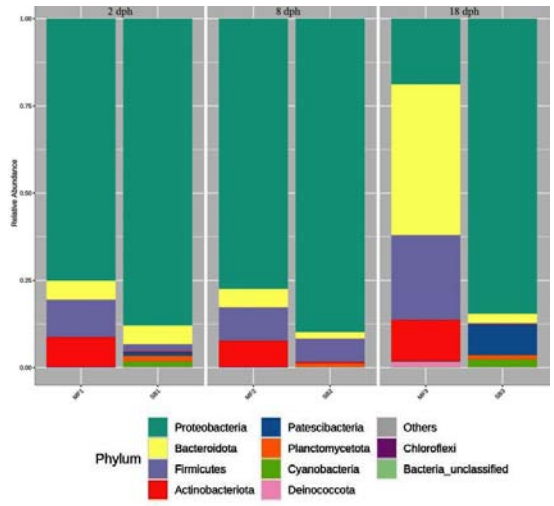
Growth kinetics of *V. owensii*

Comparative microbial profiles of Asian seabass and milkfish larvae

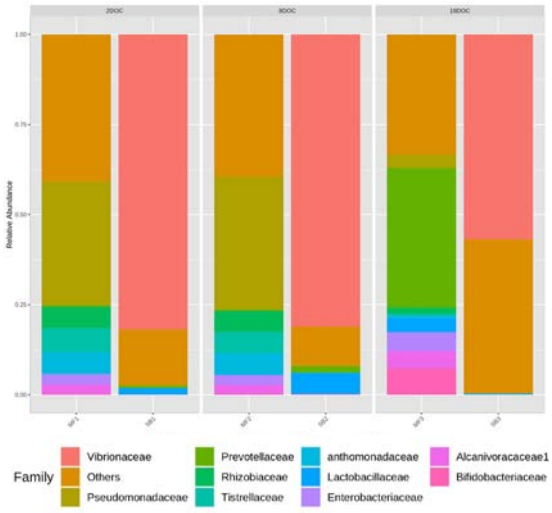
Asian seabass and milkfish are prominent brackishwater species cultured in India and their captive seed production in ICAR-CIBA's in-house hatchery serves farming communities in inland saline areas and the coastal states of India. Several factors challenge the expansion and intensification of the fish production, where healthy and disease-free seeds are made priorities of aquaculture operations. Understanding the early microbial interactions in larval development is quite necessary at this juncture. Hence, the microbial flora associated with the larvae of two brackishwater fish species, viz., Asian seabass and Milkfish using 16 S rRNA based next generation sequencing in in Illumina MiSeq Platform was analysed. The Shannon alpha diversity analysis has shown microbial population is more diverse in milkfish larvae (>3.42) compared to larvae of Asian seabass. However, both larvae at 18 dph have shown comparable diversity. Proteobactera was the dominant bacterial phyla in both the larvae. However, milkfish larvae thriving on *Artemia* in green water system has shown the highest relative abundance of phylum Bacteriodetes, wherein, the Proteobacteria, Patescibacteria, cyanobacteria were the major contributors in Asian seabass larvae at 18 dph. Family Vibrionacea and Pseudomonadacea were the dominant families in Asian seabass larvae whereas Family Pseudomonadacea (2 and 8 dph) and Prevetollaceae (18 dph) were more common in milkfish larvae. Asian seabass larvae have shown a more relative abundance of *Vibrios* (0.25 to 0.75) whereas *Pseudomonas* was most abundant in early larvae of milkfish (0.25), and its relative abundance reduces when the larvae develop to later stages (≥18 dph).

The alpha diversity analysis of Asian seabass and milkfish larval microbiome compared at 2, 8 and 18 dph of larval development

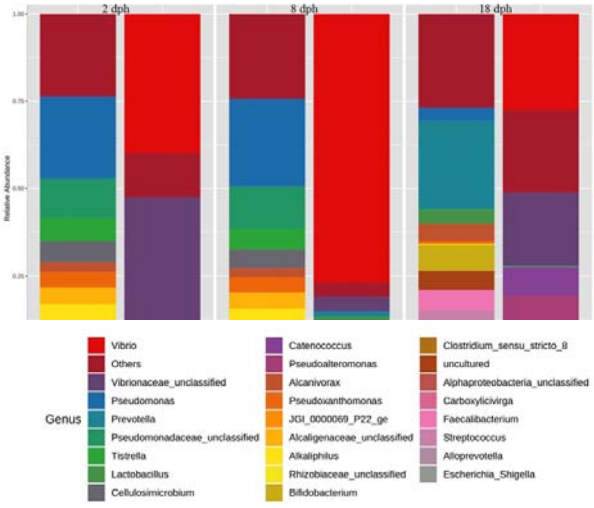
Days	Shannon alpha diversity	
	Milkfish larvae	Asian seabass larvae
2 days	3.42	2.58
8 days	3.44	1.11
18 days	3.53	3.14



Metagenome analysis of bacterial phyla in larval microbiome of Asian seabass (SB1, SB2, SB3) and milkfish (MF1, MF2, MF3) at 2, 8 and 18 dph



Metagenome analysis of bacterial families in larval microbiome of Asian seabass (SB1, SB2, SB3) and milkfish (MF1, MF2, MF3) at 2, 8 and 18 dph



Metagenome analysis of bacterial population in larval microbiome of Asian seabass (SB1, SB2, SB3) and milkfish (MF1, MF2, MF3) at 2, 8 and 18 dph

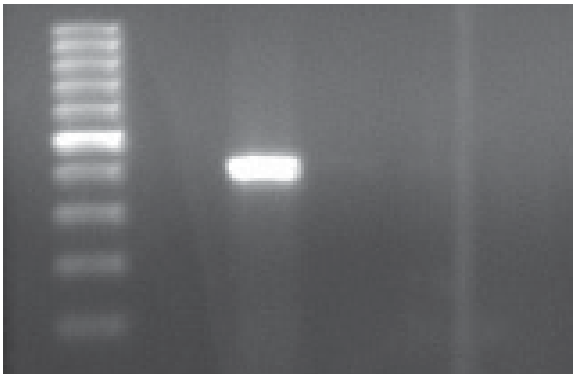
Antimicrobial Resistance and shrimp

Antimicrobial resistance (AMR) is a growing threat faced globally. Misuse and overuse of antimicrobials are the main factors that contribute to the development of drug- resistant pathogens. AMR requires urgent global action in order to achieve the sustainable development. To know the AMR impact on shrimp farming, a total of 83 shrimp samples and 30 water samples collected from different shrimp farms of Andhra Pradesh and Tamil Nadu. From the shrimp samples, 23 isolates of *Staphylococcus* sp., 50 *Escherichia coli* isolates and 74 *Vibrio* sp were isolated. From water samples three *E. coli* and two *Vibrio* sp isolates were obtained. Antimicrogram was carried out for all the isolates and found that all the *Staphylococcus* sp were resistant to Penicillin. About 17.39% isolates were resistant to both Erythromycin and Gentamicin. One *Staphylococcus* isolate showed resistant to Cefoxitin. A maximum of 18.76 *E. coli* isolates showed resistant to Amoxycillin followed by Ampicillin and Tetracycline (15.09% each). A small percentage of isolates also showed resistant to Ceftazidime (9.43%), Ceftriaxone (7.54%) and Aztreonam (3.77%). Majority of *Vibrio* sp isolates (78.94%) showed resistant to Ampicillin followed by only small percentage to Cefotaxime (6.57%), Cefoxitin (5.26%) and Ceftazidime (3.94%). This might be due to antibiotic pollution in the environment surrounding shrimp aquaculture facilities, through the release of water and pond sediments. Resistant bacteria can also enter shrimp farms through products added to the ponds, such as shrimp feed and probiotics.

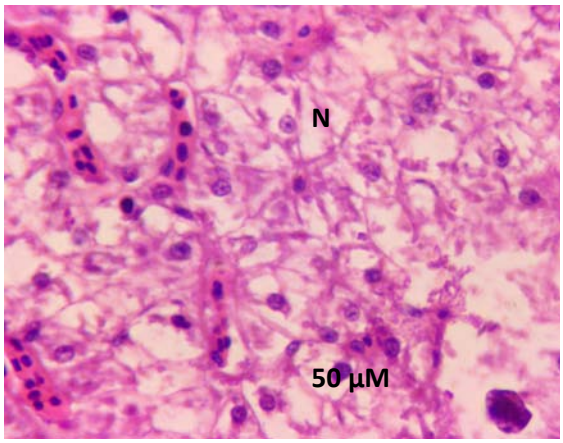
Molecular characterization of Tilapia Lake Virus in farmed Tilapia in West Bengal

Tilapia Lake Virus (TiLV) is very important disease of farmed Tilapia and causing severe mortality in farmed Tilapia throughout the world. The targeted surveillance on TiLV in farmed Tilapia was studied in three districts of West Bengal viz. North 24 Parganas, South 24 Parganas and Hooghly with special reference to Sundarbans. The disease prevalence was detected in 45.9% (17 out of 37) of the samples tested by two step semi-nested PCR and the positivity rate was 56.7% (17 out of 30 farms) of the farms surveyed. Two samples (one each from Hooghly and South 24 Parganas district) were found positive in I step and others only in II step. Four TiLV positive fish farms were associated with TiLV disease outbreaks

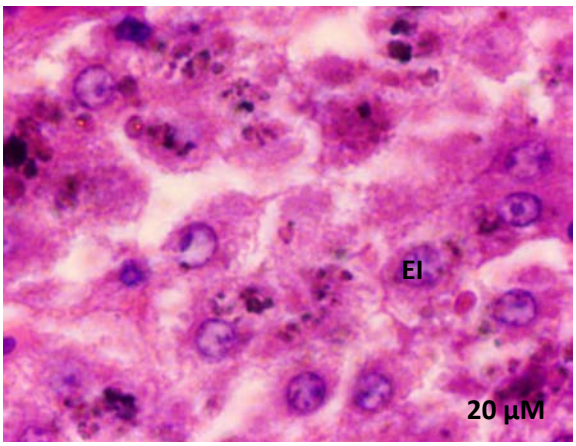
and showed disease symptoms. Other positive farms the fish appeared apparently healthy. This indicates that mere presence of virus in a fish alone is not enough for disease outbreak, but factors like pond environment and water quality influence the occurrence of disease. Histopathological analysis of infected fish liver had vacuolation, fatty changes of hepatocytes, melanomacrophage aggregation, loosely packed hepatocyte cells, pyknosis, multinucleated giant cells, eosoniphilic inclusion bodies were observed in the hepatocytes. Partial sequencing of segment three hypothetical protein gene of two isolates of TiLV, first step PCR positive, was carried out by Sanger's di-deoxy chain termination method. The similarity of the sequences was checked in Basic Local alignment search tool (BLAST) and it revealed that two isolates were more than 95% similar TiLV isolates of different parts of the World. The two sequences were 99.74% similar among themselves. A phylogenetic tree has been created based on Neighbour joining method with the available TiLV sequences of NCBI GenBank and it revealed two isolates of this study are genetically very close to the isolates of ICAR-CIFRI.



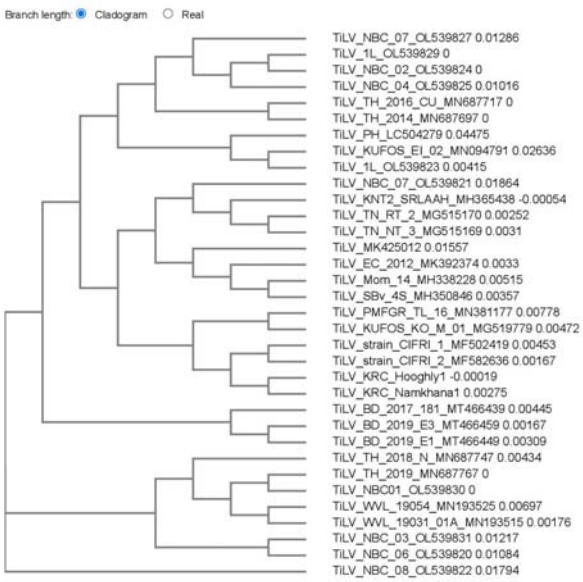
TiLV I step PCR showing 415 bp amplicon



Necrosis in hepatic parenchyma (N), pyknosis (P) and multinucleated cells (MN) X 400 H&E



Severe necrosis in hepatic parenchyma (N), giant multinucleated cells (MN), eosinophilic inclusion (EI), pyknosis (P), and karyorrhexis (K) X 1000 H&E



Phylogenetic analysis of TiLV isolates based on Neighbour joining method. Two isolates of this study are TiLV KRC Namkhana 1 and TiLV KRC Hooghly 1

Viral nervous necrosis infection in Asian seabass Fish

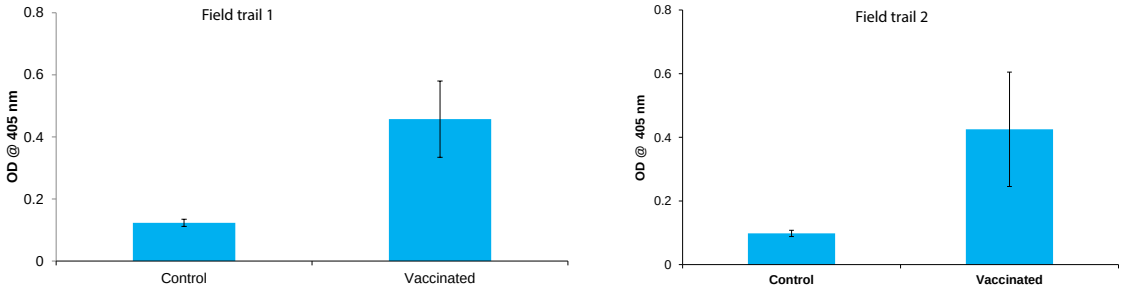
Asian seabass with average BW of 500-750 g had mortalities, in five months culture pond were collected from Chennai. The affected fish displayed skin lesions like darkened skin, emaciation, and fin erosion. On screening of tissue samples, the brain and liver samples found positive for VNN. Histopathology showed typical vacuolation in brain and ocular lesions. It was clear that the mortalities in the farm were due to VNN.

VNN affected Asian seabass fish with skin lesions

Field evaluation of recombinant viral nervous necrosis vaccine

Viral nervous necrosis (VNN) is a serious viral disease affecting more than 177 species of fishes. An injectable recombinant viral nervous necrosis vaccine was developed by ICAR- CIBA. The vaccine was found to be safe and potent for Asian seabass fingerlings and broodstock. The vaccine was further tested under field conditions. Asian seabass fingerlings (ABW 40 ± 4.6 g) 200 numbers were vaccinated intraperitoneally with recombinant VNN vaccine at the optimized dose of 100 µg of recombinant protein emulsified in commercial adjuvant and stocked in cages at two different places at farmers facilities. Two hundred unvaccinated Asian seabass fingerlings were stocked in separate cages at both the places. Blood was collected from the caudal vein two months post vaccination from control and vaccinated fish. The serum antibody titre was assessed by indirect ELISA. The vaccinated fish has significantly higher antibody titre compared to the control fish. No difference in survival or growth of the vaccinated and control fish till 11 months post stocking was observed.

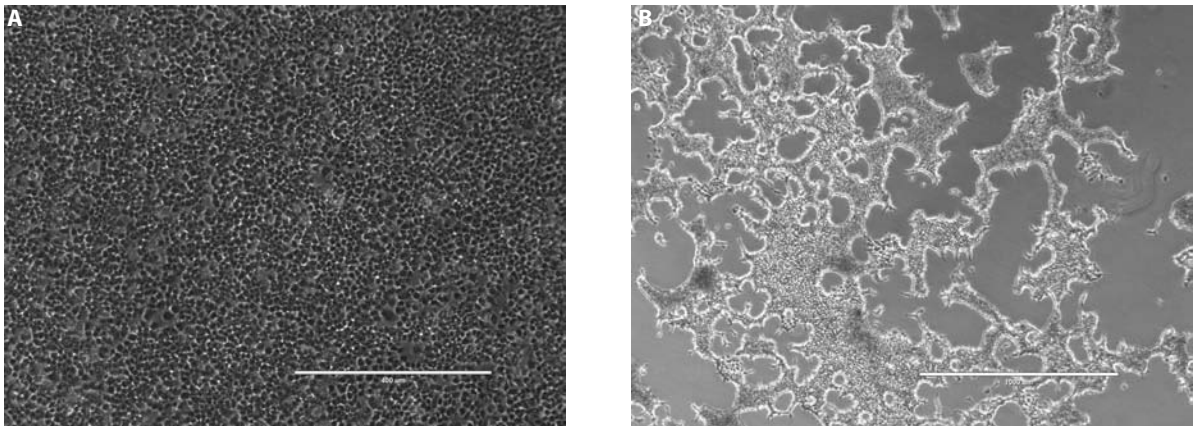
The experimental recombinant vaccine named as CIBA-Nodavac-R was released virtually by Dr. J.K. Jena, Deputy Director General (Fisheries) on 27th April, 2021 in an event organized by ICAR-CIBA. The vaccine was developed under the project consortium research platform on vaccines and diagnostics and is ready for commercialization.



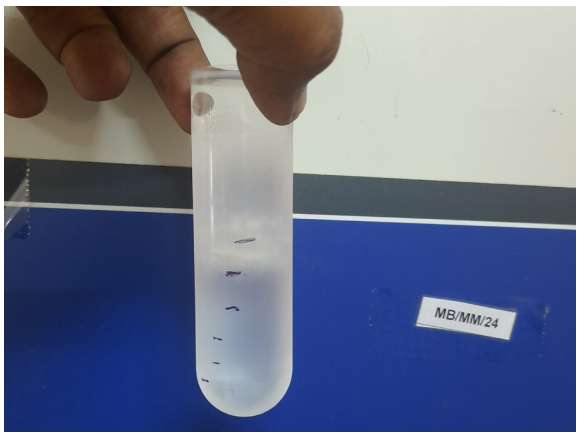
Immune response of Asian seabass fingerlings vaccinated with recombinant viral nervous necrosis vaccine under field conditions

Development of inactivated viral nervous necrosis viral vaccine

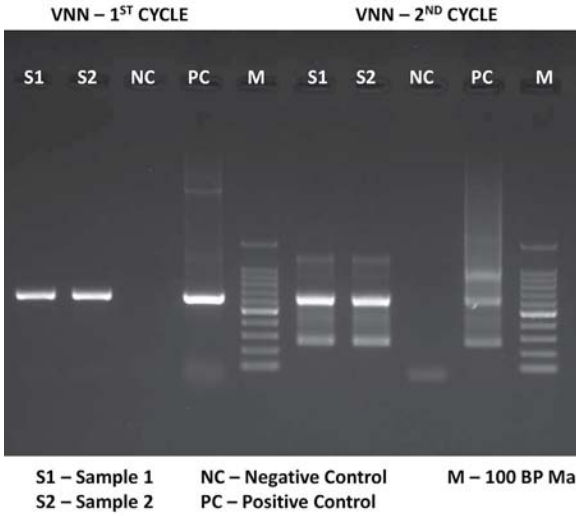
Viral nervous necrosis, a major finfish disease in aquaculture. To develop an inactivated VNN viral vaccine, VNN virus of finfish was adapted and propagated in E-11 cell line, developed from a clone of the striped snakehead fish (*Channa striata*) cells cultured in Leibovitz's Medium (L- 15) with 10% fetal bovine serum. Culture conditions of E-11 cell line was standardized for viral propagation, and viral inoculum for the onset of characteristic cytopathic effect (CPE) was optimized for 48 h post infection, for mass propagation. The infective dose of the vaccine virus was calculated using Reed and Muench method and found to be 2.5 x 10^6 $TCID_{50}$/ml. Three batches of VNN virus of 2.5 x 10^6 $TCID_{50}$/ml with the viral copies of 4.92 x 10^9 /ml were purified using density gradient centrifugation with cesium chloride. The purified virus was confirmed by using PCR and VNN viral protein coat using SDS-PAGE. Formalin inactivation of VNN virus using different concentration and duration was standardized and safety tested in cell culture and biological assay was done. Formalin inactivated (0.1%) sterility tested vaccine was administered in *L. calcarifer* juveniles for laboratory scale vaccine trial.



Morphology of E-11 cell line under phase contrast microscope; (A) Cell monolayer of E-11 cell line in 24 to 48 h (10X); (B) Cytopathic effect of VNN virus 48 h dpi in E-11 cells showing the vacuole formation, peeling of cell monolayer, cell death and aggregation (10X)



VNN viral particles at CsCl gradient 1.3 with a visible white band

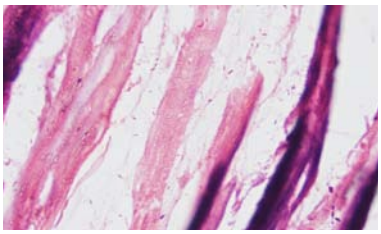


Density gradient purified virus samples S1 and S2 shows VNN positive band in nested PCR

Pathogens affecting brackishwater ornamental fish diseases

Ornamental fish industry has the prospective to contribute for the economic growth of fisherfolks in our country. This sector faces challenges due to diseases during different stages. Infectious fish diseases such as bacterial (*Vibriosis* and Gram positive), viral (Viral nervous necrosis), and parasitic (*Argulus* spp., *Caligus* spp., *Lernaea* spp., and Ancyrocephalid) infections, and non-infectious fatty liver syndrome were identified from brackishwater ornamental fishes *Monodactylus argentius, Etroplus suratensis, Scatophagus argus,* and *Neocomacentrus cyanomos*.

Gram negative bacterial infection in Silver moony, *Monodactylus argenteus*

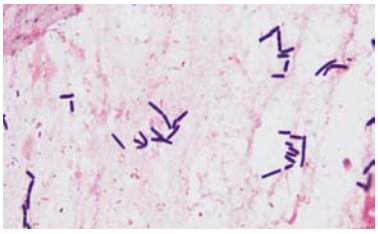


Gram negative rods collected from Silver moony, *Monodactylus argenteus*

Caligus* spp. infestation in Pearlspot, *Etroplus suratensis

Viral nervous necrosis in Pearlspot, *Etroplus suratensis*

Fatty liver syndrome in Pearlspot, *Etroplus suratensis*



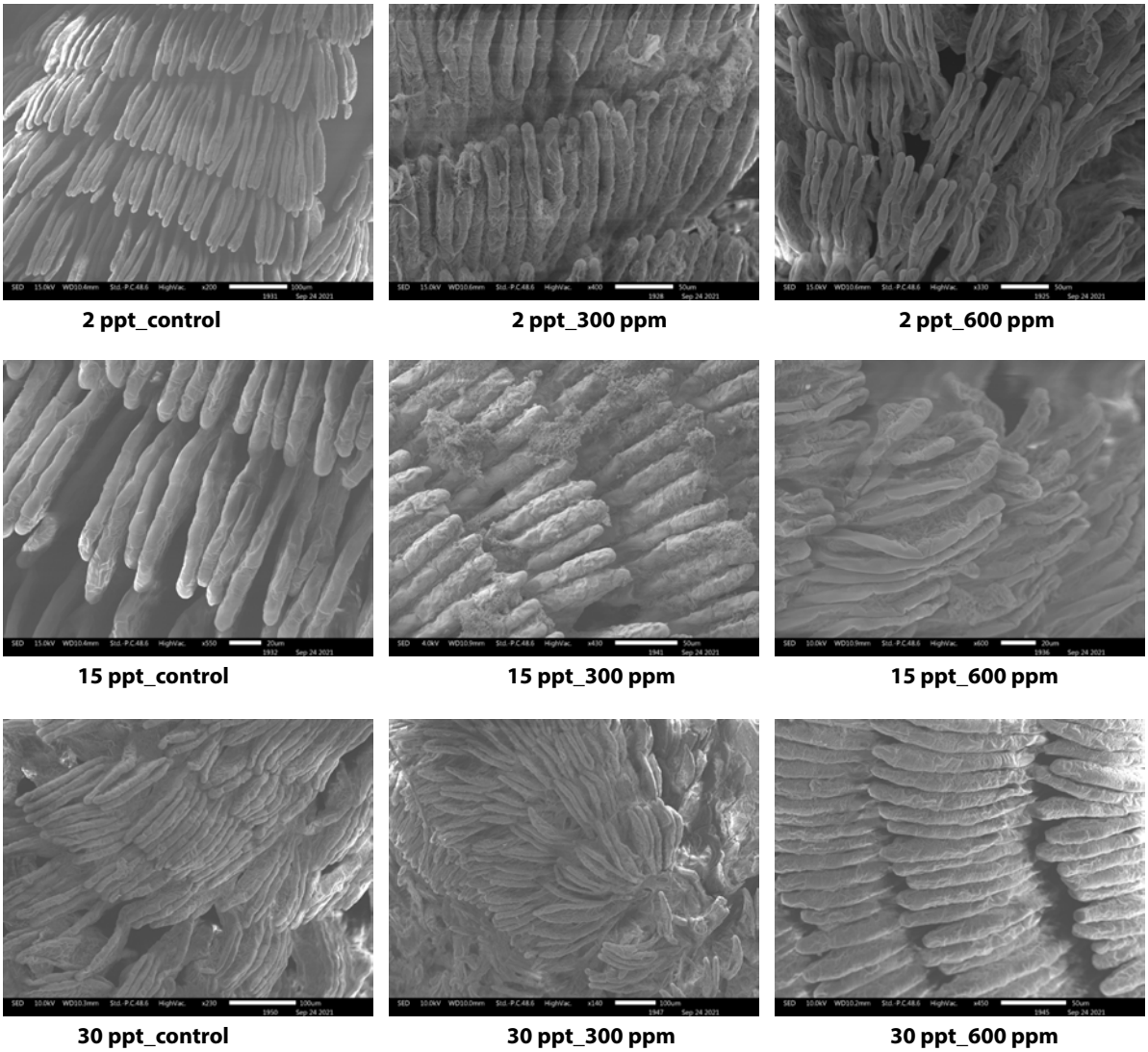
Gram positive rods collected from Black Moon tail damsel, *Neocomacentrus cyanomos*

National Referral Laboratory for Brackishwater fish and shellfish diseases

Under this project, two major cases were referred to ICAR-CIBA for disease verification. College of Fisheries, Mangalore reported presence of AHPND in one of the shrimp farms near to Bangalore, Karnataka. Shrimp and bacterial isolate submitted to ICAR-CIBA for verification. Though the bacterial isolate was identified to be *V. parahaemolyticus*, it was negative for AHPND by PCR. Similarly, the shrimp sample was also found to be negative for AHPND. In another case of submission, crab samples were referred by RGCA, Tamil Nadu for verification of suspected Mud Crab Reovirus. On verification, the samples were found to be positive for MCRV by PCR. Also, as a part of National referral Laboratory analysis, 83 imported samples from Animal Quarantine Certification Service (AQCS) and 56 samples from farmers were analyzed and a revenue of ₹ 17,71, 216 was generated.

High alkalinity stress on shrimp at different salinities

High total alkalinity (TA) in underground source water has been one of the significant concerns in coastal inland as well as arid inland saline regions for brackishwater aquaculture. TA in such source waters was recorded more than 600 ppm and as high as 1000 to 1200 ppm against an optimum range of 150-200 ppm required for *P. vannamei* farming. A yard experiment was conducted for 10 days with *P. vannamei* to understand the impact of high TA on shrimp, at three salinities (2, 15 and 30 ppt) with TA of 300 (A1) and 600 ppm (A2), with control at 150 ppm. The total haemocyte count (THC) reduced with an increase in alkalinity and was 18, 44 and 47% lower under 2, 15 and 30 ppt salinity when exposed to 600 ppm alkalinity, and similarly at 300 ppm TA. Deposition of salts was noticed over the gills with increased alkalinity. There was no mortality of shrimps, and water quality parameters were within permissible levels during the experiment.

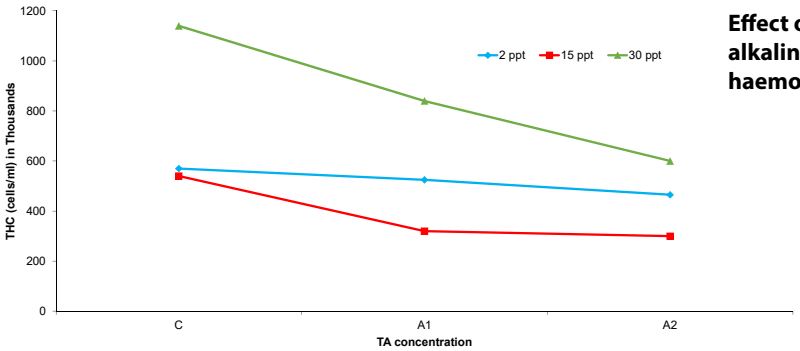


2 ppt_control | **2 ppt_300 ppm** | **2 ppt_600 ppm**

15 ppt_control | **15 ppt_300 ppm** | **15 ppt_600 ppm**

30 ppt_control | **30 ppt_300 ppm** | **30 ppt_600 ppm**

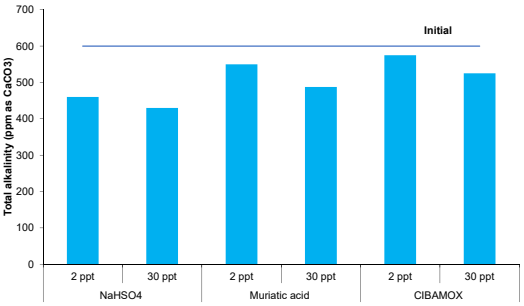
Scanning electron micrographs shows deposition of salts on gill lamellae with increase in alkalinity



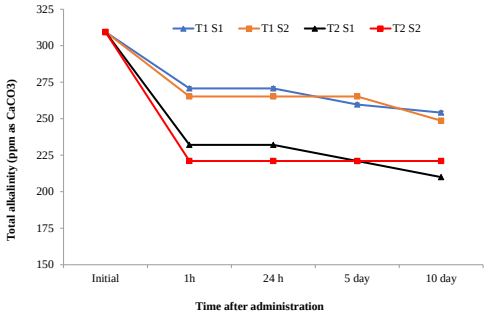
Effect of high total alkalinity on total haemocyte count

Remediation of high alkalinity in source waters

For decreasing high total alkalinity (TA) of 600 ppm as $CaCO_3$, preliminary experiment was conducted using sodium bisulphate, muriatic acid, EDTA, fermented filtrate and CIBAMOX. Results confirmed that sodium-bisulphate ($NaHSO_4$) was more effective, followed by muriatic acid and CIBAMOX. Further, the effect of sodium bisulphate @ 0.08 (T_1) and 0.16 g/l (T_2) at two different salinities, 2 ppt (S_1) and 30 ppt (S_2) was evaluated in *P. vannamei* reared tanks. A significant reduction in TA was observed in the first hour of adding sodium bisulphate (0.16 g/l) and then stabilised. TA reduction was 25 and 28% from 310 ppm at 2 and 30 ppt, respectively. During the ten-day experiment, the shrimp were healthy, and no significant change in other water parameters was observed.



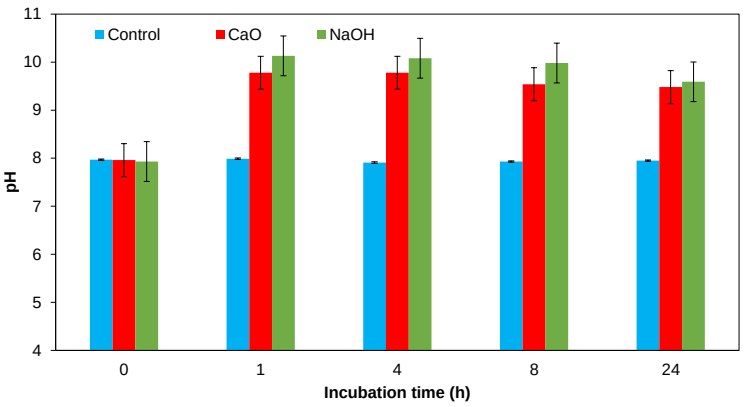
Efficacy of chemicals /biological treatments to remediate high alkalinity



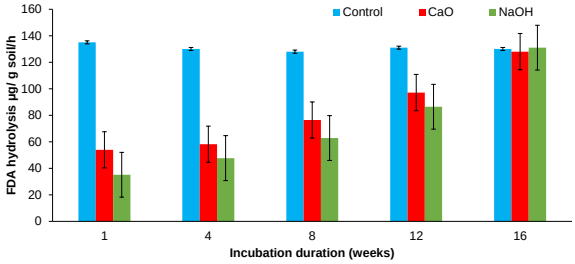
Effect of Sodium bisulphate on reduction in total alkalinity

Impact of chemicals used for EHP management on soil quality

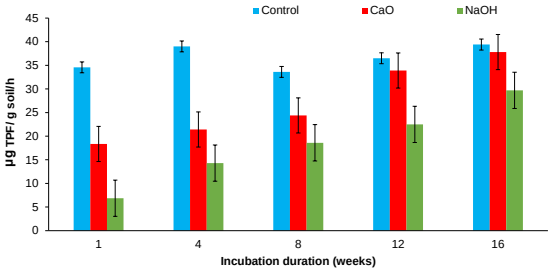
Treatment of EHP affected ponds with chemicals such as CaO and NaOH during pond preparation has become common. These highly reactive chemicals causing drastic alteration to soil pH may have an undesired impact on soil quality. Simulated soil treatment with CaO (6 tonne/ha) and NaOH (4000 ppm) was conducted to study their influence on microbial enzyme activity. CaO raised the soil pH to 9.78 within 1 h and 9.48 at 24 h. Similarly, NaOH application raised the pH to 10.13 within 1 h. Fluorescein Diacetate (FDA) hydrolysis activity was reduced to 53.9 and 35.1 from 135 µg/g soil/h within a week of application of CaO and NaOH, respectively. Similarly, within a week of application of CaO and NaOH the dehydrogenase activity (DHA) reduced to 18.4 and 6.85 from 34.6 µg TPF /g soil/h, respectively. The microbial activity recovered to the initial level by the 16th week. The results revealed that the application of chemicals for the control of EHP significantly decreased microbial activity, affecting the soil quality.



Effect of chemical treatments on soil pH



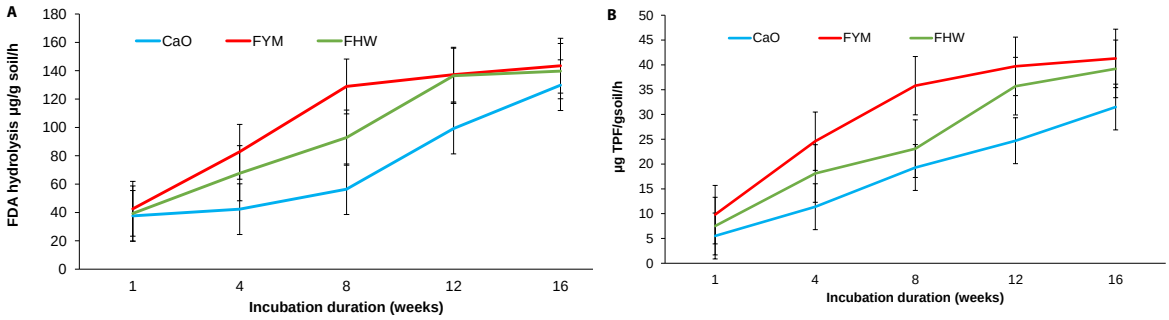
Effect of chemical treatments on soil dehydrogenase activity



Effect of chemical treatments on soil fluorescein diacetate (FDA) hydrolysis activity

Effect of organic amendments on remediation of chemically treated pond soil

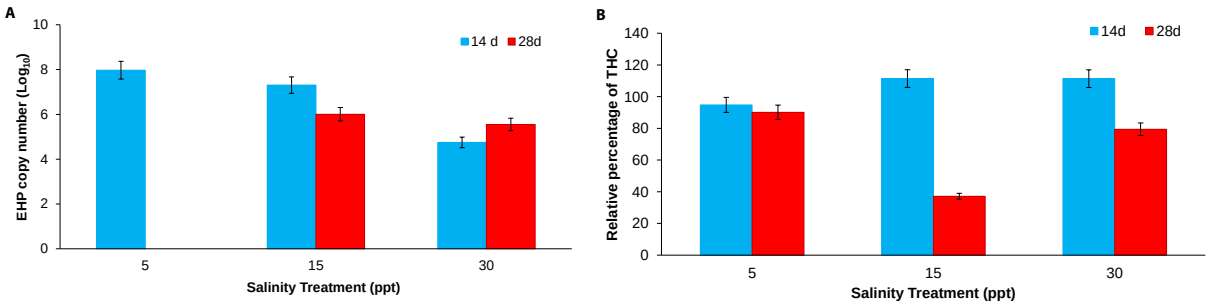
Reactive chemical application alters the soil pH and biological activities, reducing soil quality. In such a situation, organic amendments are adopted for soil quality improvement. An experiment was conducted to study the effect of farmyard manure (FYM) and fish hydrolysate waste (FHW) @ 5 t/ha on the pond soil treated with CaO on soil enzyme activity. Application of CaO reduced the FDA hydrolysis and dehydrogenase activity (DHA) to 37.6 and 5.5 µg/g soil/h, respectively. FYM application raised FDA and DHA to 128.9 and 35.8 µg/g soil/h by 8th week and FHW respectively to 136.5 and 39.7 by 12th week. Results revealed that organic amendments enhanced the biological activity in shorter duration compared to treatments without amendments. Organic amendments could be used to enhance the quality of soils treated with chemicals for sustainable aquaculture.



Effect of organic amendments on (A) fluorescein diacetate hydrolysis activity and (B) dehydrogenase activity in chemically treated soil

Effect of rearing water salinity on EHP infectivity in *P. vannamei*

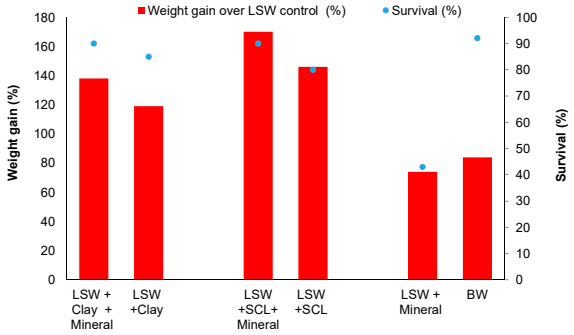
Salinity is a critical parameter in brackishwater aquaculture and plays a crucial role in EHP infectivity. An experiment was conducted to understand the effect of salinity on EHP infectivity in Pacific whiteleg shrimp, *P. vannamei*. The shrimp confirmed to be free of EHP were orally challenged for four days with EHP and reared at different salinities, 5, 15 and 30 ppt. Total haemocyte count (THC) and EHP copy number were recorded at 14 and 28 days post-challenge (dpc). EHP load and THC were high at 14 dpc in all the treatments, irrespective of salinity. Interestingly, in 5 ppt, EHP was undetected at 28 dpc, whereas in the higher salinities, copies ranged from 5 to 6 $\log_{10}$. THC level in infected shrimp at lower salinity recorded equal to control. In the higher salinity groups, more than the control level was recorded at 14 dpc, whereas, reduced at 28 dpc, indicating exhaustion of the host in fighting the pathogen.



Effect of salinity on infectivity of EHP on *P. vannamei* (A) EHP copy number (B) total haemocyte count

Contribution of soil and minerals supplementation for better shrimp farming in low saline environment

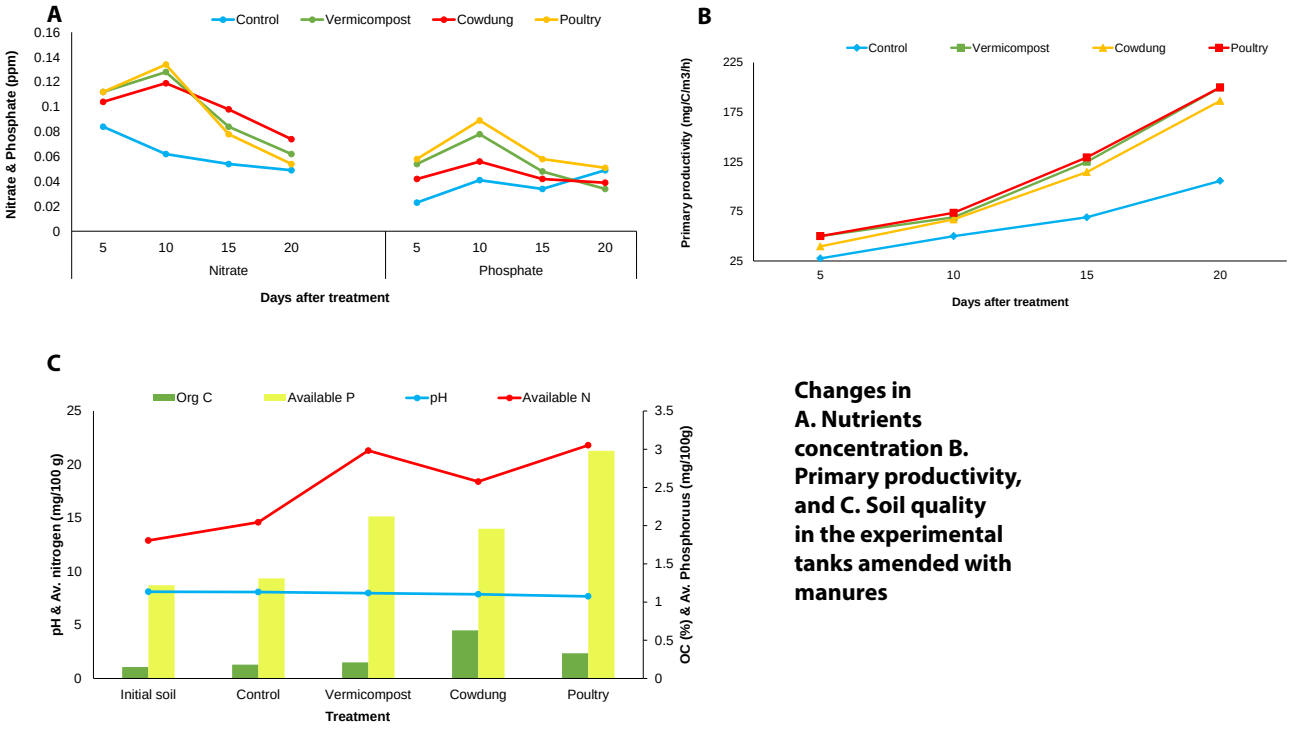
The concept of mineral supplementation for improved survival and growth of *P. vannamei* in low saline waters (LSW) is not clearly understood, and in this context, it is necessary to assess the contribution of soil besides minerals. A mineral mixture with optima concentration (Mg -260, Ca – 150, K - 120 ppm) was supplemented to the microcosm containing soils varying in texture (sandy clay loam-SCL and clay) in LSW (2 ppt). Twenty animals (1.5±0.45 g) were stocked in each tank of 300 l capacity, and the effect of minerals supplementation on survival and growth in soils and LSW (without soil) was compared with respective controls and brackishwater (BW) (25-30 ppt). In a 60-days experiment, the survival was about 90% in both soils with minerals and BW, 80 to 85% in soil controls, 43% in LSW+ mineral and 37.5 % in LSW. Increased weight gain in percent was 138, 119, 147, 170, 74 and 84 in LSW+Clay+Mineral, LSW+Clay, LSW+SCL+mineral, LSW+SCL, LSW+Mineral and BW, respectively compared to LSW control, indicating the contribution of soil (SCL better than clay). The soil plays a more significant role in increasing the survival and growth of shrimps than the minerals supplementation in LSWs.



Effect of soil and mineral supplementation on growth and survival of shrimp at low saline on survival (%) and weight gain (%)

Evaluation of the potential of vermicompost as a source of nutrients into the water phase

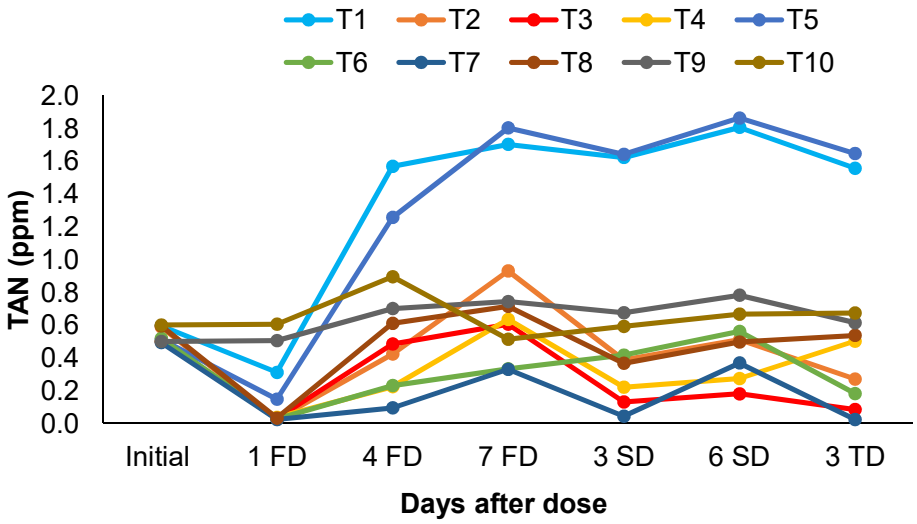
Vermicompost (VC) is being used as manure by farmers, particularly in aged ponds to improve soil health. The application of VC during pond preparation has been evaluated in comparison to cowdung and poultry manures (CM & PM). Yard experiment was carried out for 21 days in 100 l FRP tanks with saline clay loam soil. The manures were dried properly and mixed with the soil, and nutrients released into 25 ppt water and primary productivity were estimated once in 5 days. Nitrate and phosphate content increased up to 10 days and then decreased, whereas primary productivity increased in manured tanks (39.69 to 199. 9 mg C/m^3/h; high in VC and PM) compared to control (27.49 to 105.69 mg C/m^3/h). A decrease in soil pH, and an increase in organic carbon, available nitrogen and phosphorus were observed at the end compared to the initial values. Though the percent total nitrogen and phosphorus were more in PM than VC and CM, VC as manure was on par with the PM in supplementing the nutrients for the enhancement of productivity and superior to both CM and PM in decreasing the organic load.

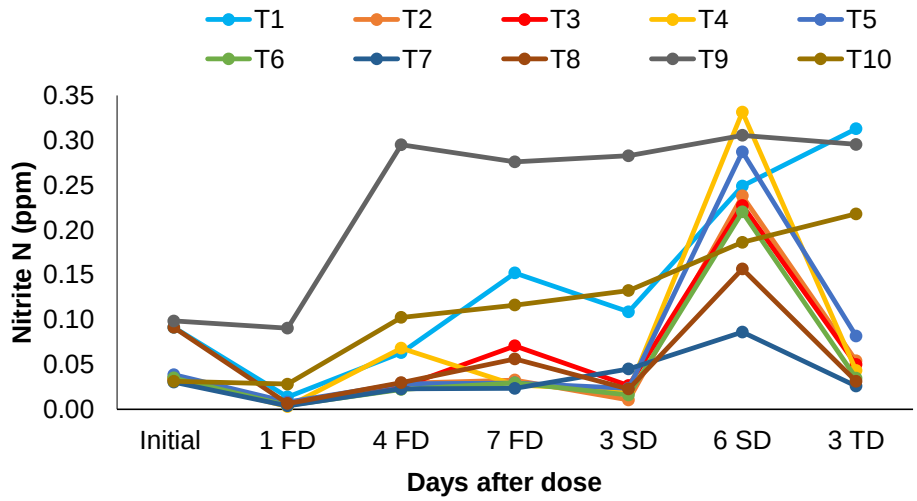


Changes in A. Nutrients concentration B. Primary productivity, and C. Soil quality in the experimental tanks amended with manures

Efficiency of fermented filtrates from agricultural by-products as prebiotics in shrimp farming

To improve the pond environmental conditions and shrimp growth, farmers are practising the application of fermentation filtrates of agricultural by-products as prebiotics. An experiment was conducted in 100 l FRP tanks with soil base in brackishwater (25 ppt) and low saline water (5 ppt), to evaluate the efficiency of fermented filtrates of wheat bran (FF1), maize corn cob waste (FF2), orange fruit pulp waste (FF3) and rice husk (FF4) as prebiotics. The first dose was applied on the next day after acclimatisation of *P. vannamei* and repeated on the 7th and 14th day. Yeast, spore-forming and certain lactic acid bacteria only survived in the filtrate due to acidic pH. Though there was a decrease in pH and alkalinity immediately after the first dose, later stabilized. FF3 was more effective in decreasing the metabolites concentration, low organic load build-up and more shrimp growth followed by FF2, FF4 and FF1 in low saline water compared to brackishwater. Heterotrophic nitrifying bacteria *Bacillus aquimaris,* an ammonium oxidizing bacteria that played a vital role in reducing the ammonia levels was isolated in FF3. The fermentation practice was more effective in the low saline water environment.





Changes in ammonia and nitrite concentration after application of fermented filtrate treatments (T1- FF1BW (brackishwater); T2- FF2BW; T3 – FF3BW; T4 – FF4BW; T5- FF1LSW (low saline water); T6-FF2LSW; T7- FF3LSW; T8 – FF4LSW; T9- BW control; T10-LSW control) DAFD - Days after first dose; DASD - Days after second dose; DATD - Days after third dose

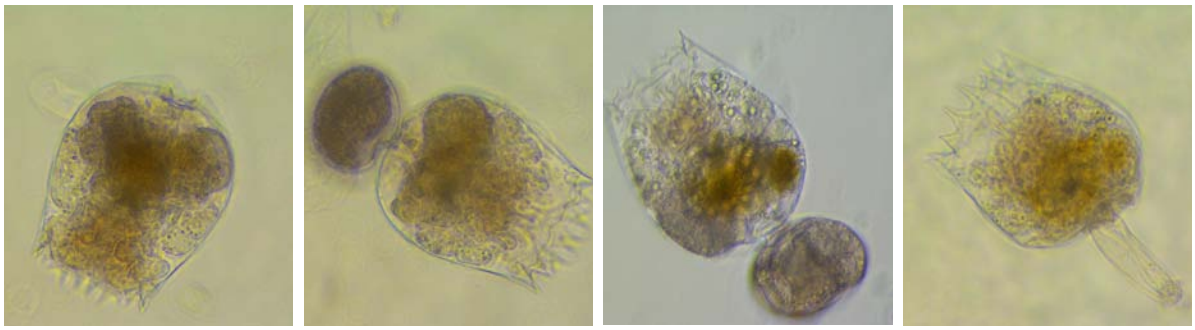
Establishment of environmental manipulation unit with temperature control facilities

A temperature control facility is a prime requirement to conduct any heat challenge experiment simulating environmental conditions. During the last phase of NICRA, we established environmental manipulation unit having smaller aquarium tanks fitted with timers and heaters to conduct experiments with chronic and cyclic temperature exposure involving larvae, fry and juveniles of milkfish and seabass. It was felt needed to establish a temperature control facility, where adult fishes (up to 12 kg biomass) can be heat challenged to understand heat-induced endocrine disruptions. We have developed two sets of water-resistant wooden units (213.36 × 195.07 × 88.39 cm) having four (566.37 l) glass tanks (152.4 × 60.96 × 60.96 cm) in an up-down manner, fitted with RAS along with sand and biological filters. Each glass tank was fabricated with a provision of further partitioning as per the experimental requirement so that adult fishes of different size groups can be used. Two new units for experimenting with adult fishes and a previous unit for juvenile fishes have been placed in a temperature-proof room. This new environmental manipulation shed can be utilised to conduct heat shock studies involving finfishes and shellfishes of different age groups.

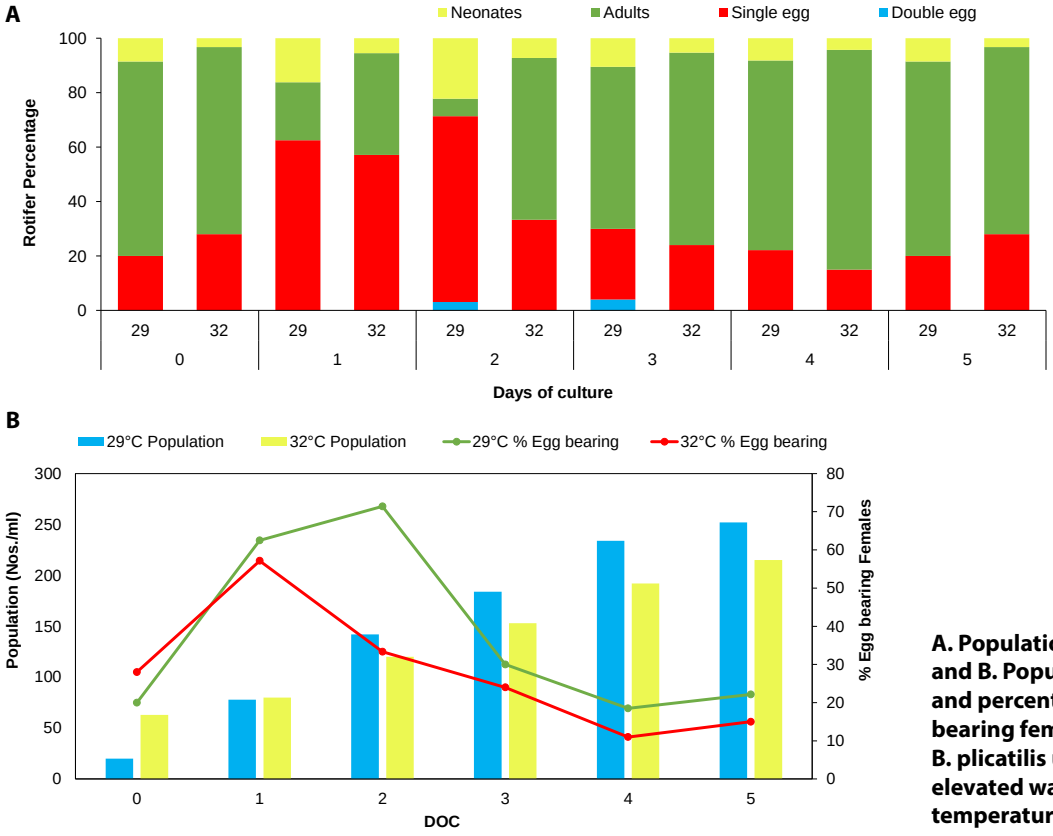
Environment manipulation unit with temperature control facility

Population growth and morphological dynamics of rotifer *Brachionus plicatilis* under chronic exposure of temperature

Rotifers are important planktonic live feeds and variations in water temperature impacts their growth, survival and reproductive performance, consecutively affecting finfish larval survival. An experiment was conducted in NICRA environmental manipulation unit, where starter population of *B. plicatilis* was exposed to 29°C (control) and 32°C (heat challenge) for 5 days to understand the effect of elevated water temperature on growth and morphology. Under isothermal condition, the total length and width of *B. plicatilis* varied from 152 - 214 µm and 113 - 130 µm, respectively, and there were no significant differences when exposed to heat challenge. Population density reached maximum after five days (252 and 215 numbers/ml in control and 32°C). Percentage of egg-bearing female, a marker of healthy rotifer population increased till 2 DOC (62.5 and 57.14%) and then decreased after 5 DOC (22 and 15%) in control and treatment, respectively. The average egg diameter was found to be 104.39 µm and 77.51 µm under 29°C and 32°C, respectively. Heat stress influenced its neonate's production (22.21 and 7.23% after 2 DOC in 29 and 32°C, respectively), which has a negative bearing on finfish larvae early survival. The results can help to develop biochemical markers for rotifer heat tolerance and climate-resilient rotifer production mechanism.



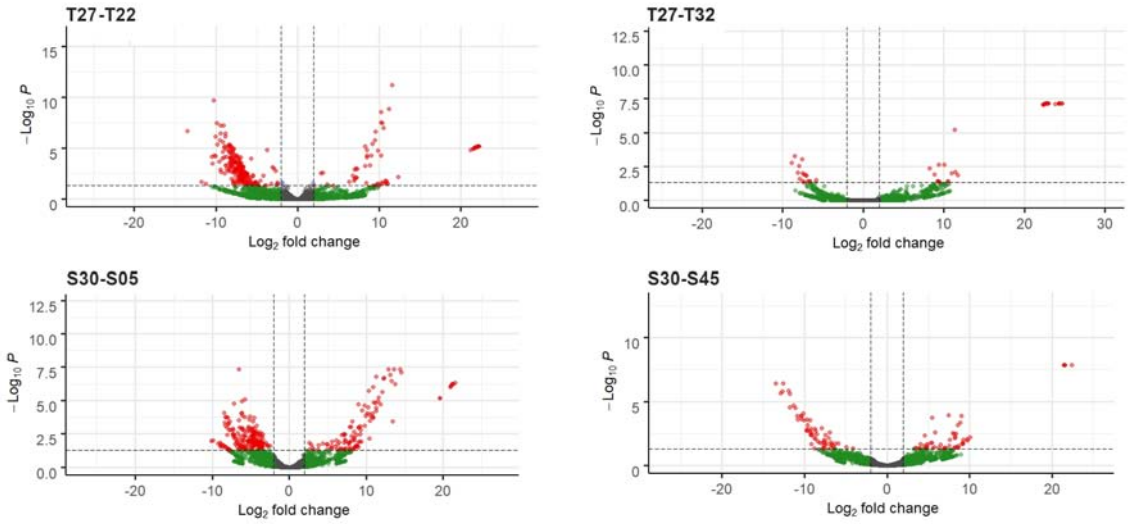
Different life stages of *Brachionus plicatilis* after 5 DOC under isothermal culture



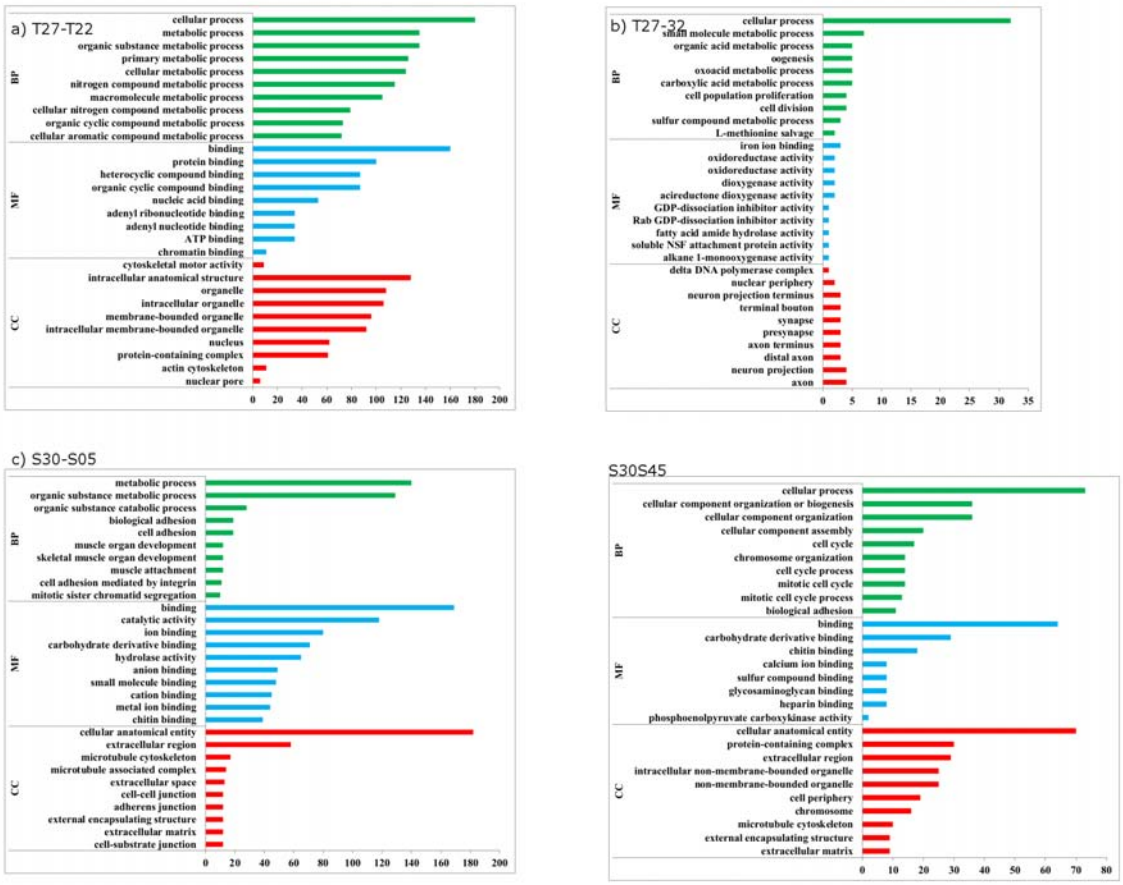
A. Population dynamics and B. Population growth and percentage of egg bearing females of *B. plicatilis* under elevated water temperature (32°C)

Transcriptional responses to acute temperature and salinity stress in *Penaeus vannamei*

Sudden variations in pond water temperature and salinity in the changing climatic scenarios are stress factors to the shrimps, affecting their growth and development. To understand the transcriptional and biochemical changes due to acute temperature and salinity stress, *P. vannamei* was exposed to 22 and 32°C from 27°C, and 5 and 45 ppt from 30 ppt for 3 hours. The quality of PCR enriched libraries was examined in Tape Station system and the Illumina NovSeq6000 system was used to sequence the high-quality 18 paired-end RNA-seq library. DESeq2 program was used to assess the differences in transcript accumulation and differentially expressed genes (DEGs) were identified as transcripts with a p-adjust < 0.05 and an absolute threshold value of the log2 ratio > 2. Gene Ontology (GO) annotations and KEGG pathway analysis were used to investigate the roles of all DEGs. A total of 336 and 407 genes were found to be differentially expressed due to temperature and salinity stress, respectively. The important enriched GO terms related to molecular functions were identified. Understanding the molecular associated mechanisms would provide more useful information for the amelioration of stress responses.



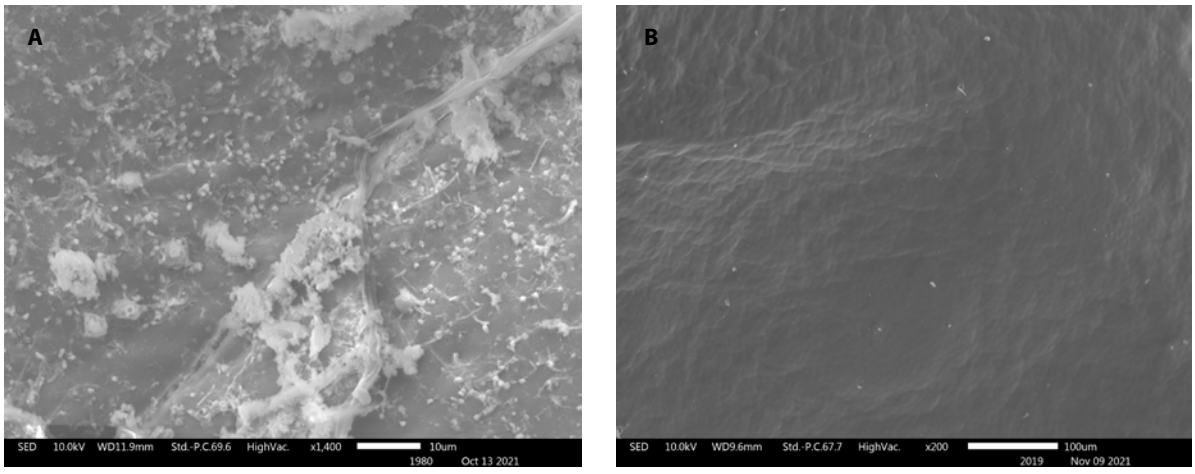
Volcano plot showing number of differentially expressed genes in each comparison of temperature (a & b) and salinity (c & d) stressors



Enriched gene ontology terms of temperature (a &b) and salinity (c & d) stressors

Effect of salinity on mineral deposition on the carapace of *Penaeus vannamei*

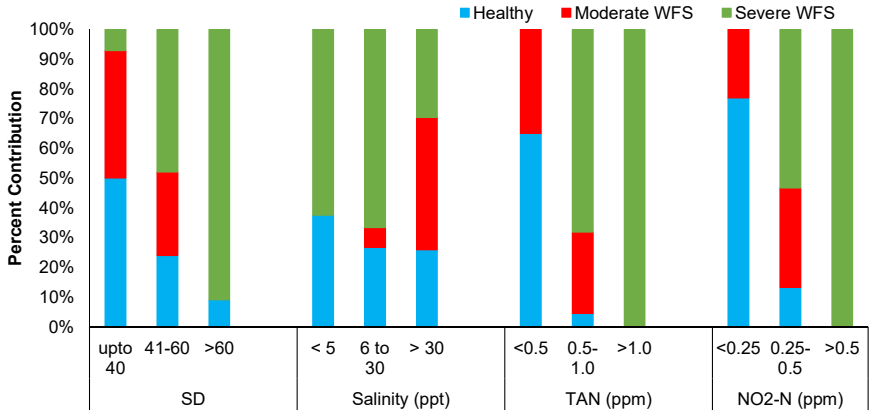
In our earlier studies on the effect of varying salinity on growth and mineral composition in *P. vannamei,* the mineral profiles of water and whole shrimp carcass were negatively correlated for calcium (-0.830), potassium (-708) and Ca: P ratio (-0.654). The calcium and Ca:P ratio (7.998 g/100 g on dry matter basis and 6.09) in the exoskeleton was also higher in shrimp reared in low salinity (3 ppt) compared to the shrimp reared in high salinity (60 ppt) (4.43 and 2.51 g/100 g on dry matter basis), respectively. To understand whether the mineralization pattern is uniform or not throughout the carapace, the present study was carried out by rearing the shrimp at 20 ppt and 3 ppt for 42 days after slow acclimatization to low salinity. The shrimp carapace samples after the experiment were processed under Scanning Electron Microscope (SEM). The SEM images have shown uneven deposition of minerals on the carapace of shrimp reared in 3 ppt indicating that it is not uniform hardening of the exoskeleton to prevent the moulting process.



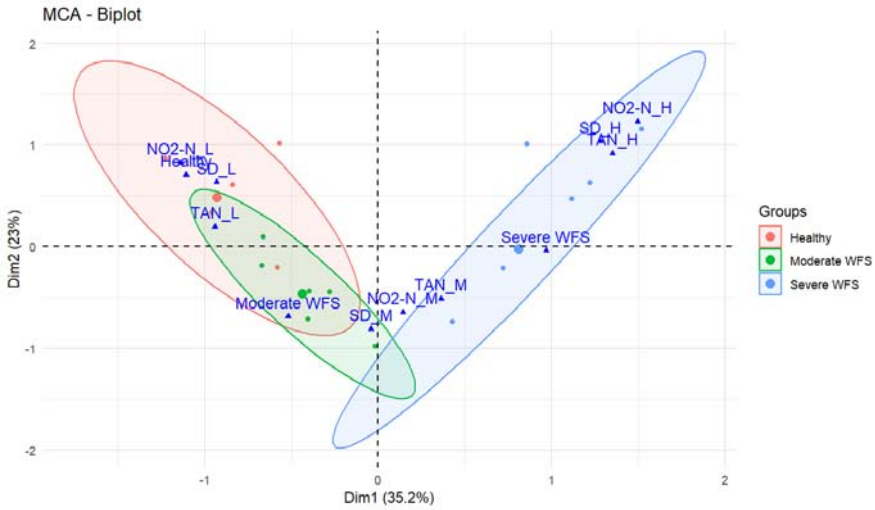
SEM photograph of shrimp carapace reared at (A) 3 ppt (1400x magnifications) and (B) 20 ppt (200 x magnifications)

Association of pond environmental parameters with White Faecal Syndrome (WFS) in *P. vannamei*

Water, soil and shrimp samples were collected from a total of 50 farms from Nellore (8) and West Godavari (12) districts in AP and Nagapattinam (10), Pattukottai (6), Ramnathpuram (8) and Tiruvallur (6) districts of TN. The stocking density (SD) ranged from 25 to 100/m^2, and salinity from 0 to 41 ppt. Based on the investigations, 14 ponds were categorised as healthy, 13 as moderate WFS with slight growth retardation, and 23 as severe WFS with high level of growth retardation and mortality. All the WFS affected shrimp were EHP positive, but the degree of WFS varied. The critical variables associated with WFS were SD, total ammonia nitrogen (TAN) and nitrite (NO_2-N) in pond waters. Multiple Correspondence Analysis revealed that rather than a single critical factor, a combination of factors is responsible for varying degrees of WFS: healthy ponds were more associated with low TAN and NO_2, and low to medium SD; moderate WFS with low to medium TAN, medium NO_2 and medium SD; severe WFS with medium to high TAN and NO_2 and high SD. Though EHP is a precursor for WFS, deteriorated pond environment aggravated its severity.



Number of farms (%) in each category of critical variables associated with WFS



MCA factor and biplot maps showing the association of critical variables with WFS

Assessment of suitability of inland saline waters of Uttar Pradesh for brackishwater aquaculture

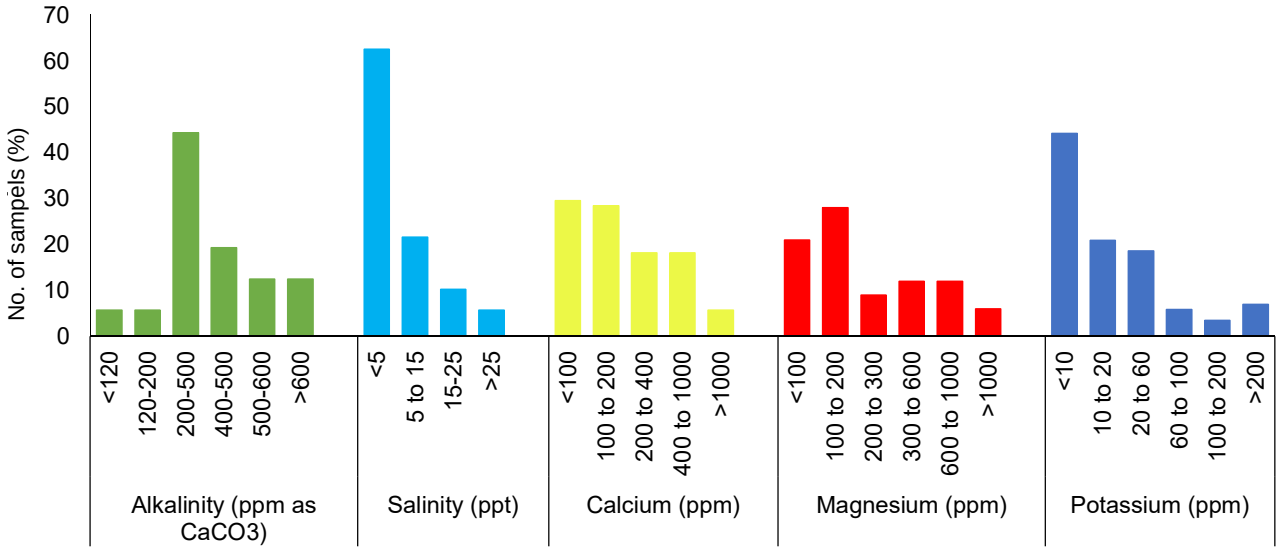
Ideal water quality parameters required for shrimp farming have been derived from farming in coastal waters which may not hold good with inland saline waters (ISW). The analysis results of 88 ISWs from Mathura District, Uttar Pradesh were evaluated for their suitability to brackishwater aquaculture (BWA). Based on the water parameters range, the number of samples in optimal range are categorised for each parameter. The recommended salinity for ISWs is 5 to 25 ppt. ISWs had an excess of magnesium and calcium than seawater due to which higher hardness compared to coastal waters of similar salinity. Alkalinity as ppm $CaCO_3$, ideally shall be 120 to 200 and farmers have been successfully raising crops even up to 400 to 500, and more than 600 is not recommended. Regarding minerals, there was a lot of variation in concentration and had inappropriate ionic ratios. The calcium concentration was comparatively very high affecting the Mg/Ca (0.30-2.75, only 8 samples above 2) and Ca/K ratios (0.45-125.53, only 10 samples below 1), signifies the supplementation of Mg and minerals. ISWs not suitable for agriculture (>5 ppt), and that have no other conflicting users can only be used for BWA after evaluating the suitability of each.

Map showing number of sampling stations in Mathura District, UP

Chemical properties and mineral profile and of inland saline waters in Mathura District, Uttar Pradesh

Water Parameter	Range	Samples in optimum value (%)
pH	7.15-8.52	100
Salinity (ppt)	0-40	38
Total Alkalinity (ppm $CaCO_3$)	40-1000	69
Total Hardness (ppm $CaCO_3$)	250-12700	28
Calcium (ppm)	32-1600	47 (76)*
Magnesium (ppm)	36-2235	24 (80)*
Potassium (ppm)	2.8-545.3	9 (49)*

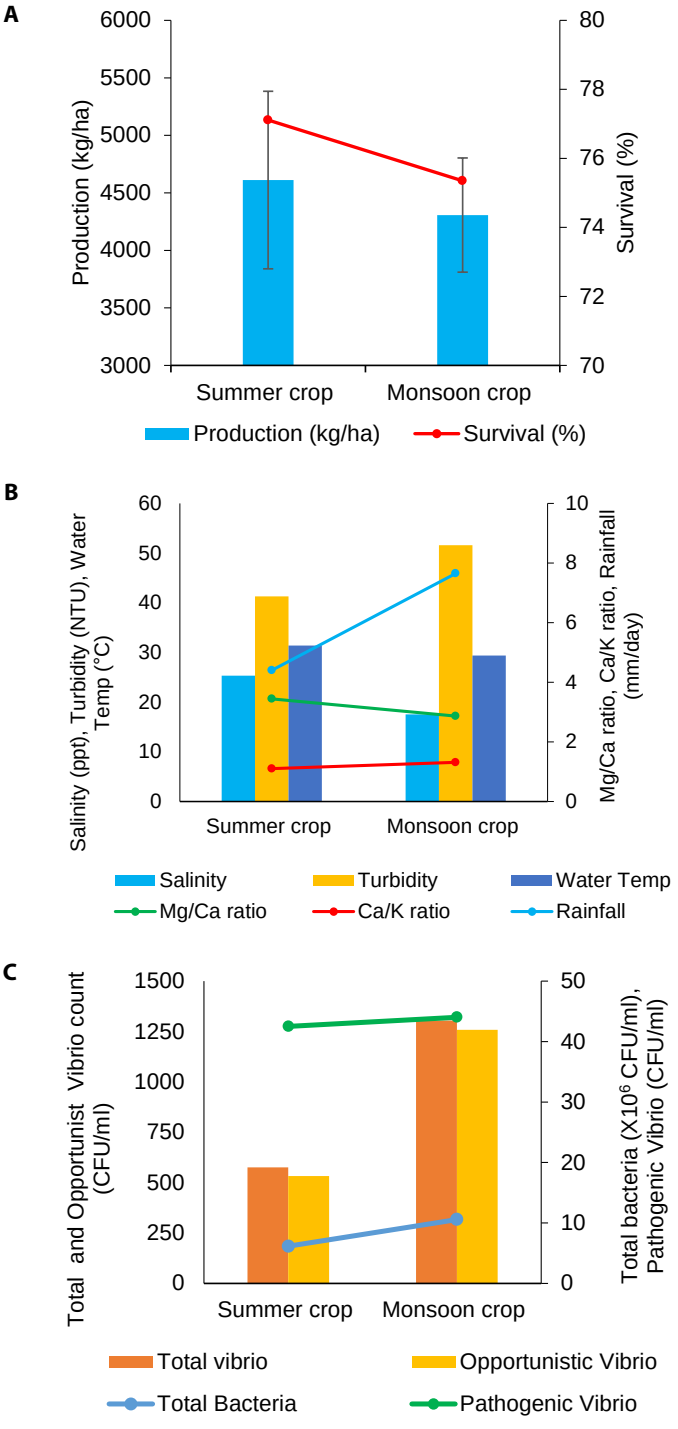
*Mineral supplementation can increase the number of samples in optimal range.



Categorisation of inland saline waters

Water quality, microbiology and production parameters of shrimp farms during the summer and monsoon crops

Shrimp farming during the monsoon season is influenced by the incessant rainwater that causes changes to the water quality parameters, which are not properly understood. Water quality and microbiological parameters were assessed from six distinct shrimp farms (*P. vannamei*) located within the Navsari region, Gujarat during the summer (March to July) and monsoon crops (July to November). The data obtained from the farms during the same crop were pooled and compared with the other using a two-sample t-test. The monsoon crops registered lower ($p<0.05$) water temperature, salinity, alkalinity and hardness as compared to summer crops. pH trends are dependent on plankton dynamics rather than rainfall. The total heterotrophic bacteria, total and opportunistic *Vibrio* were higher ($p<0.05$) during the monsoon crop, whereas pathogenic *Vibrio,* DO and TAN did not vary significantly. The ionic concentrations and ratios were significantly affected between the crops. Survival rate during the monsoon and summer crop varied from 52-100% and 68-83% respectively, though mean survival was similar between the groups.

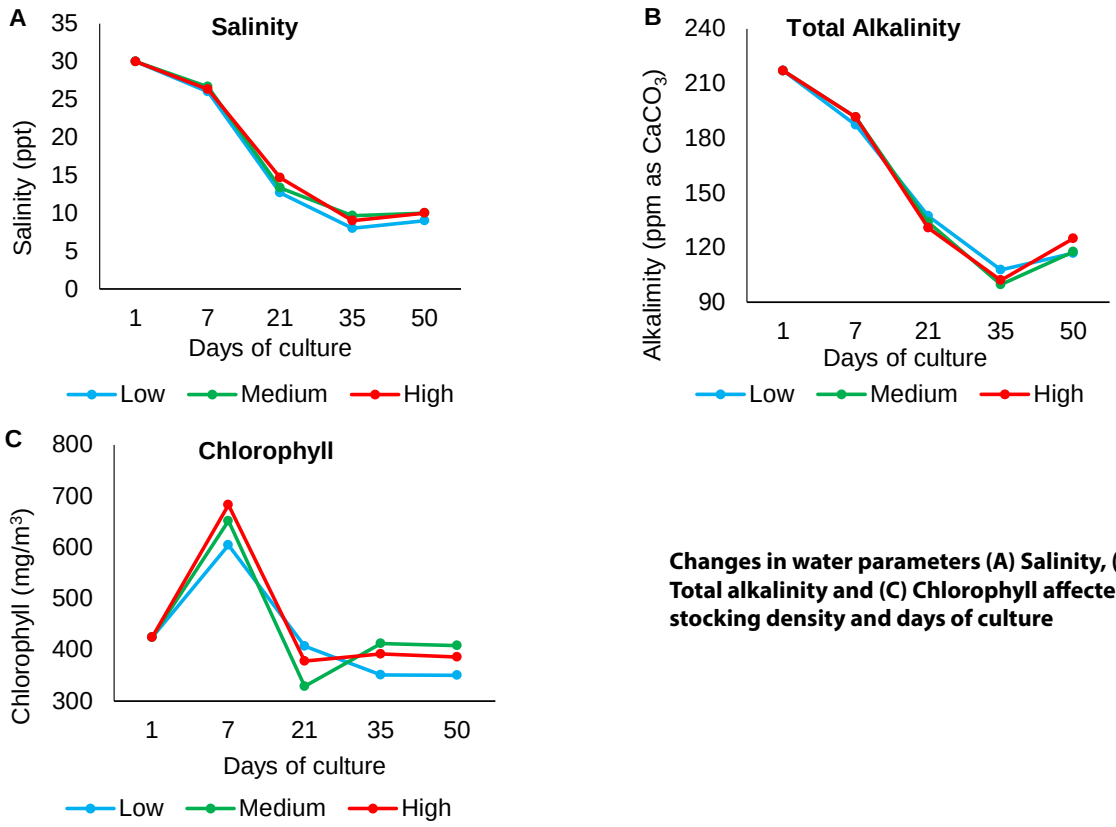


These observations suggest that production parameters are more dependent on factors like seed quality, husbandry followed, etc. rather than changes in water quality due to seasonal variations; however, understanding this shall dictate the husbandry practices to be followed.

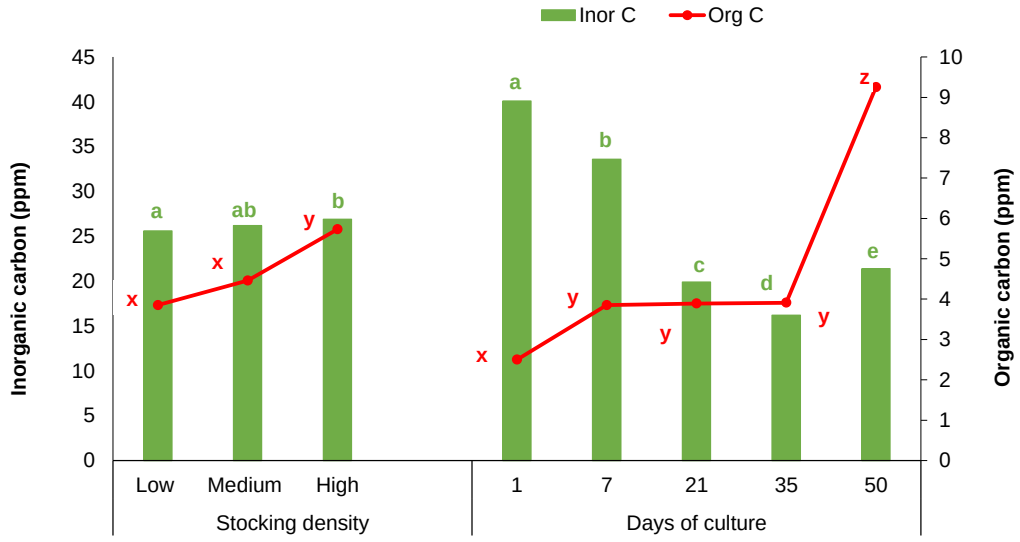
Average values of (A) water parameters and rainfall (B) Microbiological parameters and (C) Production and survival during summer and monsoon crops

Effect of stocking density on dynamics of carbon fractions in vannamei culture

The contribution of excessive usage of carbon as inputs in intensive and semi-intensive aquaculture systems to the global carbon cycle is poorly understood. To comprehend this concept, initially, the effect of stocking density (SD) on carbon fractions in pond water was determined. *P. vannamei were* reared for 60 days in 500 l tanks at three different SDs, 20/m^2 (Low), 40/m^2 (Medium), and 60/m^2 (High) in an outdoor experiment. Maximum shrimp growth and survival were registered in high and medium SD treatments, respectively. A decrease in salinity, alkalinity and chlorophyll (no defined trend) was observed with days of culture (DOC) in all the treatments due to heavy rainfall during the experiment. The inorganic carbon fraction forms a major component of the total carbon (ppm), which showed a decrease with DOC in all the treatments and an increase with SD (Low-29.5; Medium-30.7; High-32.6). The organic carbon (ppm) content showed a significant increase with DOC and was maximum with high SD (11.39) compared to medium (9.73) and low (6.64). The database on carbon fractions of different input and output processes of shrimp culture is essential for estimation of carbon budgeting and in turn its contribution to global warming.



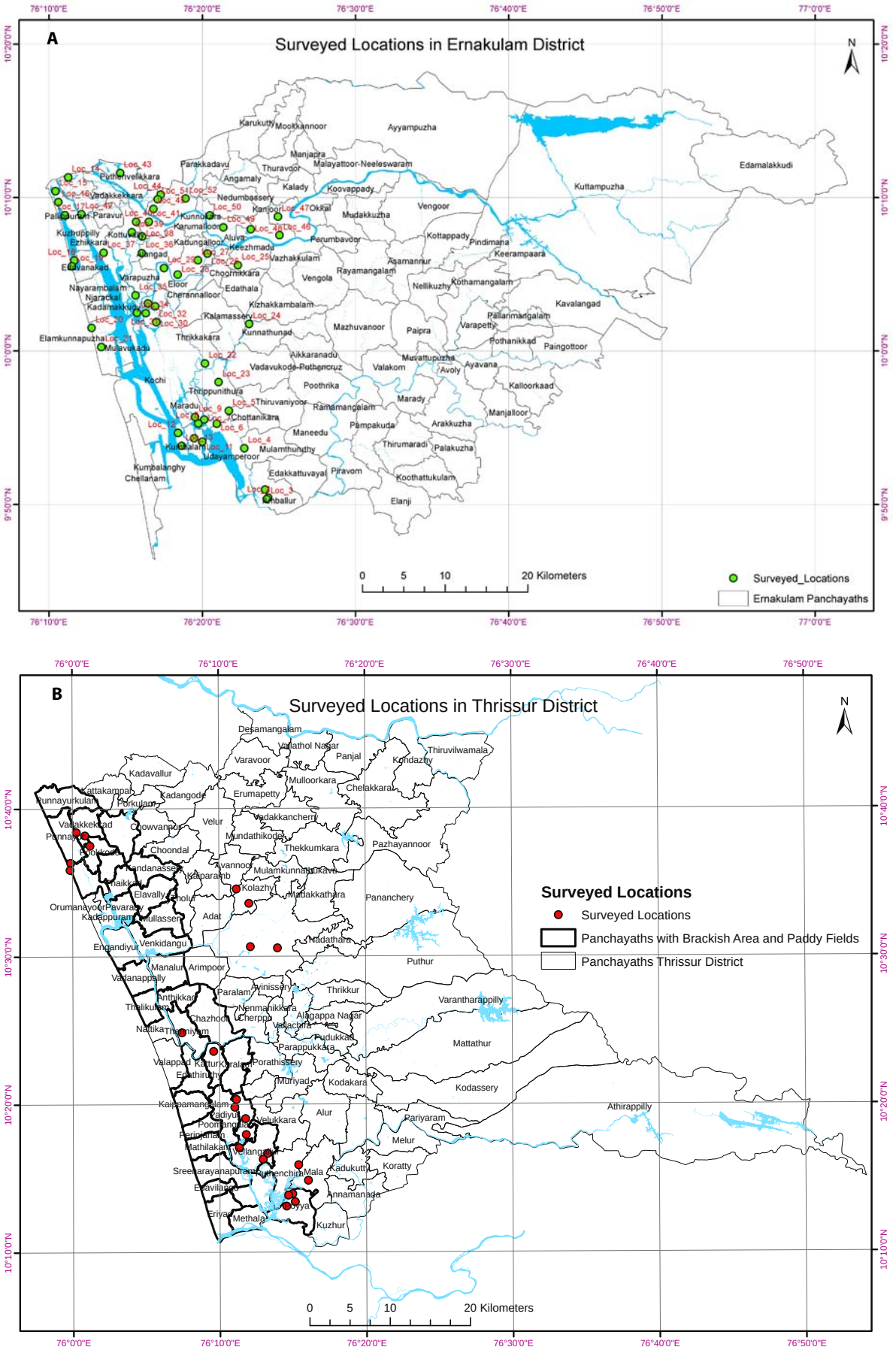
Changes in water parameters (A) Salinity, (B) Total alkalinity and (C) Chlorophyll affected by stocking density and days of culture



Effect of stocking density and days of culture on carbon fractions (Mean values with similar alphabets for inorganic carbon (a to e) and organic carbon (x to z) are not significantly different

Evaluation of the suitability of derelict paddy fields for shrimp farming in Kerala

A study was conducted to assess the suitability of the derelict paddy fields, which are not being used for any agriculture activities for more than 10 years, for shrimp farming and its environmental and social impact in Thrissur (n=24) and Ernakulam (n=52) districts of Kerala state. The total derelict paddy fields area identified using remote sensing was 559 ha in Thrissur and 940 ha in Ernakulam Districts. Based on the analysis results of water (pH, salinity, dissolved oxygen, ammonia, nitrite, total hardness, total alkalinity) and soil (pH, organic carbon, electrical conductivity) from abandoned paddy fields and nearby brackishwater sources, 117.4 ha (21%) and 179 ha (19%) were found to be suitable for an extensive system of shrimp farming/ polyculture of shrimp and finfishes in Thrissur and Ernakulam districts, respectively. About 33% (39 ha) and 86% (154 ha) of farmers are willing to take up shrimp farming immediately, with a projected employment generation of 23,400 and 92,400 man-days and, estimated revenue of ₹ 6.76 and ₹ 26.7 crores from Thrissur and Ernakulam districts, respectively. The conversion of derelict paddy fields to sustainable aquaculture will enhance the aquaculture production of the state, ensuring the livelihood security of a considerable percentage of farmers.



Surveyed locations in derelict paddy fields of (A) Ernakulam and (B) Thrissur districts, Kerala for their suitability to brackishwater aquaculture

Economics of *P. vannamei* farming in earthen and lined ponds

The lining of earthen ponds is one of the practices for a profitable and sustainable shrimp culture. The performance and economics of *P. vannamei* culture were compared in earthen and lined ponds. 250 GSM HDPE (high-density polyethylene) material was used for lining the ponds. The HDPE material is flexible and can be easily fused or glued together during installation. Shrimp culture under earthen and lining affects the survival rate and production of *P. vannamei*. In three months, shrimp attained a weight of 21 g and 19.3 g under earthen and lined ponds, respectively. The required polythene lining material for 1 Ac is 46,000 ft^2, and its durability is around 5 years. The lining cost is ₹ 6/ft^2. Though initially, the profit per crop was more in earthen ponds, lining ponds can be more profitable in the long run due to the possibility of higher stocking densities and more number of crops per year in lined ponds. The economic analysis showed a higher benefit/cost ratio in the lined ponds. The practice of lining earthen ponds is recommended for successful culture in sandy and acidic soils.

Lined pond

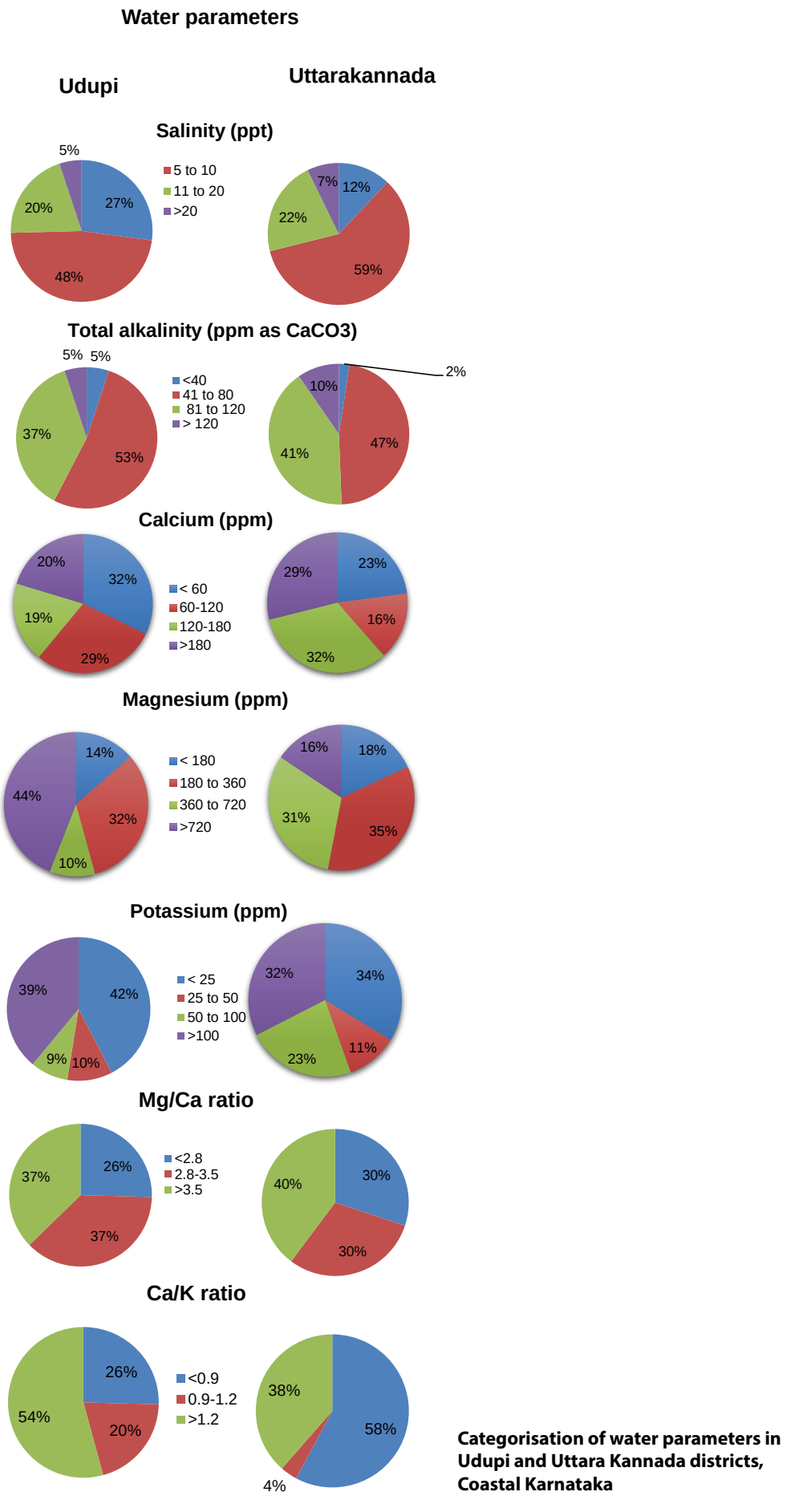
Earthen pond

Economics of *P.vannamei* culture in earthen and lined ponds

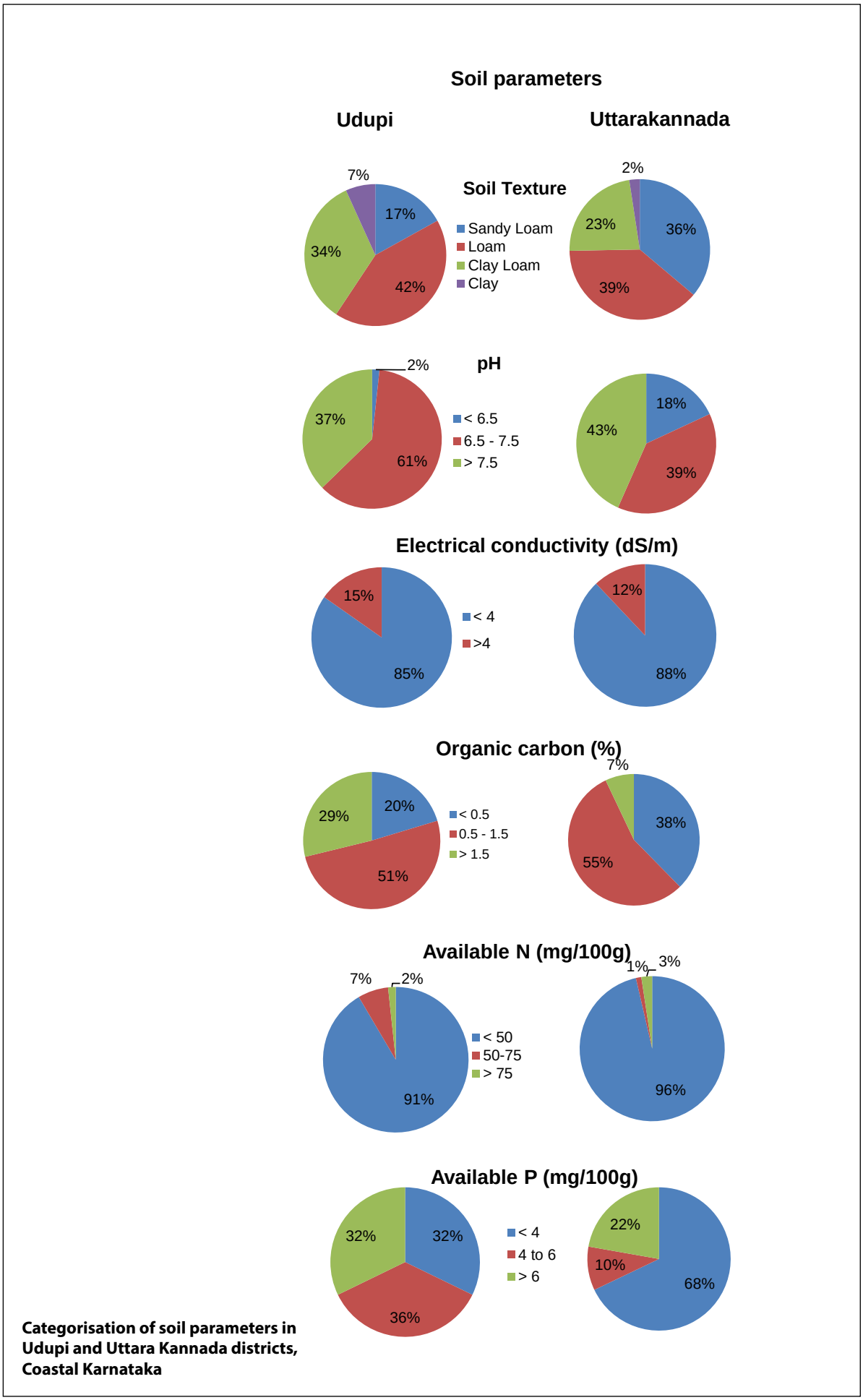
Parameter	Earthen Ponds	Lined Ponds
No of crops per year	2 to 3	3 and more
Time required for pond preparation in weeks	4 to 6	1 to 2
Average production/ha/year	6250	7400
Average price realized/kg	325	325
Gross costs (Variable + depreciated fixed costs ₹/ha/year)	17,50,000	19,24,000
Gross returns (₹/ha/year)	20,31,250	24,05,000
B/C ratio	1.16	1.25

Characterisation of shrimp culture source waters and pond soils of coastal Karnataka

Pond soil and source water samples from Kundapura and Byndoor Taluks in Udupi (n=62), and Kumta, Ankola, Karwar, Bhatkal and Honnavar Taluks in Uttara Kannada (n=86) Districts, coastal Karnataka were characterised for physicochemical parameters. Sandy loam was the dominant soil texture, and a large number of soils were in 6.5-7.5 and >7.5 (good) for pH and 0.5-1.5% (medium) for organic carbon and <50 mg/100 g (poor) for available nitrogen in both the districts. Soils in the Kadwad village of Karwar Taluk were highly acidic (pH-2.6). About 32 and 68% of soils were poor in available phosphorous (<4 mg/100 g) in Udupi and Uttara Kannada districts, respectively. Most of the water samples were in the optimum range for pH, alkalinity and turbidity. About 39 and 61%, 10 and 31%, 39 and 32%, 37 and 30%, and 20% and 4% of samples were optimum for calcium, magnesium, potassium, Mg/Ca ratio (2.8-3.5), and 0.9-1.2 for Ca/K ratio in Udupi and Uttara Kannada districts, respectively. Overall, all the areas are suitable with proper management practices, except for acidic soils in Karwar region, polythene lining is recommended.



Categorisation of water parameters in Udupi and Uttara Kannada districts, Coastal Karnataka

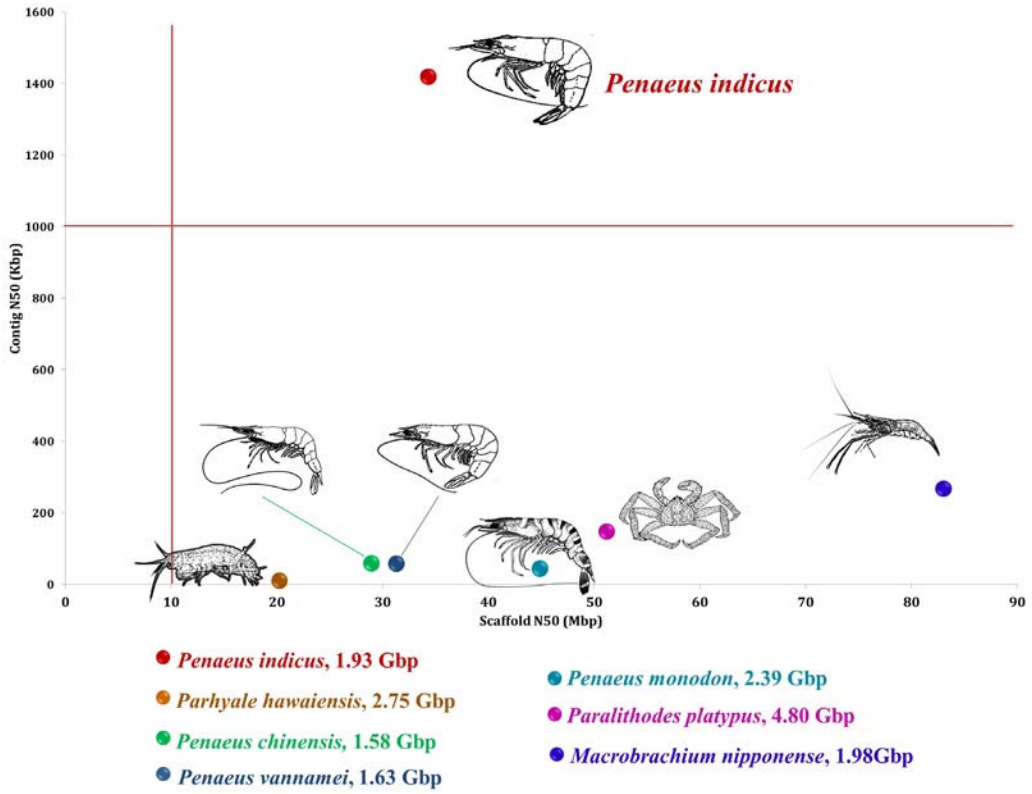


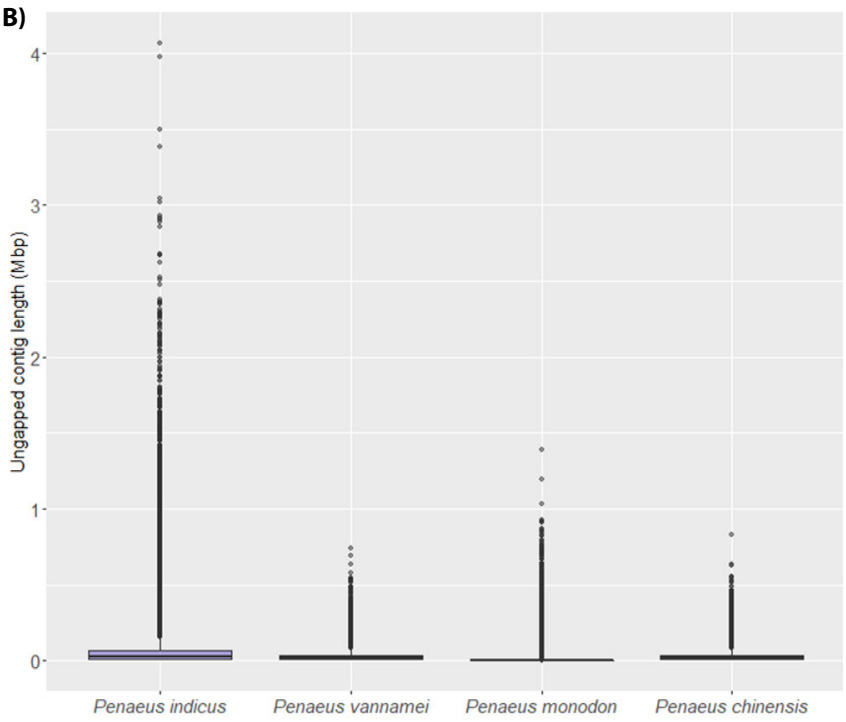
Categorisation of soil parameters in Udupi and Uttara Kannada districts, Coastal Karnataka

A superior, contiguous whole genome assembly for *Penaeus indicus*

The genetic improvement programs being operated in shrimp benefit hugely from genomic resources. About 83% of the global farmed shrimp production in 2019 (FAO, 2020) is contributed by a single species, *Penaeus vannamei*. Such global dependence on a single species is not an ideal scenario for sustainability of shrimp farming industry. For India, the future genetic improvement programmes with focus on native species like *P. indicus* would benefit aquaculture with increased productivity and sustainability. To this end, we have generated assembly of *P. indicus* genome with an aim to integrate genomic information into future breeding programmes to improve desired economic traits. The genome assembly of *P. indicus* is the only Crustacean assembly to meet the reference standards of 1 Mb contig N50 and 10 Mb scaffold N50 lengths, among genomes of >1.5 Gb assembly length. The assembly is 1.93 Gb length (34.4 Mb scaffold N50) with 28,720 protein-coding genes and 49.31% repeat elements. The *P. indicus* assembly has 31.99% of simple sequence repeats, the highest among sequenced animal genomes. In comparison to other shrimp genomes having short contig lengths, the *P. indicus* assembly has 346 un-gapped contigs of over 1 Mb length and betters other shrimp genomes on sequence contiguity. The assembly has applications to genetic improvement programs, evolutionary studies and stock management.

A)





Quality assessment of assembly generated for *P. indicus* in comparison to the other shrimp genome assemblies. **A**. Plot of contig N50 and scaffold N50 lengths of finished large (>1.5 Gb) crustacean genomes. The *P. indicus* is the only large crustacean genome assembly that has >1 Mb contig N50 and >10 Mb scaffold N50 lengths. **B.** Un-gapped contig length distribution for finished shrimp genomes. The genome assembly of *P. indicus* has more contigs longer than 1 Mb length.

Chromosome-scale genome assembly of *Mugil cephalus*

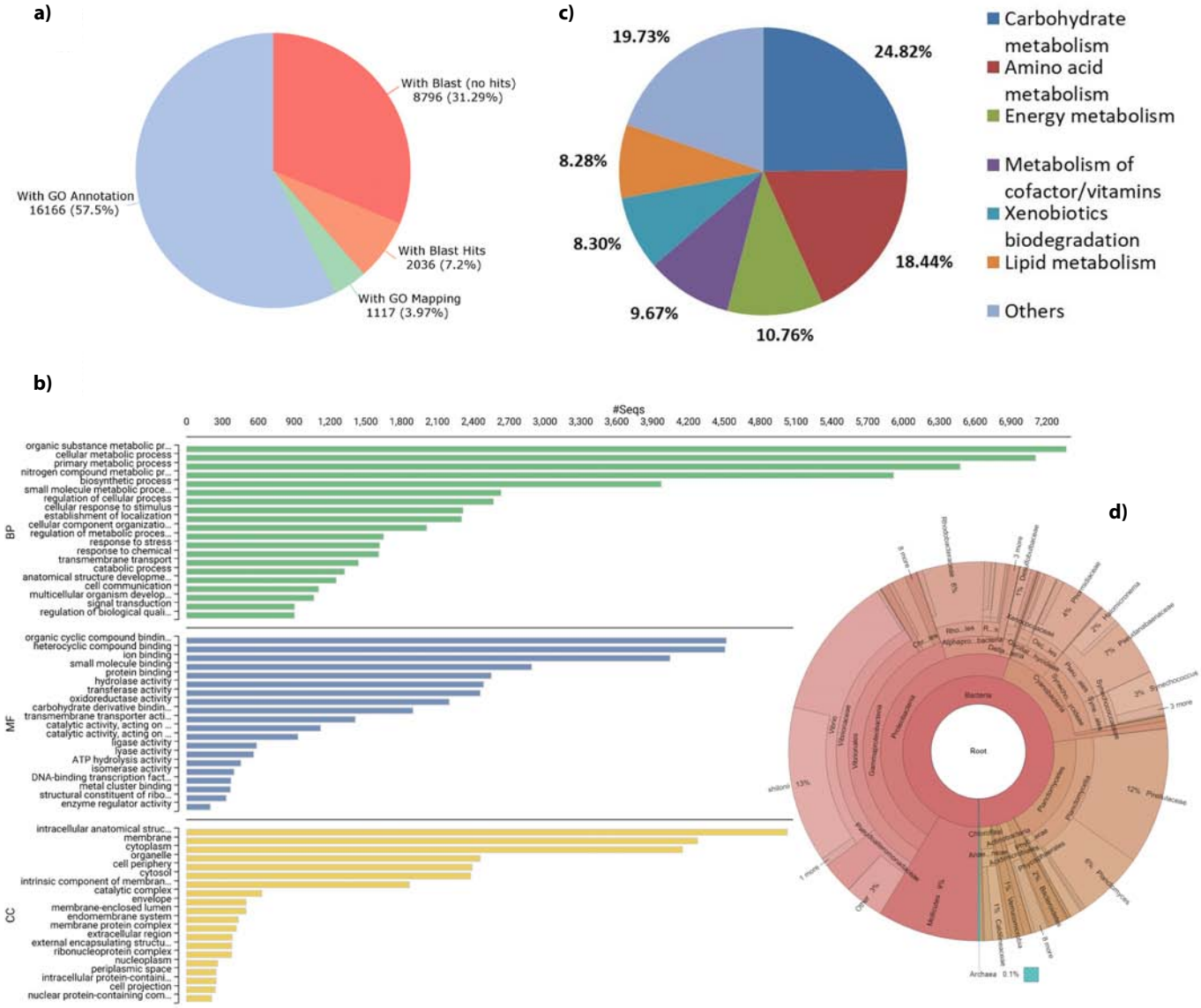
In the previous year, we have reported a contig-level genome assembly for *M. cephalus* using 91 Gb of sequence data generated on Pacbio Sequel II sequencer. In this year, we have used additional Pacbio data along with Illumina short reads and Arima HiC reads to produce a chromosome-scale genome assembly. Overall, 257 Gb of Pacbio reads were used for generating contigs which were polished with Illumina reads and scaffolded to chromosomes using HiC reads. The final assembly contains 24 pseudochromosomes representing 634 Mb of assembly length with N50 metric of 28.3 Mb. The genome completeness was assessed as 96% complete, using BUSCO v5.2.2 against the Actinopterygii_odb10 orthologous database. The genome was found to contain 11.72% of repeat elements of which DNA transposons were the predominant repetitive element. The genome was predicted to harbour 27,269 protein-coding genes based on the evidence from RNAseq data, Isosequencing data and proteins from the genomes of related species.

Profile of repetitive elements in the genome assembly of *M. cephalus*.

Repeat class/family	Number of elements	Length occupied (bases)	Percentage of sequence
SINEs	19,692	22,85,123	0.36
LINEs	73,955	1,54,84,657	2.44
LTR elements	39,804	55,63,353	0.88
DNA transposons	2,33,659	3,36,64,198	5.30
Rolling-circles	5,881	5,55,616	0.09
Unclassified	1,743	3,01,835	0.05
Small RNA	3,363	2,68,065	0.04
Satellites	2,879	3,62,353	0.06
Simple repeats	3,52,967	1,39,66,215	2.20
Low complexity	48,556	25,04,867	0.39

Transcriptomic and metagenomic resources for *Penaeus indicus* juveniles

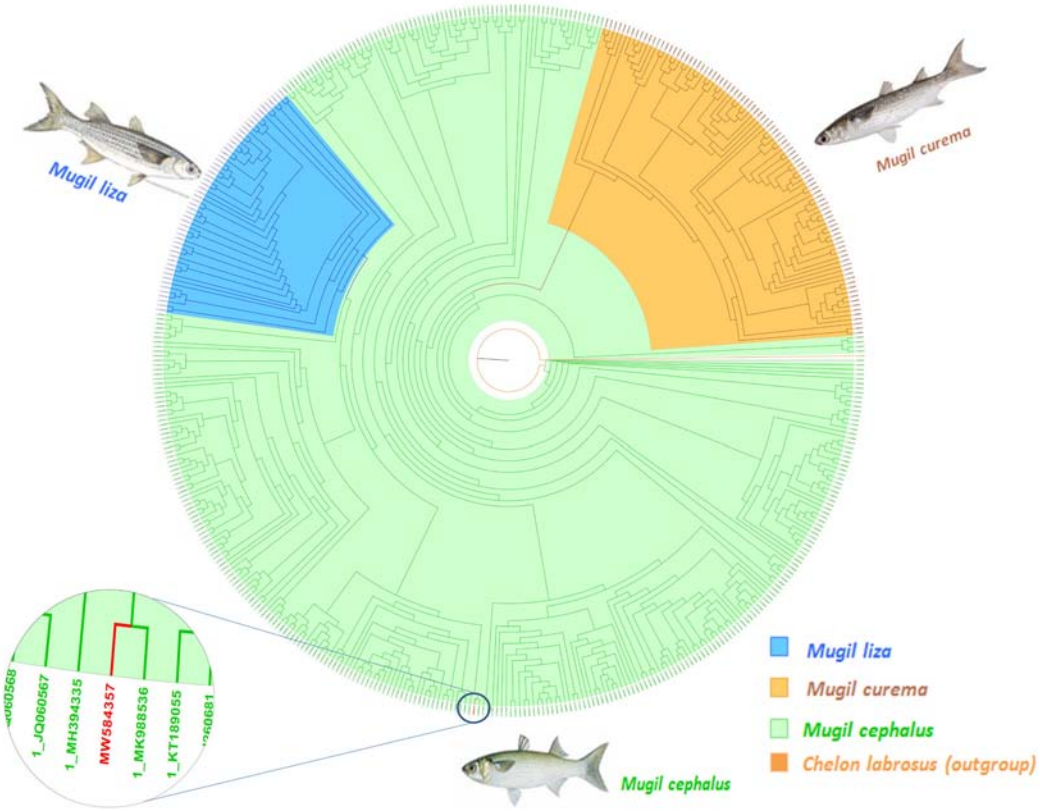
Advances in next-generation sequencing technologies have contributed to the significant rise in genomic resources of several organisms. However, there has been a slow pace in building such information generally for crustaceans. There is limited information available on genomic resources of *P. indicus*, which needs to be generated. In this study, data on hepatopancreas transcriptome and gut metagenome were generated for *P. indicus*. Analysis of assembled transcripts revealed 28,115 unigenes of which 16,166 were functionally annotated. Prominent GO terms include organic cyclic compound binding, Organic substance metabolic process and intracellular anatomical structure were among the top assignments for Molecular Function, Biological Process, and Cellular Component categories respectively. Major KEGG pathway representations include carbohydrate metabolism (24.82%), amino acid metabolism (18.44%), energy metabolism (10.76%), and metabolism of cofactor/vitamins. Among the single sequence repeats of unigenes, tri-nucleotide repeats were found to be the most abundant class followed by mono and di-nucleotides. Proteobacteria, Planctomycetes, Cyanobacteria, and Tenericutes were found to be major phylum level associations in intestinal microbiota of *P. indicus* juveniles, while Vibrio, Planctomyces, and Synechococcus were among the identified highly abundant genera. This study reported annotated hepatopancreas transcriptome of *P. indicus* juveniles along with its intestinal microbial communities.



a) Annotation summary of unigenes b) Distribution of most abundant Gene ontology (GO) terms c) Represented KEGG pathways of unigenes d) Representation of intestinal microbial composition through Krona plot

Phylogenetic analysis of *Mugil cephalus*

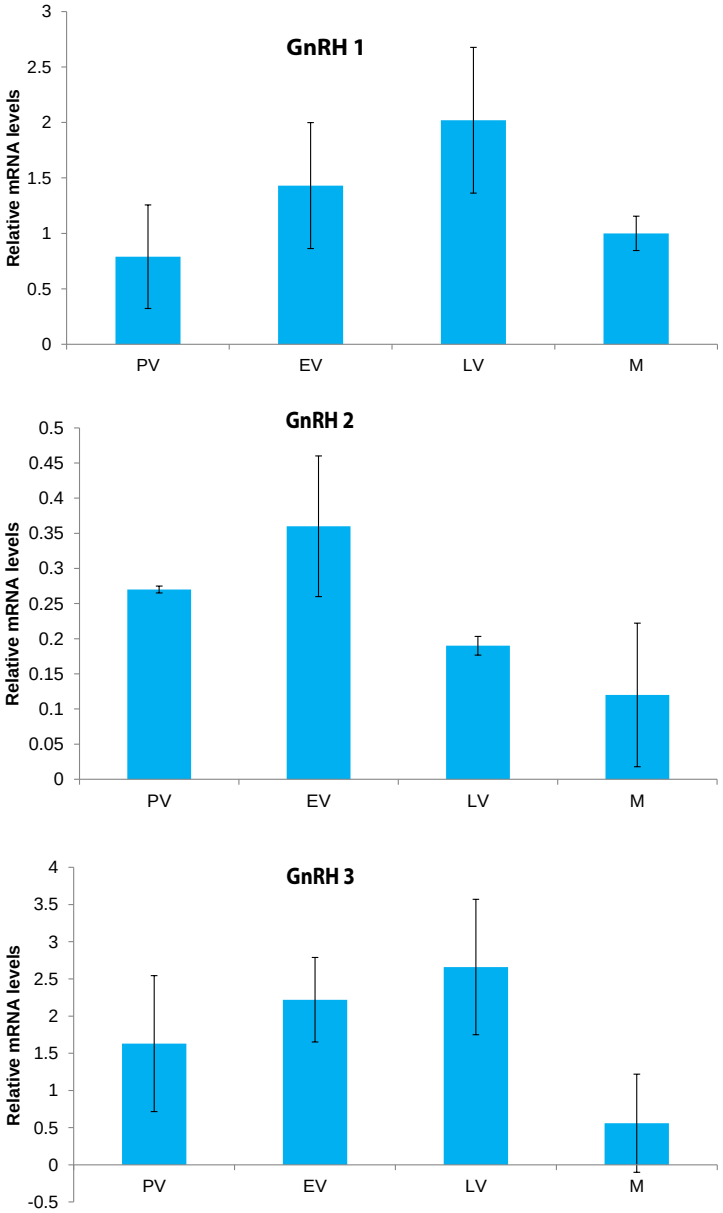
Mugil cephalus, the grey flathead mullet, is commonly distributed across the world and mostly inhabits inshore sea, estuaries, brackishwater areas. It is of important commercial value to global fisheries and aquaculture with high demand for mullet roe. This widely distributed fish species belongs to family Mugilidae which comprises 26 genera and 79 valid species. The phylogenetic analysis was carried out using partial COI gene sequence of *M. cephalus* (GenBank accession number MW584357). The analysis included sequence accessions of related mullet fishes from the BOLD database. In total, about 478 accessions of CO I gene were used for analysis. The final consensus alignment was used to build Maximum Likelihood (ML) tree in RAxML keeping *Chelon labrosus* as outgroup.



Maximum likelihood phylogenetic tree of partial COI gene sequence of 478 *Mugil* species. Branch labels show the designated NCBI GenBank accession numbers for the individual samples and the lab generated sample accession is shown in red

GnRH expression in Etroplus suratensis

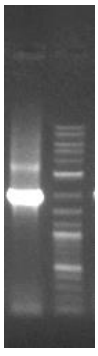
A precise coordination of neuroendocrine hormones acting through the brain-pituitary-gonad axis regulates reproduction in vertebrates. Among the neurohormones, gonadotropin-releasing hormone (GnRH), is the key regulatory molecule modulating the synthesis and release of gonadotropins from the pituitary, which in turn act downstream on the gonads to release sex hormones. *Etroplus suratensis* expresses three forms of GnRH (GnRH1, GnRH2 and GnRH3) in the brain. To understand the physiological roles of the respective forms of GnRH in reproduction, the differential mRNA expression levels of three forms of brain GnRH in females at previtellogenic (PV), early vitellogenic (EV), late vitellogenic (LV) and oocyte at mature stage (M) were examined by real-time quantitative PCR. The highest expression levels of brain *gnrh* 1 and *gnrh* 3 mRNA were observed in LV stages of ovarian development while *gnrh2* mRNA transcript levels were maximum at EV stage. The results indicate a good correlation of brain gnrh mRNA levels with the reproductive condition, suggesting the involvement of these molecules in the regulation of ovarian function.



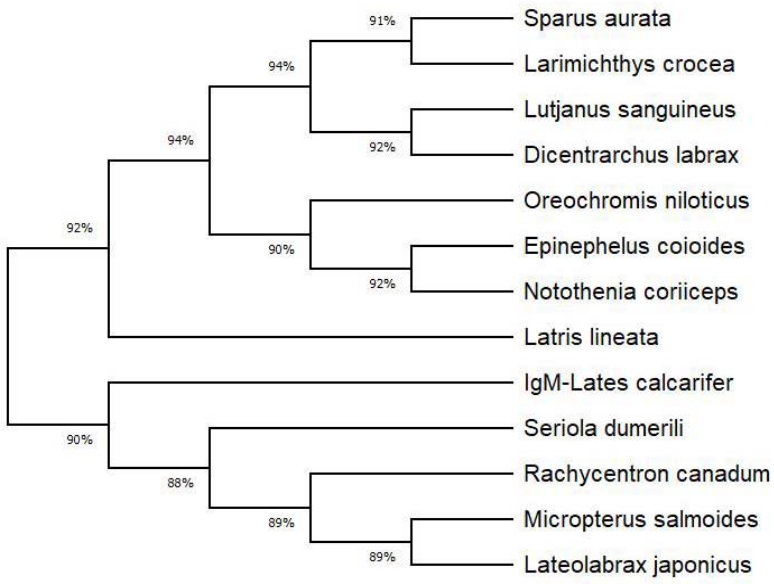
GnRH mRNA levels during different stages of development in *E. suratensis*

Molecular cloning and sequencing of Immunoglobulin M heavy chain gene of Asian seabass *Lates calcarifer*

Immunoglobulin M (IgM) is the primordial immunoglobulin of the adaptive immune system which is found in monomeric and tetrameric forms in circulating blood of teleosts. To characterise the IgM gene of Asian seabass, *Lates calcarifer* (*LcIgM*), fingerlings weighing about 20 g were infected with Red-spotted grouper nervous necrosis virus intramuscularly. *LcIgM* was PCR amplified from kidney tissues three days post-infection using gene specific degenerate primers LcIgM-F: 5´GATGGACTATAGGACAGGACTGC3´ and LcIgM-R: 5´CTACTGGGCCTTGCAYGTTTC3´. The obtained amplicon was cloned using pGEMTeasy vector and sequenced. The obtained sequence was 1740 bp in size. The partial *LcIgM* lacks 2 nucleotides at 5'end and 9 nucleotides at 3'end. The *LcIgM* was predicted to yield a peptide of 579 amino acid (aa) length. Signal peptide was predicted to contain amino acids 1-19. The deduced peptide of IgM was predicted to have four domains viz. heavy chain variable domain (21-135aa), first constant domain of heavy chain (142-288aa), third and fourth constant domain of heavy chain (459-563aa) and Ig superfamily domain (253-332aa). Prosite predicted conserved characteristic cysteine residues which are involved in intra-domain disulfide bridges are present in all the four domains. Phylogenetic tree revealed *LcIgM* clustered with R*achycentron canadum* whereas *Lutjanus argentimaculatus* and *Dicentrarchus labrax* formed another cluster.



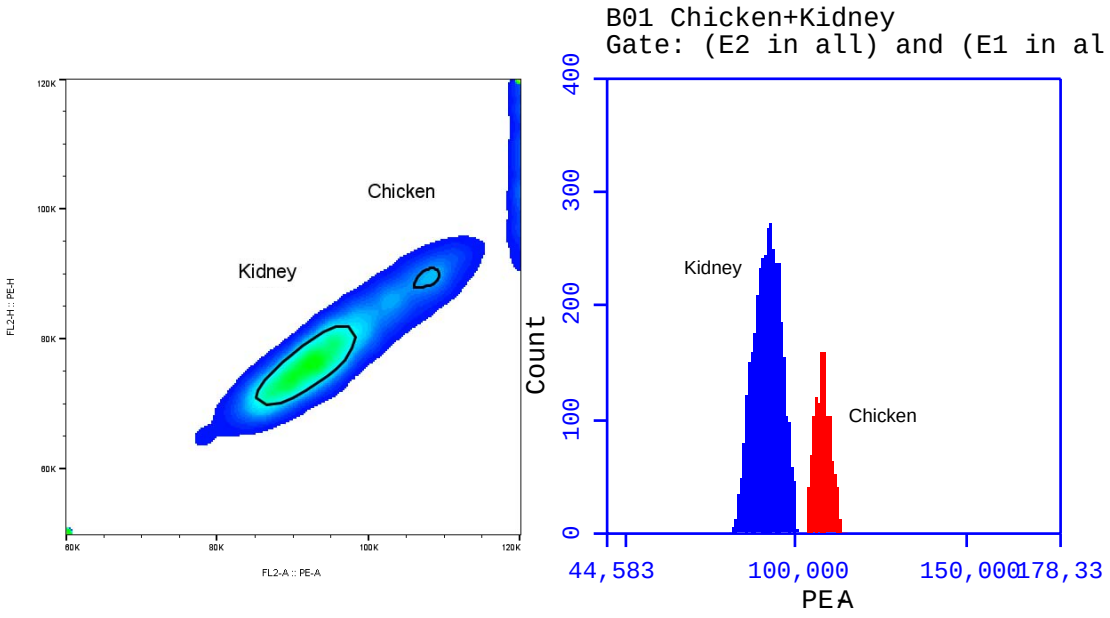
PCR amplification of 1740 bp size of Asian seabass IgM heavy chain gene



Maximum likelihood phylogenetic tree constructed on deduced peptide of IgM heavy chain gene of Asian seabass

Genome Estimation of Mangrove red snapper, *Lutjanus argentimaculatus*

The flow cytometry readings were acquired on BD Accuri™ C6 flowcytometer for control chicken erythrocytes and the samples. For genome size estimation, the gating of the density plots was carried out and histogram data was acquired using FlowJo Software. Generation of density plot and histograms for genome size estimation from kidney tissue is shown below. The average genome size of *L. argentimaculatus* was estimated to be 1.06 pg.



Generation of density plot and histograms for genome size estimation of *L. argentimaculatus*

Pearlspot full-sib families and their growth performance: An initiative on selective breeding

To sustain and prosper in aquaculture the availability of good quality seed, feed, health and management are required. Although, several developments had been achieved on the later components; the improvements on seed had been achieved or in process for only few species. Here we have established six pealspot full-sib families on experimental basis to record the growth parameters which would be useful for selective breeding. Adult Pearlspot fish were grown in FRP tanks for breeding. Ten pairs were identified and transferred to ten different FRP tanks. Among them six pairs spawned successfully. After spawning, the larvae were cultured in the nursery tanks till 60 and 90 days to develop them into fingerlings.

Meantime, six cages (1 m × 2 m) were built and placed in KES pond. The six full sib fingerlings were then stocked in six different cages. At the time of stocking the P^H and the salinity of the lagoon were 7.2 and 24PPT. The total body length and body weight of all the families were recorded. Survival rate was observed to be ranged between 90.2 to 99.2%. Bodyweight was almost doubled in all the families between 30th and 60th day of stocking. Body weight parameter had higher coefficient of variation than the body length.

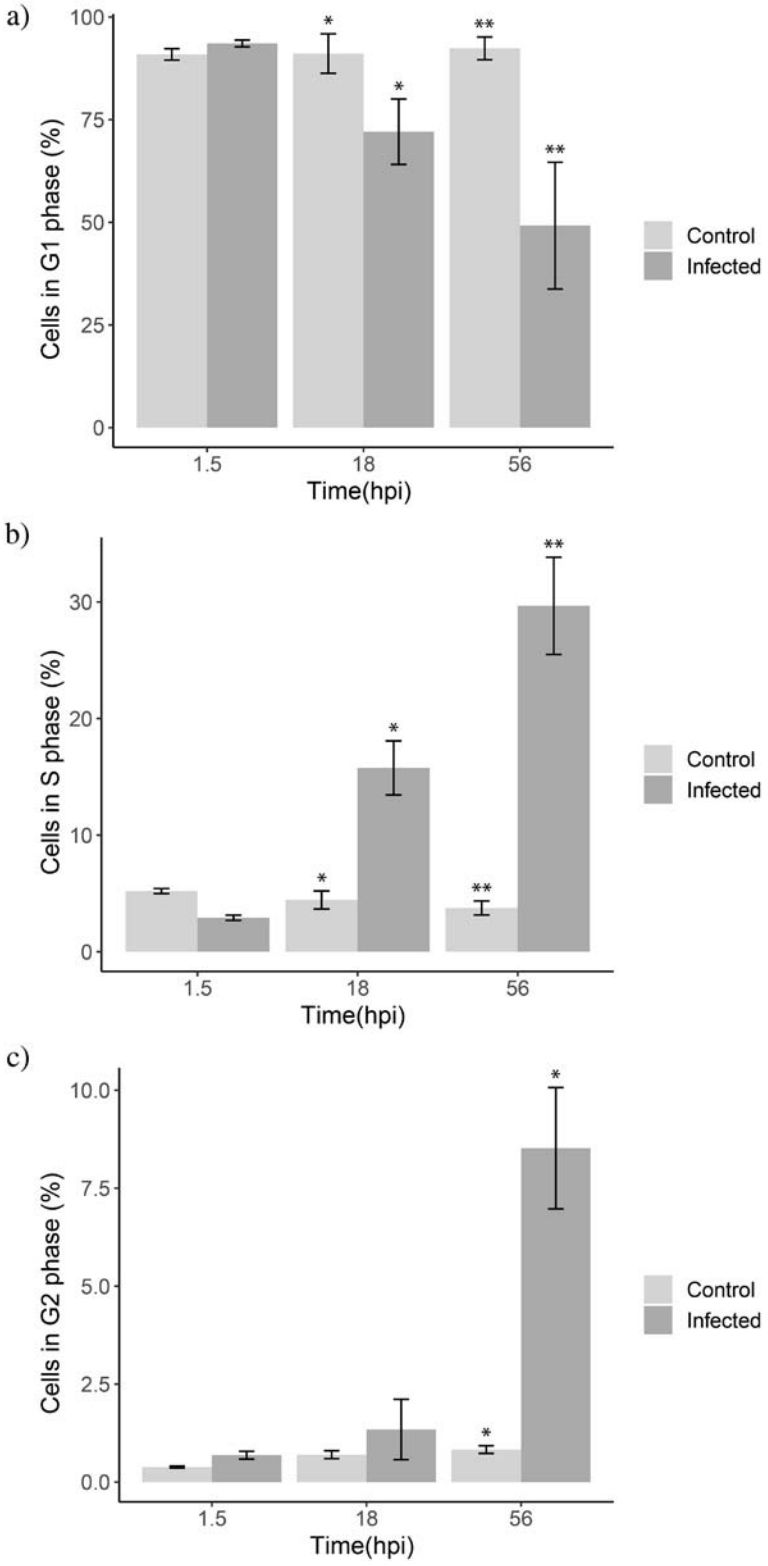
Growth parameters of pearlspot full-sib families

Growth parameters		Family 1	Family 2	Family 3	Family 4	Family 5	Family 6
Stocking in cages		at ~ 90th day post hatch			~ 60th day post hatch		
No of fishes stocked		82	38	55	120	117	110
Fishes survived after 120 days of stocking		74	37	53	119	116	108
Survival (%)		90.2	97.3	96.4	99.2	99.1	98.2
Total body length	Mean on 30th day of stocking (cm)	6.4±0.13	6.2±0.13	6.1±0.29	4.1±0.17	5.1±0.15	6.3±0.31
	Mean on 60th day of stocking (cm)	7.5±0.16	8.6±0.15	7.7±0.38	5.1±0.11	6.2±0.22	7.1±0.29
	Mean on 120th day of stocking (cm)	8.77± 0.17	9.68 ± 0.23	8.86 ± 0.34	6.79 ± 0.14	7.59 ± 0.21	8.0 ± 0.13
	Coefficient of variation (%)	7.08	8.92	14.53	7.71	10.63	5.91
Body weight	Mean on 30th day of stocking (gm)	5.7 ±0.34	6.0±0.56	5.8±0.72	1.2±0.12	1.7±0.18	2.4±0.46
	Mean on 60th day of stocking (gm)	11.94 ±0.62	16.18 ±1.12	12.22 ±1.82	3.12 ±0.16	6.23 ±0.40	9.78 ±1.03
	Mean on 120th day of stocking (gm)	19.94 ± 1.08	25.86 ± 1.64	21.29 ±2.60	8.86 ±0.53	13.07 ±1.17	14.51 ± 0.60
	Coefficient of variation (%)	20.25	23.69	45.64	22.52	33.48	15.37

Six full-sib pearlspot fish families cultured separately in six cages in pond

Effect of WSSV infection on cell cycle regulation, respiratory burst and cytoplasmic free calcium concentration in *Penaeus vannamei*

Molecular interactions between the host and viruses during the course of infection involve several mechanisms to suppress host cellular processes, or stimulate immune response. In order to study the effect of WSSV infection on shrimp immune response, cell-cycle regulation, respiratory burst and cytoplasmic free calcium (Cf-Ca^{2+}) were analysed at 1.5 hpi, 18 hpi and 56 hpi in haemolymph of WSSV infected *Penaeus vannamei* shrimp by flow cytometry. WSSV induced proliferation of haemocytes with very high levels of respiratory burst and cytoplasmic free Ca^{2+} concentration in WSSV-infected *P. vannamei*, indicating functional interlink between these parameters which might have a damaging role in WSSV-infected *P. vannamei*.

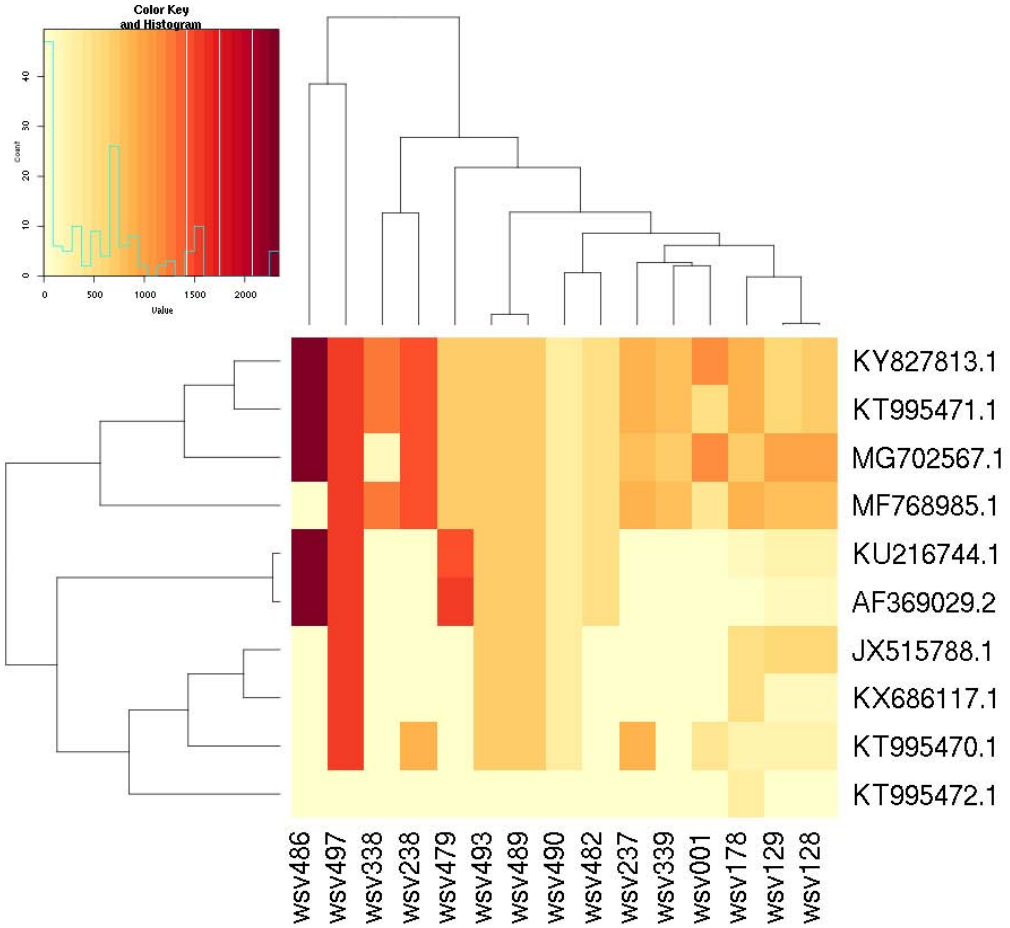


Flow cytometry cell cycle analysis of haemocytes from control (n = 3 at each time point) and WSSV-infected (n = 3 at each time point) (Group I) shrimps across different time points (a) G1 phase (b) S phase (c) G2 phase

Batch-mode utility of Missing Regions Finder for virus comparative genomics involving multiple isolates

Pathogenic virus research benefits from tools that could directly indicate the missing genomic regions and coding sequences (CDS) between isolates/strains. Such tools are of special importance to virus cases like White Spot Syndrome Virus, WSSV where the genomes are highly-similar, length-varying with inconsistent genome annotation features. Comparative genomic tools primarily focus on genomic similarities but ignore genome length differences. Often, the loss or gains of genomic regions are attributed to the degree of virulence. In this context, earlier we have developed a tool called Missing Regions Finder, MRF to document the missing genomic regions and CDS in a query genome in comparison to a reference genome.

However, in viruses with more CDS, knowledge of those major CDS differing between genomes helps researchers to quickly focus on them first. Same is the case with viruses having a high number of genomes, where advances would be rapid, if focus can be brought down quickly to few genomes. The said knowledge can be gained quickly if we can analyse multiple genomes simultaneously. To achieve this, we have developed a batch mode utility of MRF as command-line version that allows us to compare multiple genomes in single run. This batch mode utility of MRF offers the versatility of analyzing multiple query genomes against a reference and sort the results based on user defined criteria along with graphical outputs such as heatmap. In virus research, this is an advancement to find the differences between genomes and to quickly identify the important CDS/genomes that require early attention from researchers.

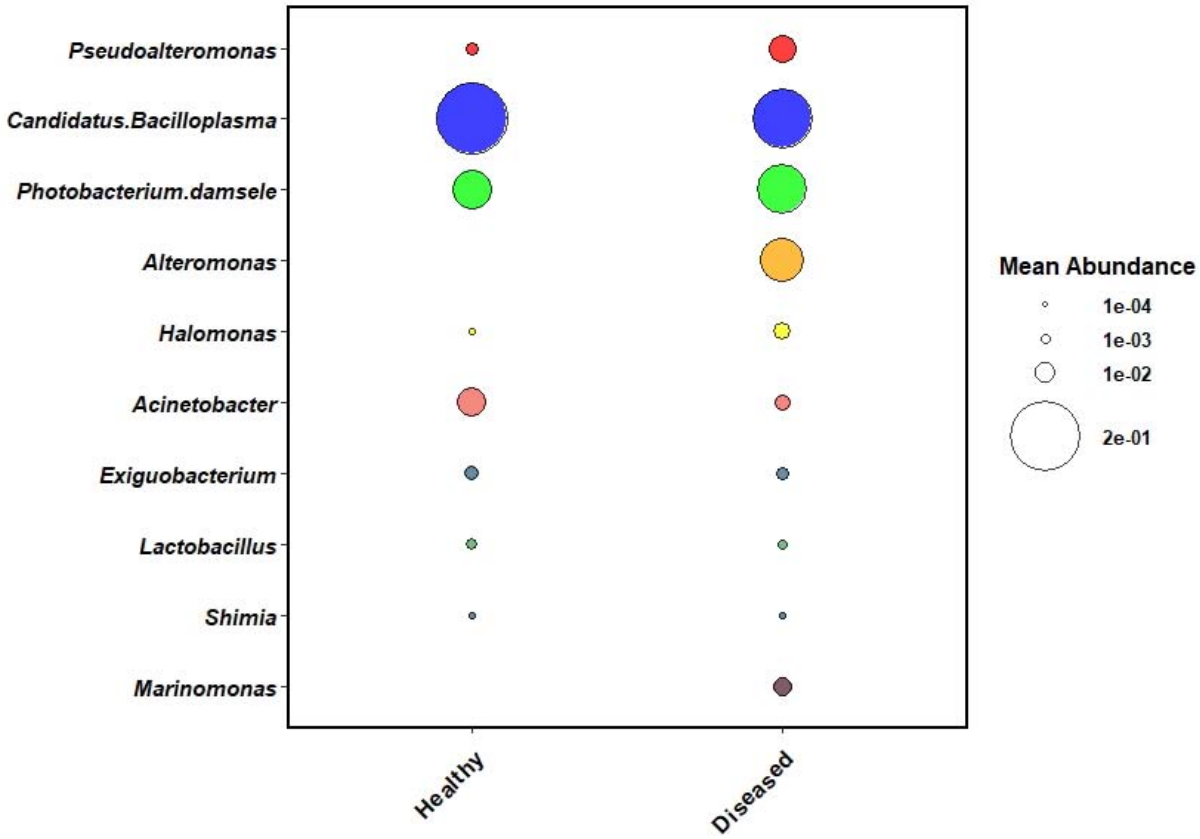


The heatmap plot generated by MRF in batch mode for WSSV genomes. Here 11 query genomes (AF369029, AF440570, JX515788, KT995470, KT995471, KT995472, KU216744, KX686117, KY827813, MF768985, MG702567) are compared to a reference genome (AF332093) in one go. The heatmap is depicting the ten genomes that exhibited high missing genome lengths and the CDS contributing to missing genome lengths. The heatmap is accompanied by a clustering of genomes based on missing genome regions

A Meta-analysis approach for identification of potential taxonomic biomarkers for health in *P. vannamei*

Naturally occurring microbial consortia exert several biological activities by participating in host immune response, nutrient absorption, pathogen defence and disease resistance. It is critical to understand the taxonomic compositions as they contribute to health and disease. We performed meta-analysis across multiple Bioprojects to capture potentially consistent taxonomic biomarkers that discriminate in diseased and healthy contexts. The data inclusion criteria for meta-analysis were 16S rRNA-based microbiome studies in public repositories on *P. vannamei* in healthy and diseased conditions. In total, six studies spanning 259 samples (117 healthy & 142 Diseased) were considered for meta-analysis.

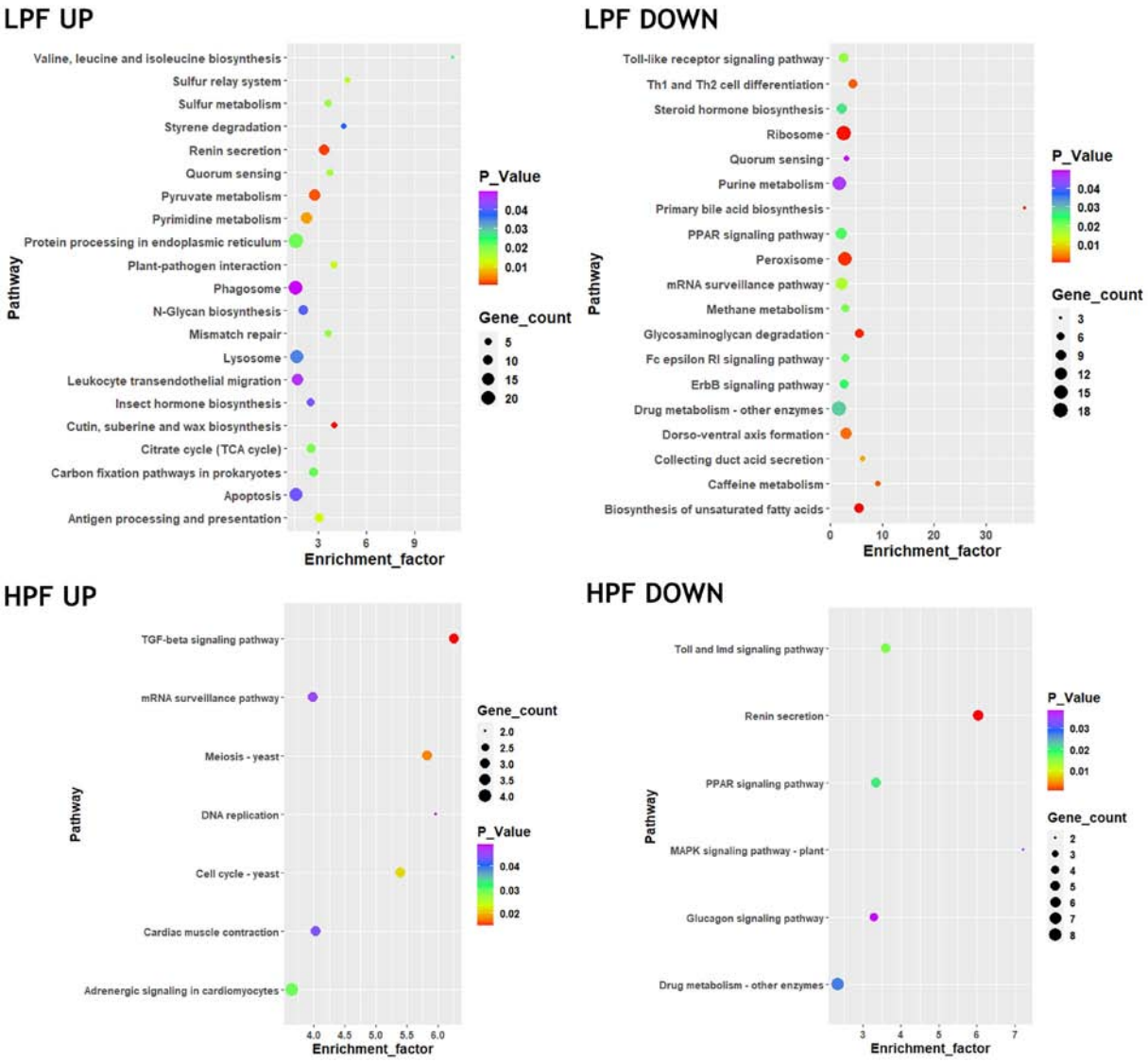
The retrieved amplicon data of each study were processed separately and merged using QIIME2 pipeline. The PERMANOVA analysis revealed a significant difference in the microbial communities between the samples in the healthy and diseased groups (p <0.05). The most predominant phylum among healthy/diseased groups were *Proteobacteria* (65% in healthy vs. 72% in diseased) and *Firmicutes* (30% in healthy vs. 20% in diseased). The Linear discriminant analysis effect size (LEfSe) identified 32 healthy and 73 diseased genera as potential biomarkers of health. Our meta-analysis-based finding suggests that the genera, *Acinetobacter* and *Alteromonas* varied substantially among healthy and diseased groups, respectively. Insights obtained from our study can effectively aid in designing microbial consortia harnessing beneficial microbes and hampering pathogenic microbes.



Potential taxonomic biomarkers identified for discriminating healthy and diseased states in *P. vannamei*. The size of the circle relate to the mean abundance of the genera across the groups. The *Alteromonas* and *Acinetobacter* with a p - value < 0.0001 and LDA score > 4 are identified as potential disease and health discriminatory genera

Impact of varying dietary protein levels on metabolic pathways of shrimp

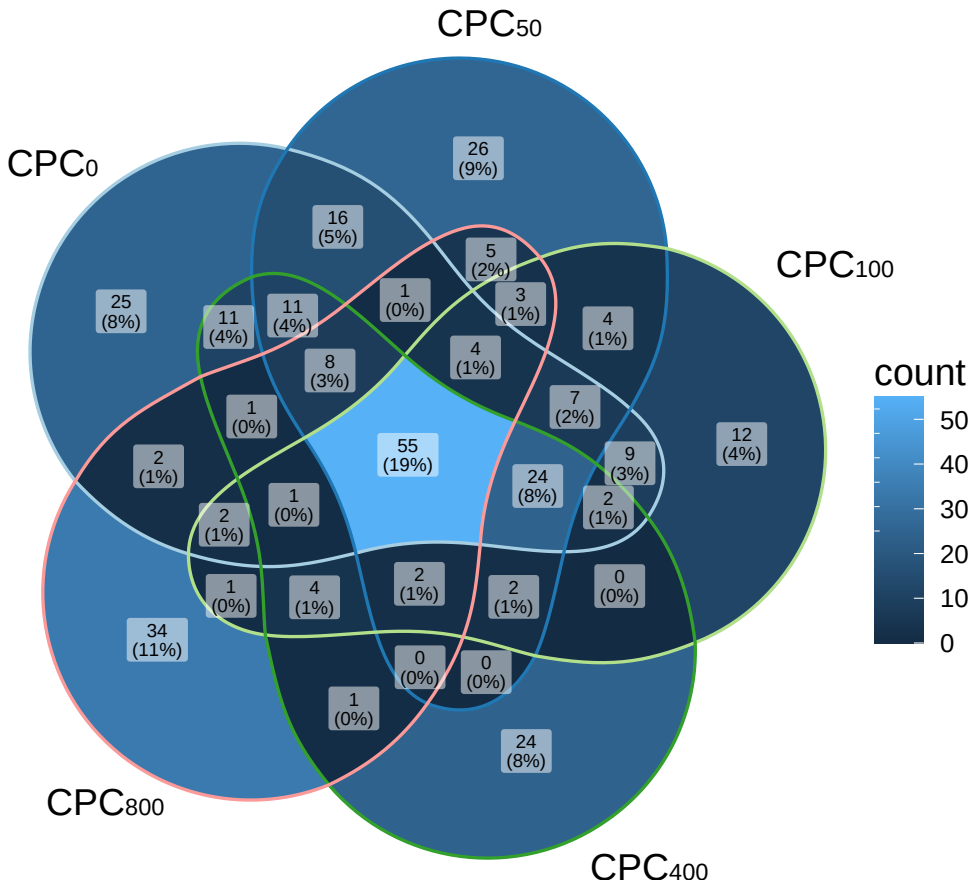
Development of cost-effective feeds by optimizing protein levels is an active area of research in shrimp aquaculture. Dietary protein requirements of the shrimp are widely studied as it is vital for growth and development of the animal. Here for the first time, the influence of feeds with varying dietary protein levels on the gene expression pattern of the American white shrimp (*Penaeus vannamei*) was studied. An indoor tank culture experiment was conducted in a flow-through system for a period of 45 days with five groups (feeds with varying levels of protein) viz., 22%, 27%, 37%, 42% and 47% and three biological replicates. RNAseq data has been generated from hepatopancreas tissues. A total of 2575 differentially expressed genes (DEGs) were identified on comparing treatment groups with control group (37%). DESeq2 was used for generating DEGs with the parameters of log fold change (logFC) and adjusted p values set at >2 and <0.05 respectively. These DEGs were functionally annotated using the Omixbox tool. Among the enriched GO terms, localization, lipid binding, catalytic activity, transport, carbohydrate derivative binding, hatching behavior, phospholipid binding were found to be significant for low protein feed whereas for high protein feeds response to organic substance, cellular component organization, organelle organization, maintenance of protein location, regulation of biological process, response to stimulus, response to hormone, protein binding were found to be enriched. Cutin, suberine and wax biosynthesis, Biosynthesis of unsaturated fatty acids, Ribosome, Primary bile acid biosynthesis, Glycosaminoglycan degradation were among the highly enriched KEGG pathways for low protein feed groups while Renin secretion, TGF-beta signaling pathway, Toll and Imd signaling pathway were highly enriched in high protein feed groups.



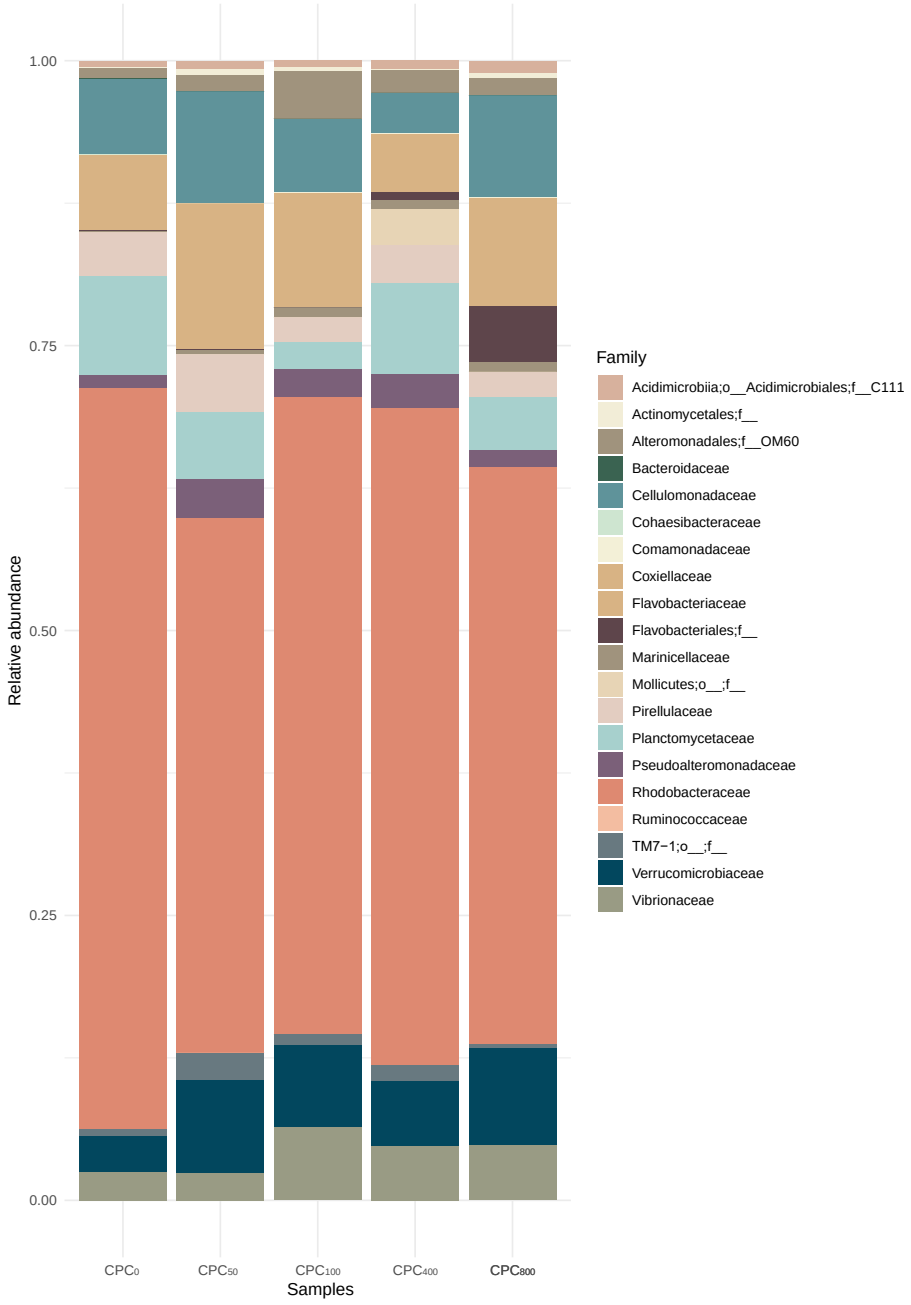
Enriched KEGG pathways for Low protein Feed (LPF) and high protein feed (HPF) groups

Dietary *C*-Phycocyanin (CPC) alters the gut microbiota in Pacific whiteleg shrimp, *Penaeus vannamei*

Phycocyanin, a protein responsible for photosynthesis in Spirulina, was found to be beneficial in treating variety of diseases. This experiment was performed to examine the impact of dietary C-Phycocyanin (CPC) extracted from *Arthrospira maxima* on the gut microbiome of Pacific whiteleg shrimp, *Penaeus vannamei*. Shrimp (N = 500, 3.99 ± 0.11 g/shrimp) were fed with experimental diets of varying levels of CPC supplementation at 0 (control CPC_0), 50 (CPC_{50}), 100(CPC_{100}), 400 (CPC_{400}), 800 (CPC_{800}) and 1600 (CPC_{1600}) mg of CPC per kg diet for 6 weeks. The gut microbiome of *P. vannamei* was studied using V3-V4 hyper-variable region (~250 base pairs) of 16S rRNA by high-throughput sequencing. Out of the total of 297 OTUs identified in the genus level, 55 OTUs were found to be common between all the treatments. Highest level of unique OTUs was found in CPC_{800} group (34 OTUs) and the lowest level of unique OTUs was found in CPC_{100} group (12 OTUs). The graph shows abundance of 20 dominant bacterial families. Family *Rodobacteraceae* was found to be dominant in all the groups. In the control group the dominance is followed by *Planctomycetaceae*, whereas in the treatment groups the dominance is followed by *Flavobacteriaceae* in lower concentrations (CPC_{50} and CPC_{100}), *Planctomycetaceae* in CPC_{400} and *Verrucomicrobiaceae, Flavobacteriaceae* and *Cellulomonadaceae* in almost equal amounts in CPC_{800}.



Venn diagram showing unique and shared OTUs (Operational Taxonomic Units) in the gut microbiome of *Penaeus vannamei*, with four different doses of CPC and control group diets, at genus level



Relative abundance of gut microbiota composition of *Penaeus vannamei* receiving four different doses of CPC and control group diets, at family level

CRISPR/Cas9 mediated growth enhancement in *Etroplus suratensis*

Growth enhancement in fish using CRISPR/Cas9 helps to increase the bodyweight of food fishes and reduce the culture period, thereby more effective than traditional breeding techniques. An experiment was conducted to check the efficiency of CRISPR/Cas9 for growth enhancement in a potential candidate brackishwater species *Etroplus suratensis* (pearlspot) through permanent knock out of myostatin (muscle suppressor gene). Therefore, the myostatin gene has been cloned, characterized, and designed guide RNAs. The efficiency of guide RNAs was evaluated by transfecting a Ribonucleoprotein complex (RNP) of guide RNA and GFP-tagged Cas9 protein @ different concentrations into the brain cells (passage No. 38). Successful integration of the RNP complex in the cell nucleus was evident by the emission of green fluorescence under microscopic observation. DNA was isolated from all the treatments and myostatin gene was amplified using gene-specific primers. Mutation detection using T7 endonuclease enzyme was carried out to check the mutation success. The amplified fragment was sequenced to confirm the result further. The resulted sequence aligned with the control sequence in MEGA software and found nucleotide changes at the target region of the treatment samples. The result showed point mutation at the targeted region; however, further experiments need to be conducted to validate the result.

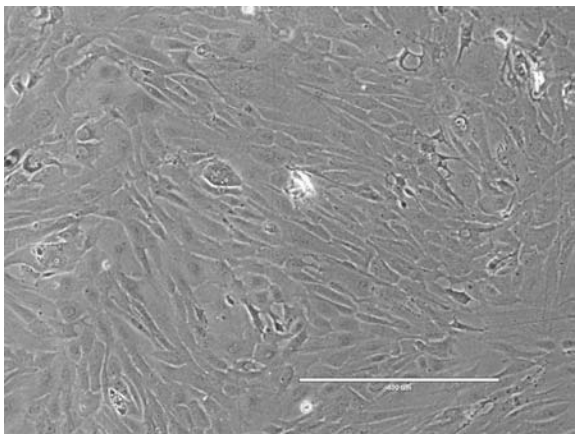


Image of treated cells captured under phase contrast microscopy. Magnification 10

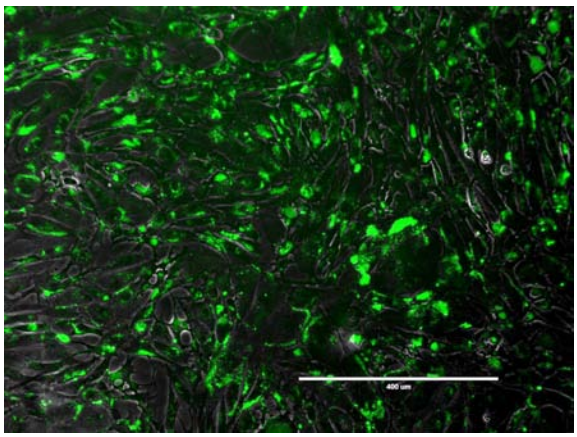
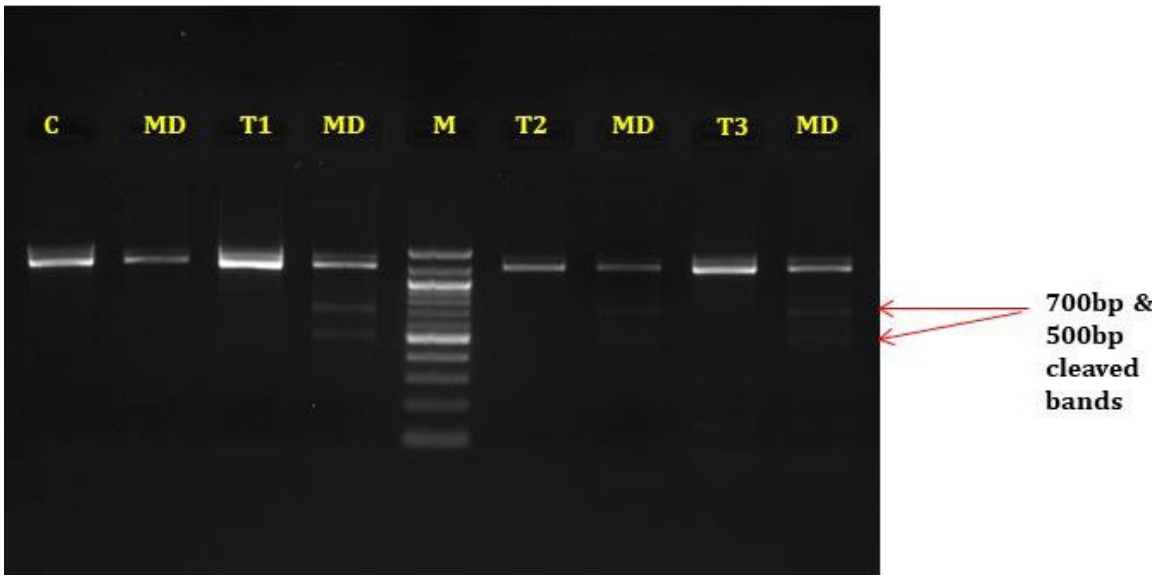


Image of treated cells showing green fluorescence. Magnification 10X



Gel picture showing the cleavage pattern of targeted fragment in treatment and control after Mutation detection assay. C-Control; T1,T2,T3-Treatments; MD-Mutation Detection

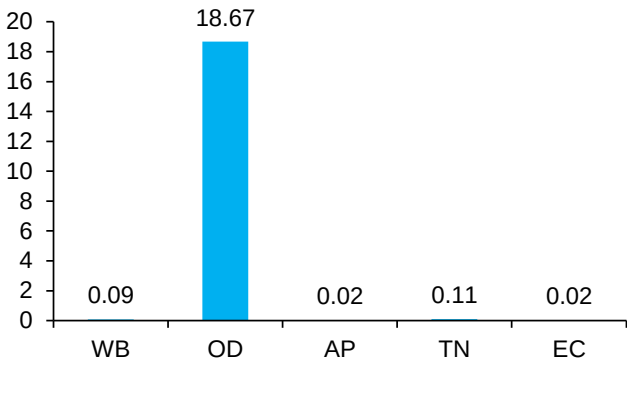
```
C1 GAGGGGAAATGACTTGGCCGTGACCGCCG-CGGAGCCAGG
C2 GAGGGGAAATGACTTGGCCGTGACCGCCG-CGGAGCCAGG
C3 GAGGGGAAATGACTTGGCCGTGACCGCCG-CGGAGCCAGG
T  GAGGGGAACCCCTGCCTCTGTGACTGCTTCCCCAGCCAGG
```

Alignment of mutated sequence with control sequence C1,C2,C3- control; T- Treatment

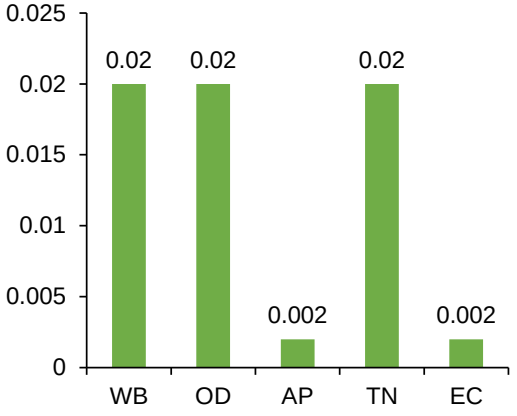
Social Sciences and Development

Sectoral growth of shrimp farming in India

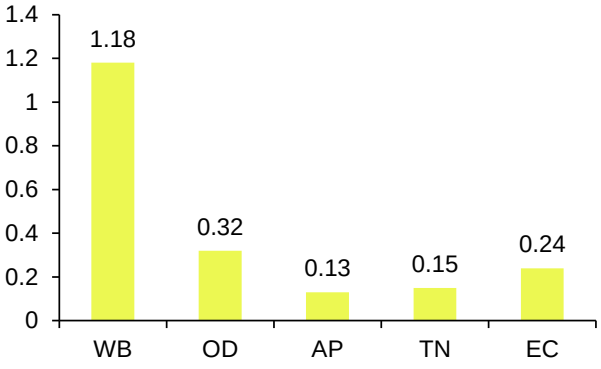
The trends in growth rates for shrimp farming area, production and productivity in India were estimated for the period 2009-10 to 2020-21 (Source: Aquastat). Moderate growth rate in farming area and production and higher growth in productivity were observed in the East Coast. However, lesser growth rate in farming area was observed, but it was reverse in the case of production and productivity in the West Coast.



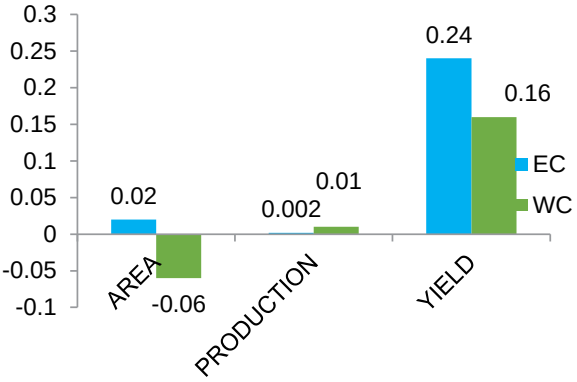
Compound Growth Rate of Shrimp Area in % in East Coast of India (2009-10 to 2019-20)



Compound Growth Rate of Shrimp Production in % in East Coast of India (2009-10 to 2019-20)



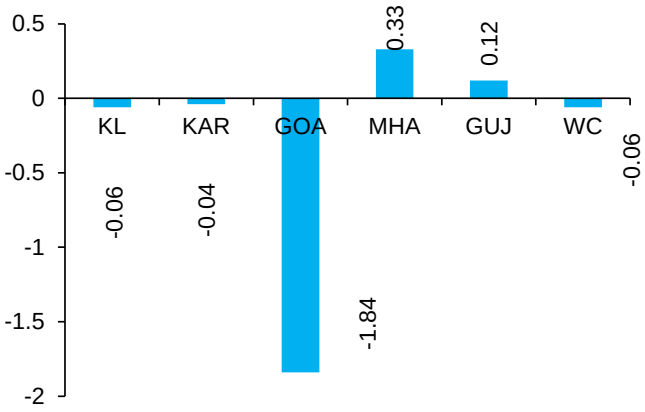
Compound Growth Rate of Shrimp Productivity in % in East Coast of India (2009-10 to 2019-20)



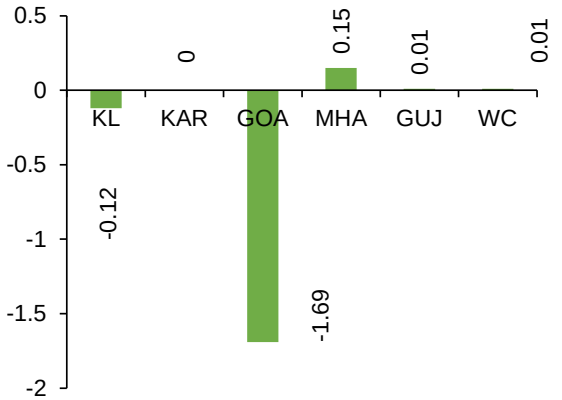
Coastal Wise CGR % of Area Production and Yield

At all India level, higher growth rate was estimated for productivity for the period 2009-10 to 2020-21. The coast wise trend indicated that in the East Coast, the trend in increase in productivity was more, may be due to better adoption rate of scientific package of practices in convergence with the Government support in the major shrimp producing state of Andhra Pradesh.

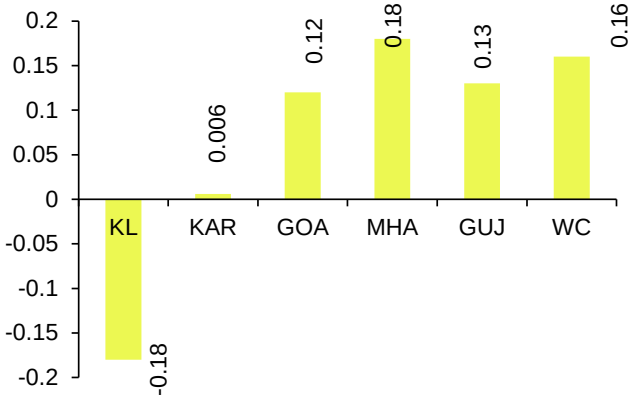
Further the area and productivity effect on shrimp production was estimated using the decomposition analysis model viz., $P= A_0(Y_n-Y_0)+Y_0(A_n-A_0)+\Delta A*\Delta Y$; Where P = Change in Production, A_0=Area in Base Year, A_n= Area in Current Year, Y_0= Productivity in base year, Y_n= Productivity in Current, Year, ΔA= Change in Area (A_n-A_0), ΔY= Change in Productivity. The results indicated that productivity and interaction effects are more in shrimp production. This indicates that technology adoption is playing a significant role. This positive trend need to be further sustained and technology adoption rate of BMPs need to be increased for realizing higher productivity on a sustainable level.



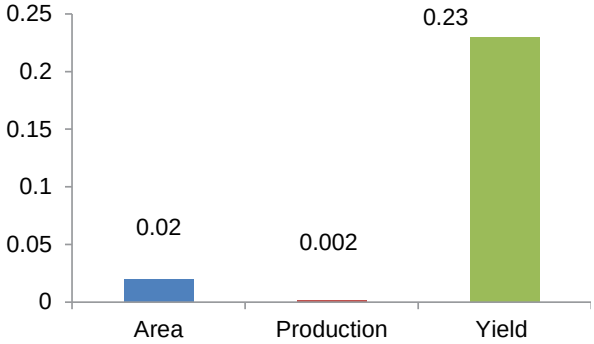
Compound Growth Rate of Shrimp Area in % in West Coast of India (2009-10 to 2019-20)



Compound Growth Rate of Shrimp Production in % in West Coast of India (2009-10 to 2019-20)



Compound Growth Rate of Shrimp Yield in % in West Coast of India (2009-10 to 2019-20)



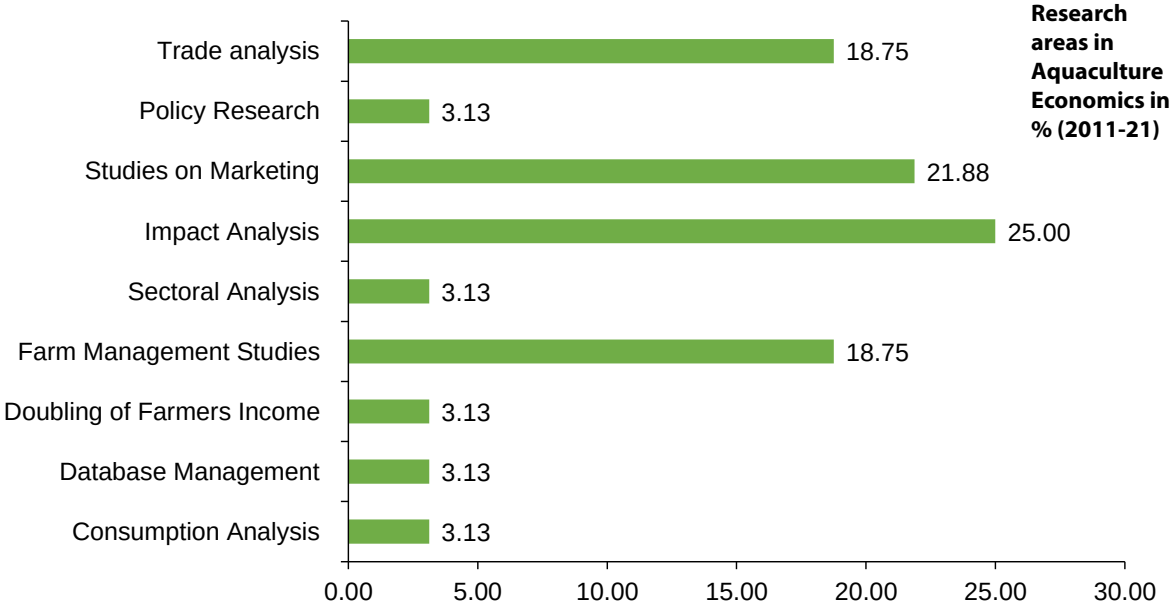
All India Compound Growth Rate in % of Area Production and Yield of Shrimp (2009-10 to 2019-20)

Perspectives of Social Sciences research in CIBA

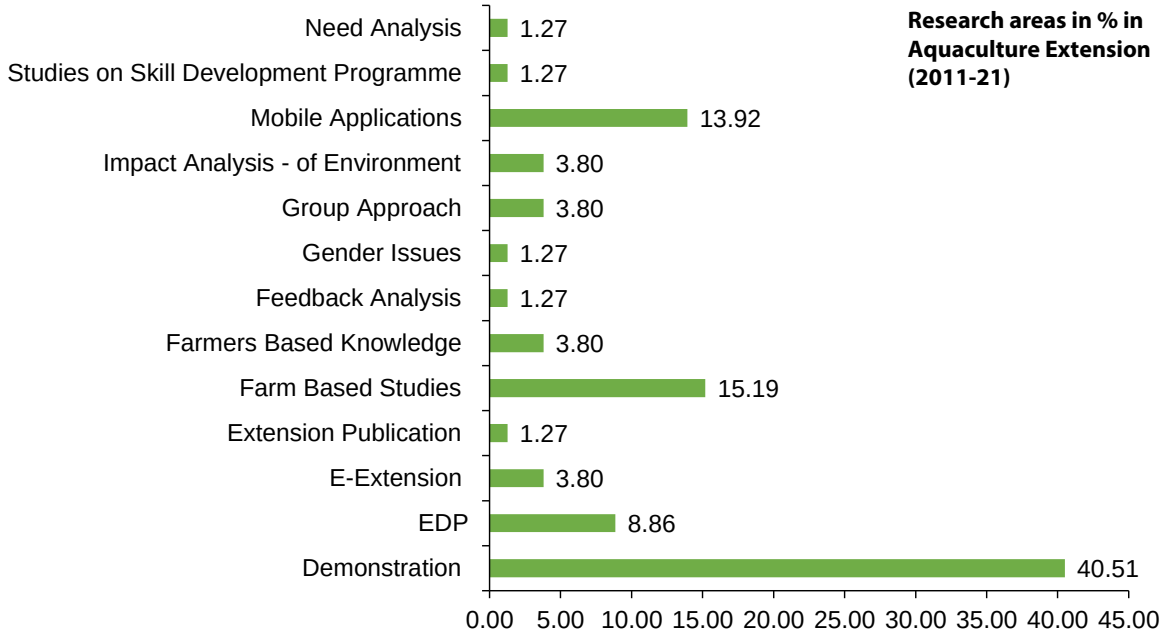
Based on secondary data collected from the Annual Reports of ICAR CIBA a study was conducted on focus areas of research in social sciences during 2011-2021.

Aquaculture Extension

Content analysis of the annual reports revealed that technology assessment and refinement through front-line demonstrations had a major share of 40.51% of research activities of aquaculture extension, followed by field studies (15.19%), studies on mobile applications (13.92%), and Entrepreneurship Development (EDP), which accounted for 8.86%. Other research areas included need assessment including that of training, skill development, impact analysis of environment, group approach, gender issues and feedback analysis, extension publications and e-extension.



Research areas in Aquaculture Economics in % (2011-21)

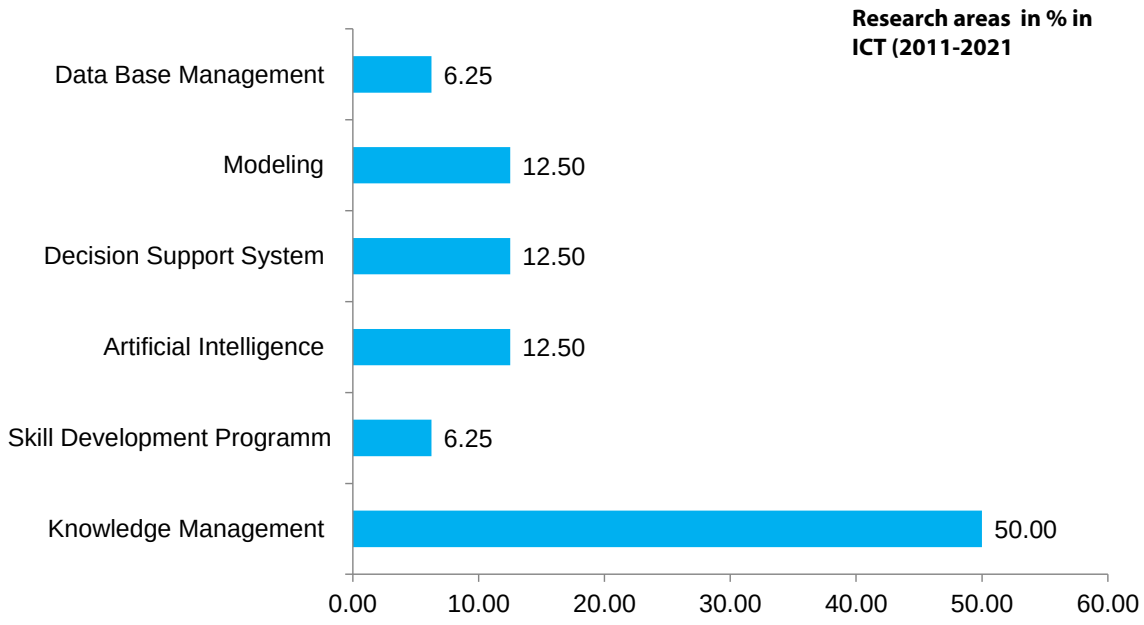


Aquaculture Economics

In case of aquaculture economics, impact analysis of CIBA technologies had the maximum share of 25%, followed by studies on marketing (21.88%), farm management (18.75%) and trade analysis (18.75%). Other research areas included policy research, sectoral analysis, doubling of farmers income, database management and consumption analysis.

ICT application in aquaculture

Major share of research in ICT application in aquaculture was in knowledge management platforms (50%) followed by modeling (12.5%), decision support system (12.5%) and Artificial Intelligence (12.5%). Other research areas included database management and skill development programmes.



Considering the above results and based on the inputs from research advisory committees the following may be the priority research areas on which future research activities of Social Sciences Division may be focused.

Priority areas of social sciences research for brackishwater aquaculture development

Aquaculture Extension	Aquaculture Economics	ICT in aquaculture
➢ Research on system specific 'farming technology application and refinement' in brackishwater aquaculture. ➢ Pragmatic approaches and strategies for efficient extension advisory services for sustainable brackishwater aquaculture. ➢ Entrepreneurship development in brackishwater aquaculture through Farmer Producer Organization (AFPO). ➢ ICT enabled aquaculture extension research and technology communication. ➢ Technological backstopping for improving the livelihood status of resource poor aqua farmers. ➢ Development and validation of AI based shrimp farm management modules in brackishwater aquaculture farming.	➢ Impact assessment of CIBA technologies through Total Factor Productivity ➢ Policy research on institutional insurance ➢ Assessment of macro level demand for critical inputs for finfish development in India ➢ Techno-Economic analysis of shellfish and finfish farming systems with focus on risk management strategies ➢ Marketing, trade and consumption pattern of shrimp and selected finfishes.	➢ Application of Artificial Intelligence for BWA ➢ Decision Support Systems for BWA ➢ Database Management of BWA farmers and other major stakeholders

Product gap analysis for shrimp crop insurance

ICAR-CIBA through a formal MoU with Oriental Insurance and Alliance Insurance Brokers, strived to bring back shrimp crop insurance. Four Public Sector Unit (PSU) general insurance companies and a private insurance company have shown interest in bringing out shrimp crop insurance products after discussion with ICAR-CIBA scientists. CIBA facilitated the insurance companies to redesign their product suiting to farmers' requirement. Based on interactions with shrimp farmers in Nellore district, Andhra Pradesh and Tiruvallur district, Tamil Nadu, a product gap analysis was performed to compare the current state of insurance offers and desired state of shrimp crop insurance by the farmers, the gaps and remedies suggested are given below.

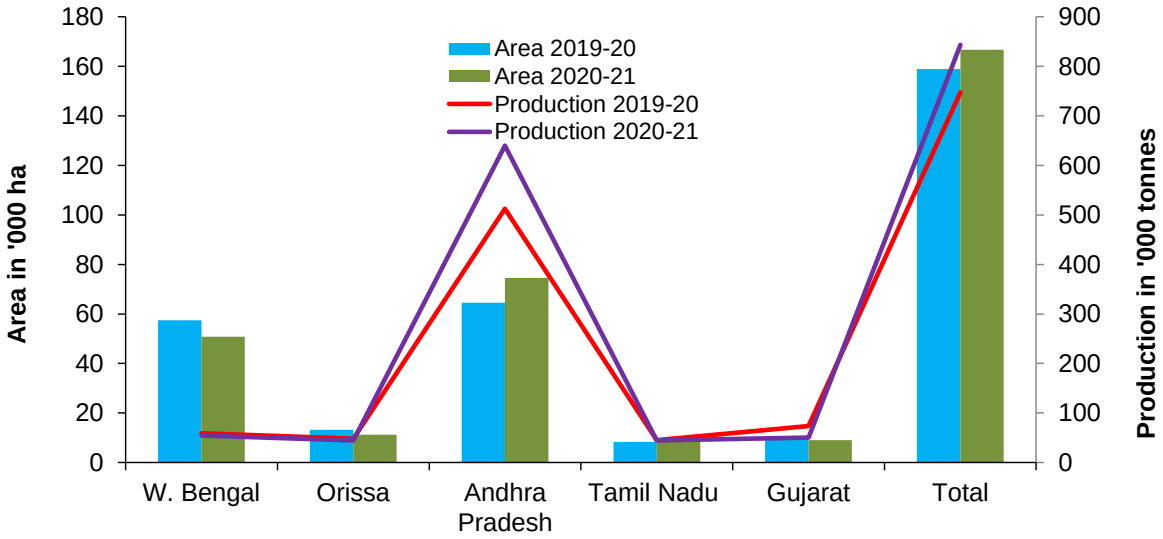
Product Gap Analysis of insurance product proposals Vs consumer desired requirements

Parameter	Current State- Insurance companies' offers	Desired State- Shrimp farmers requirement	Gap	Remedies suggested
Premium on sum insured (input cost)	2.7 to 4%	1-2%	1.7 to 2%	Farmers awareness of insurance product need to be increased; Government support, if materializes for 50% premium, that will fill the gap
Coverage	80% of input cost	100% of input cost	20%	Government support on premium may offset this gap
Type of insurance	Parametric-weather based	Comprehensive including disease cover	Without disease cover farmers are not interested	Insurance companies need to engage qualified surveyors for aquaculture insurance
Type of loss	Total loss	Partial losses also to be covered	20 to 80%	Unless insurance companies have full-fledged aqua field staff, partial losses cannot be covered due to few delinquent/negligent claim cases
Duration	Full crop	45 to 60 days	40 to 60 days	Insurance companies should be made aware of insurance requirement from farmers' point of view

The discussions with farmers' revealed their willingness to take up shrimp crop insurance. However, their expectations include: premium subsidy support from the government, full coverage, comprehensive insurance including disease cover, and for about first two months period of culture. The above analysis brought out the necessity of government support at least during kick start period and conducting nationwide awareness campaign to sensitize insurers and farmers to bridge the gaps.

Impact of COVID-19 pandemic on Indian shrimp production

Lockdown due to COVID-19 pandemic has brought significant changes in Indian shrimp aquaculture. ICAR-CIBA based on stakeholders' perception forecasted a 30-40% decline in production during the summer season of 2020 and subsequent drop in export volume. The timely interventions by the Union and State governments declaring aquaculture as an essential activity facilitated the easy movement of farm inputs, services and produce which helped in minimizing the adverse impact of COVID-19 associated restrictions on the sector as whole.



Growth rate of area and production of Indian shrimp

It was observed that the pandemic adversely affected the shrimp production in Gujarat, Odisha and West Bengal states mainly because the farmers in these states practiced only summer crop and depend on the southern states for the shrimp seed. Due to movement restrictions in the initial days of COVID-19 and fear of uncertainty in the availability of inputs and market many farmers did not prefer to stock their ponds. However, in case of Andhra Pradesh, 25% increase in shrimp production was achieved during 2020-2021 may due to the reason that farmers who had not stocked their ponds as a precautionary measure during the summer season of 2020, prepared their ponds well and might have stocked slightly higher densities during the winter crop season. Further, crop holiday during 2020 summer might have contributed for productivity improvement in the subsequent crop. However, the overall national production and export of farmed shrimp during 2020-21 was reduced by 10% compared to the previous year.

Impact of COVID-19 on shrimp exports

COVID-19 pandemic adversely impacted the shrimp demand from various importing countries which ranged from 10 to 30%. The total shrimp quantity exported in 2020-21 was 5.9 lakh tonnes worth USD 4.4 billion. It was a decline by 9.47% in value terms and 9.50% in quantity compared to 2019-20. USA was the largest importer with 46% (2.72 lakh tonnes) of Indian shrimp followed by China (1.02 lakh tonnes), European Union (70,133 t), Japan (40,502 t) and South East Asia (38,389 t). Shrimp import by China was drastically declined by 30% from1.4 lakh tonnes in 2019-20 to one lakh tonnes in 2020-21. In case of USA and EU, the impact was marginal and exports declined by 4.9% and 5.3% respectively in 2020-21. The exports to South East Asia and Japan were not affected by the pandemic. The total export of *P. vannamei* shrimp was decreased from 5.12 lakh tonnes in 2019-20 to 4.92 lakh tonnes in 2020-21.

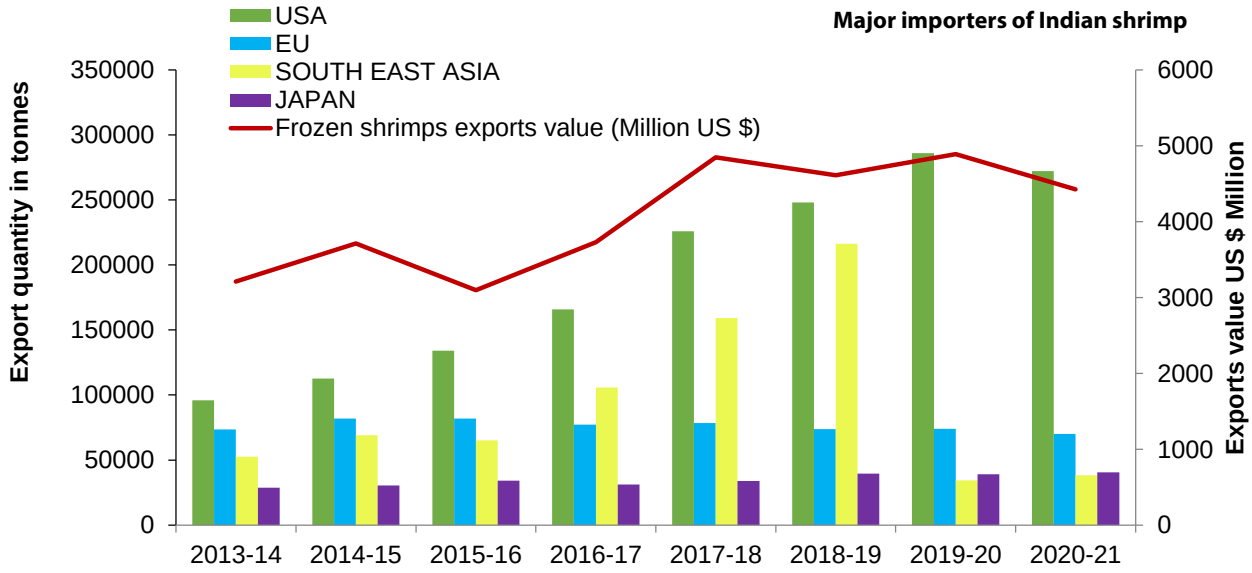
Impact of COVID-19 on Indian shrimp exports to major importers (in tonnes)

Countries	2019-20	2020-21	Growth %	Share % of exports quantity
USA	2,85,904	2,72,041	-4.85	46.09
EU	74035	70133	-5.27	11.88
South East Asia	34439	38389	11.47	6.50
Japan	38961	40502	3.96	6.86
China	1,45,710	1,01,846	-30.10	17.25
Others	73204	67364	-7.98	11.41
Total exports in Volume	6,52,253	5,90,275	-9.50	
Total exports value (Million US $)	4889	4426	-9.47	

Source :www.mpeda.gov.in

Major shrimp importers from India

India exported fish and fishery products worth US$ 5.96 billion where shrimp contributed 45.8% by volume and 66.3% by value during 2020-21 (www.mpeda.gov.in). Shrimp occupies top position in terms of earning foreign exchange vis-à-vis other agricultural commodities in India. Indian shrimp exports to US grow from 14% to 46%, while exports to EU and Japan reduced by 37% to 12% and 16% to 7% respectively during the past decade.



(Source: www.mpeda.gov.in)

Panel data regression (Gravity model) to determine variables impacting Indian shrimp exports (2010-11 to 2020-21)

Determinants of Indian shrimp imports to USA, China, EU, South East Asia and Japan were examined using an augmented gravity model of international trade to explain the effect of economic and noneconomic variables in the international shrimp trade. Secondary data were used in a panel dataset that consisted of both time series and cross-sectional data. The number of observational period as time series data was 11 years, from 2010-11 to 2020-21. India's shrimp export quantity to top five importing countries were considered as dependent variable and five independent variables were GDP per capita of partner countries (currency US$), GDP per capita of India (currency US$), population of partner countries, population of India and economic distance between top five importing countries and India.

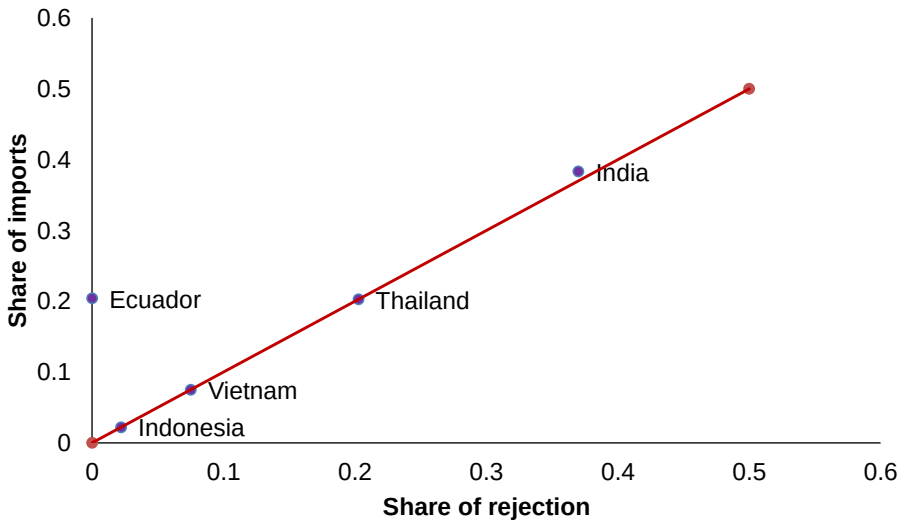
Gravity Model Estimates of Indian shrimp exports during 2010-11 to 2020-21

Coefficients	Estimate	Std error	t value	Pr(>|t|)
GDP_Percapita_partner	2.0685e+00	2.1054e+00	0.9825	0.330333
GDP_Percapita_India	-5.6331e+02	1.9117e+02	-2.9467	0.004765 **
GDP_partner	-2.2445e-08	9.0760e-09	-2.4730	0.016640 *
GDP_India	4.4525e-07	1.4504e-07	3.0699	0.003373 **
FDI Partner	9.1870e-09	1.7851e-08	0.5146	0.608943
FDI India	2.2917e-07	9.2725e-07	0.2471	0.805751
Population Partner	2.6153e-03	1.1317e-03	2.3110	0.024754 *
Population India	-5.3072e-04	3.7388e-04	-1.4195	0.161607
Economic distance	1.7142e+03	3.8165e+02	4.4916	3.86e-05 ***
Real Interest rate	-1.5507e+00	2.9360e+03	-0.0005	0.999581
Real exchange rate	-1.4292e+03	6.4803e+02	-2.2054	0.031786
Inflation %	-1.9494e+03	1.9894e+03	-0.9799	0.331589

*** 1%. ** 5% and * 10% level of significance

Causes of shrimp import rejection by USA and Relative Rejection Rate (RRR)

Compliance of import shrimps with food safety standards are strictly monitored by USA, EU and Japan. The USA refusal data from USFDA for 2021 was updated to the rejection database developed by ICAR-CIBA and various indices and reason for refusals were worked out. The ratio of country share of total rejections to share of total imports by USA for the period 2021 is given below as a graph. This provides a convenient measure of performance of countries relative to one another over the period. The 45° line represents the boundary between relatively good and bad performers in terms of rates of rejections. Thus, a country whose share of rejections is less than its share of imports is classified as a relatively good performer. India is on above the line which implies that their share of rejections is less than their share of exports. The share of US rejections of Thailand, Vietnam and Indonesia is in line with their share of exports. Shrimp exports are rejected by importing countries for many reasons. Reasons were classified into three groups namely: microbiological, chemical and inadequate controls. In 2021, number of Indian shrimp refusals by USA was 84 in which filthy and *Salmonella* were the major reasons (94%) followed by veterinary drugs (6%) and nitrofuran (1%). RRR of Indian shrimp imports was 0.97 and Vietnam (0.78). Thailand rate of rejection in compared to rate of imports was very high (4.55).



Relative rejection Rate of shrimp imports by USA

Reasons for the rejection of importing shrimps by USA

Reason	Relative Rejection Rate (%)				
	India	Vietnam	Thailand	Ecuador	Indonesia
Salmonella	0.48	0.00	0.00	0.00	0.00
Filthy	0.25	0.05	3.26	0.00	0.00
Filthy & Salmonella	0.16	0.00	1.19	0.00	0.09
Nitro Furan	0.01	0.14	0.00	0.00	0.00
Vet Drugs	0.06	0.55	0.00	0.00	0.00
Nitrofuran, Vet drugs	0.00	0.00	0.00	0.00	0.00
Others	0.00	0.05	0.10	0.00	0.02
TOTAL	0.97	0.78	4.55	0.00	0.11

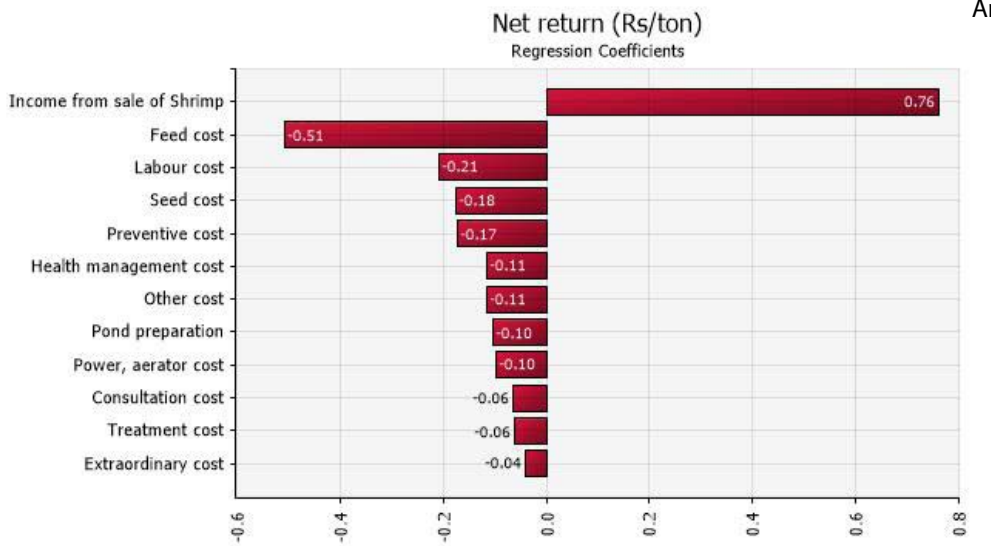
Methodology on stochastic model using excel@ Risk to estimate economic loss due to diseases in shrimp farms

A stochastic model was developed to estimate the economic loss due to *Enterocytozoon hepatopenaei* (EHP) disease in *Penaeus vannamei* shrimp farms and identify the associated key risk factors at the farm-level. The quantitative risk analysis for specific effects of the disease was estimated by Monte Carlo simulation using excel@Risk. A questionnaire based farm survey was conducted to estimate the loss due to EHP in major shrimp farming states of Andhra Pradesh (n=116), Tamil Nadu (n=66) and Gujarat (n=99) in India. The occurrence of the EHP was found to be positively correlated with the higher stocking density, indicated that stocking more than the carrying capacity of the pond led to stress which paved the way for pathogen manifestation. The observed harvest of size variations in shrimp and higher FCR could be attributed to EHP. Biological loss due to EHP was 75.21% and highly significant. The cost of prevention of EHP was 15.22% and the treatment cost was 4.30%, along with an extraordinary cost of 5.26% with an average loss of ₹ 61,778 tonne^{-1} at farm-level. Regression sensitivity analysis revealed that the farm gate price was the strongest stochastic variable and one unit increase in farm gate price of shrimp positively influenced the net return by 0.76 units. The significant factors negatively influencing the net returns were expenditure on feed (0.51), seed (0.19) and labour (0.18). The net return estimated using Monte Carlo simulation in EHP affected farms was ₹ 14,390 and the distribution revealed that nearly half of the farmer respondents lost their investment due to EHP.

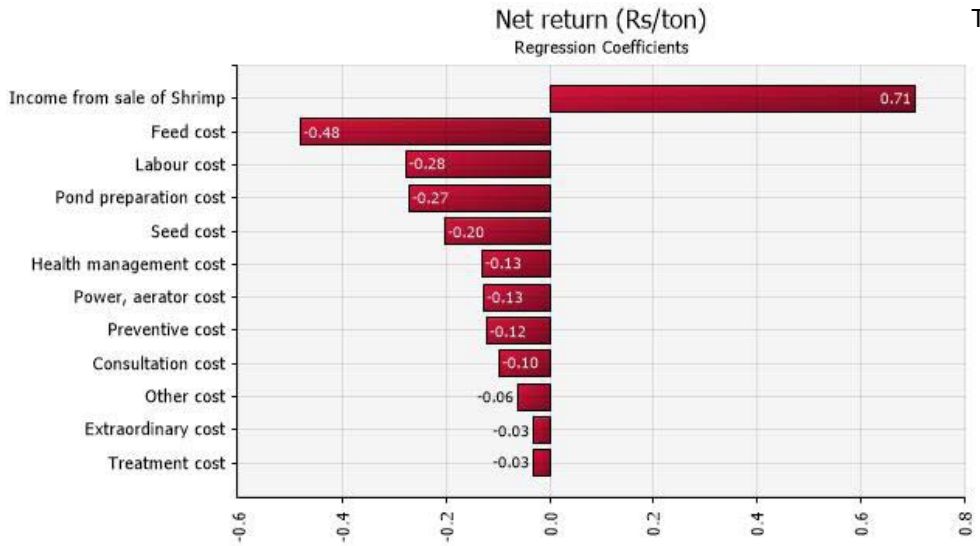
Direct costs of EHP outbreak in shrimp farms (Rs t^{-1})

Particulars	Andhra Pradesh	Tamil Nadu	Gujarat	India
Biological loss (BL)	66,784	51,025	21,586	46,465
Treatment cost (TC)	4,190	2,035	5,715	2,658
Extraordinary cost (EC)	2,710	2,065	695	3,250
Preventive cost (PC)	11,720	7,765	3230	9,405
Total Direct Cost	**85,404**	**62,890**	**31,226**	**61,778**

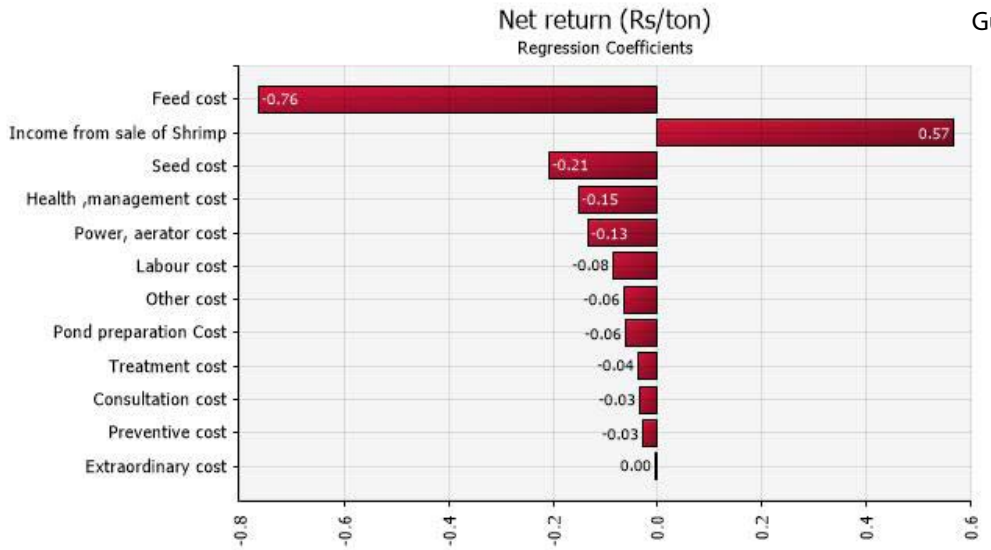
Andhra Pradesh



Tamil Nadu



Gujarat



Tornado plots showing the regression coefficients of affected shrimp farms

Front-line demonstration on community fish farming integrated with agro-based production systems for the livelihood development of tribal families

Two tier milkfish farming in pond and pens, seabass nursery rearing in hapas, crab fattening in pen and boxes integrated with duckery, poultry and vegetable gardening was demonstrated as a livelihood development model for the scheduled tribal families. The activities were taken up by adopting group approach. The demonstrations have facilitated in mainstreaming of scheduled tribal communities with the development of livelihood assets, capacity development and linking them with development departments of the state. The income from these demonstrations was deposited in a bank account for the continued adoption integrated farming system which provided them sustainable livelihoods.

Crab farming in pens and boxes, seabass nursery rearing (in hapas) and milkfish farming in community pond and open pen by Scheduled Tribal families of Lakshimipuram Tribal Nagar, Kattur village and Dr. K.P. Jithendran, Director, ICAR-CIBA interacting with the beneficiaries

Integrated Community Development options for coastal Scheduled Caste families

Aquaculture of mudcrab, milkfish farming in community pond and in open pen, nursery rearing of Asian seabass in pond and grow-out in community pond and rural fish food unit were established and demonstrated as a sustainable livelihood development model for the coastal scheduled caste families. As an integrated development initiative community library cum study centre and kitchen garden were also developed. Development of livelihood assets, capacity development, awareness creation on the developmental schemes for the SC families and linking the community with development departments of the state have been done to provide them sustainable livelihoods and overall socio-economic development. Follow up studies have shown that the above initiatives have provided them livelihood support and enhanced their participation in the developmental initiatives of the state government.

Mudcrab farming in pens and boxes, seabass nursery rearing (in hapas) and milkfish farming in community pond and open pen by SC beneficiaries

Mud crab farming in pen and floating HDPE boxes

Mud crab fattening in pen was demonstrated for the *Irula* tribal beneficiaries in different salinities. Mudcrabs (*Scylla serrata)* of 400-1100 g size were stocked. Crab farming was done in two pen structure made up of plastic reinforced GI mesh net each 14 m^2 size and also in floating HDFPE fattening boxes. The culture period was 30-35 days. Crabs were fed with trash fish @ 10% of the total biomass. Two cycles were conducted and the results are given below.

Comparative analysis of crab farming in different salinities

Type of culture	Pen culture	
CYCLE 1	**Pen-1 with salinity 3-4 ppt**	**Pen- 2 with salinity 32-34 ppt**
Pen size (sq. m)	14	14
Avg. Carapace width (mm)	14.95	14.72
Avg. Body weight (g)	630.82	622.76
Total no stocked (Nos)	48	54
Total weight stocked (kg)	30.8	35.2
Survival (%)	68.75	62.96
Total weight harvested (kg)	20.88	21.17
Total crab produced (kg)	49.28	41.17
Total revenue generated (in ₹)	**33,690**	**39,980**

The survival was slightly higher in the low saline farming (62-68%) and it indicated that crab fattening could be taken up in low saline waters. However, this needed further confirmatory studies. A production of 49.28 kg of crab was harvested from the first cycle realizing an amount of ₹ 33,690/-.

Crab farming by SC & ST beneficiaries at Kattur village and Thonirevu village

Frontline Demonstration of livelihood development opportunities for coastal landless poor families in Chengalpattu distract

Two livelihood development options viz., nursery rearing of Asian Seabass (*Lates calcarifer*) and farming of Milkfish (*Chanos chanos*) were demonstrated to show their production potentials and location adaptability. The demonstrations were taken up in open brackishwaters which are unutilized and used only for brackishwater aquaculture. It is an opportunity for the coastal landless poor families of Scheduled Caste and Tribal communities as an alternative/additional livelihood activity spending hardly two hours per day. The families could plan their farming of either or both depending on the availability of fish seed. Considering the effort, investments and returns both the systems are viable and, sustainable. The families were provided with livelihood assets in the form of nursery and grow-out pen systems, critical inputs and capacity development. It was a group activity wherein the families could share their responsibilities and plan their other employment activities. The group was linked with suppliers of seed, feed and market. The interventions exhibited a win-win approach by providing additional livelihood activity to the rural poor as well as efficient utilization of unutilized brackishwater resource.

Assessment of livelihood development options for coastal landless poor

Techno-economic parameters	Nursery rearing of Asian Seabass	Milkfish farming in Pens
Stocking size & density	1.2-2.0 cm @ 500 Nos/Hapa	0.1-0.3 g @ 500 Nos/Hapa
Feed used and FCR	Seabass Nursery^{Plus}; 1.8-2.2	Low protein feed (28-30%);
Duration in Days	57-73	60-65 (nursery + 180 (grow out)
Survival in %	36-54	80
Average size at harvest in cm	3-14	20 g @ nursery & 280-330 g in grow out
Average income per cycle in ₹	39,500	25,596
Mean monthly income per family in ₹	4,938	3,899

Harvested Milkfish

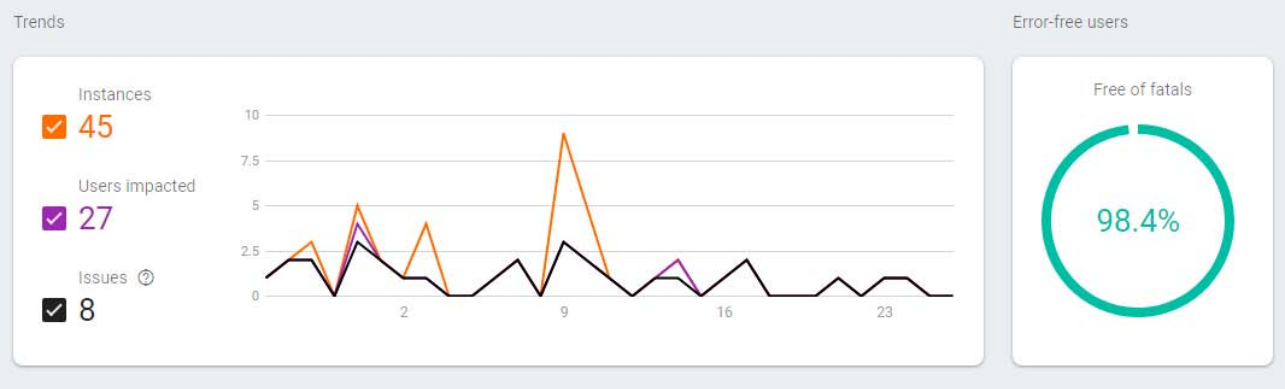
Asian Seabass Fingerlings

Perceived effectiveness of CIBA ShrimpApp in facilitatting shrimp farmers

Perception is operationalised as the opinion of end users on the functional attributes of mobile application measured in terms of its usefulness in farm decision making, design functionality and extension service function. A Likert type perception index containing 27 statements reflecting the above three attributes was developed and employed to ascertain the users' perceptions on the application of CIBA ShrimpApp. The results indicated that the respondents perceived that the mobile application aided them in quality seed selection (71%), estimation of various inputs (73%), disease diagnosis and prevention (65%) and water quality management (63%) to a major extent. Majority of the respondents (70%) felt that the mobile application established linkage between the scientific institution and the end users. Similarly, majority of the end-users perceived positively on app design and functionality (62%), user friendliness (64%), connectivity (60%), and unambiguous technical content provided through the application. Most of the respondents felt that the application served the extension education function effectively. About 60% of respondents perceived that advisories given in the application were practically worked to the satisfactory level.

About three fourth of respondents (73%) felt that the application served as a knowledge improvement tool. Almost half of them (51%) opined that farmers required hands-on training to use the application and shared the app information among their fellow farmers. Further, it was felt that the contents may be translated in to vernacular languages for the benefit of small scale farmers. Therefore, more awareness camps need to be conducted extensively on popularising the mobile application among the stakeholders and convert the app in major vernacular languages to enhance the wider usability of mobile application.

The app has more than 27500 cumulative downloads and rated as 4.5 out of 5.0. The application was found to have improved the knowledge level of end users to the tune of 20-37%. The Google firebase application data showed that 98.4% of users of CIBA ShrimpApp were free from errors and crashes. The user preferences and ranking of app modules showed that among the modules input calculators module was ranked as the first (68.10%) followed by disease diagnosis (61.50%) and BMP module (60.10%). Successful and profitable shrimp farming is a function of inputs optimization and disease prevention, therefore, these modules were efficiently utilized for day-to-day operations in shrimp farming.



Crash handling and error free users of the CIBA Shrimpapp

Perceived effectiveness of the mobile application – CIBA ShrimpApp (n=180*)

S.No	Functional Attributes of Mobile application - CIBA ShrimpApp	% of respondents
Subject matter function		
1.	App aids in selection of quality shrimp seed	71.11 ± 12.76
2.	App aids in calculation of the input requirements accurately	73.15 ± 18.32
3.	App aids in disease diagnostics to prevent and manage diseases	65.48 ± 13.06
4.	App aids in optimizing water quality parameters and their management	62.96 ± 18.40
5.	App aids in improving the productivity	65.92 ± 14.53
6.	App aids in effective pond management &reducing the production cost	54.72 ± 16.72
7.	App paved the way to access scientific information from the researchers.	70.00 ± 15.10
8.	App aids in supply chain integration (inputs and market)	68.63 ± 13.95
9.	App can supplement the extension workers function	64.86 ± 14.19
10	Difficult to get farm specific solutions through Vanami Shrimpapp.	39.51 ± 23.21
App design and functionality		
11.	Functionality and navigation are user friendly	64.20± 18.25
12.	The app modules are interconnected	60.49± 16.52
13.	Layout and design are user friendly	74.07± 12.34
14.	App works in off line it is easy to access at any time anywhere	69.14± 16.25
15.	The app is getting updated as per the needs of the users	53.09± 24.32
16.	The app is interactive and holds the attention of the farmer	54.32± 19.54
17.	The contents are clear and unambiguous	67.90± 12.34
18.	The contents are directly usable and actionable	59.26± 14.51
19.	This app is an innovative tool	62.96± 16.52
Extension education function		
20.	The advisories are practical and satisfactory	60.49± 14.25
21.	The App helps in knowledge improvement	72.84± 08.54
22.	App helps in saving time and cost in seeking technical advise	59.26± 24.60
23.	Advantageous over the traditional methods of knowledge dissemination	59.26± 22.50
24.	It is an educative tool for farmers and extension workers	61.73± 09.62
25.	Farmers require training to use this app	51.85± 08.14
26.	Mobile app is very useful and worthy contribution to the sector	65.43± 12.30
27.	The queries raised are answered within two working days	50.62± 18.24

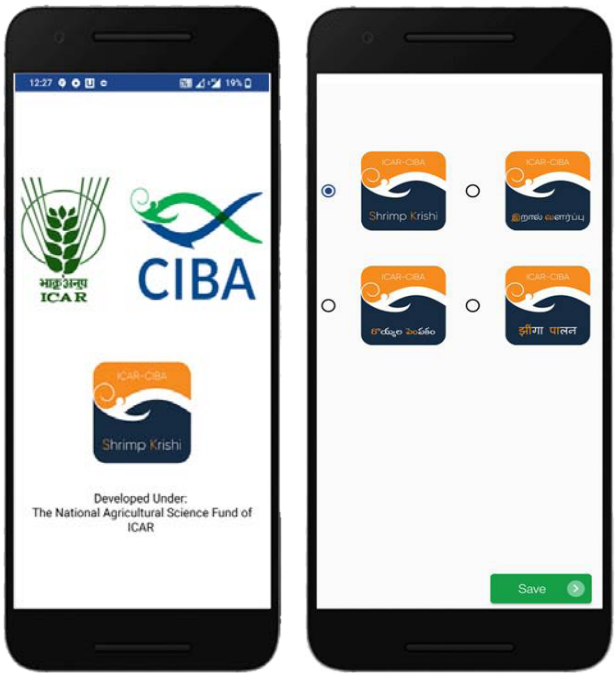
** Multiple responses*

Ranking the modules of CIBA ShrimpApp (n=180)

Modules	Garret Score	Percentage	Rank
Input calculations	4702	68.10	I
Disease diagnosis	4243	61.50	II
BMPs	4233	61.30	III
Risk Assessment	4144	60.10	IV
FAQs	3958	57.40	V
Updates & Advisory	3914	56.70	VI
Govt. Regulations	3871	56.10	VII
Post a Query	3772	54.70	VIII

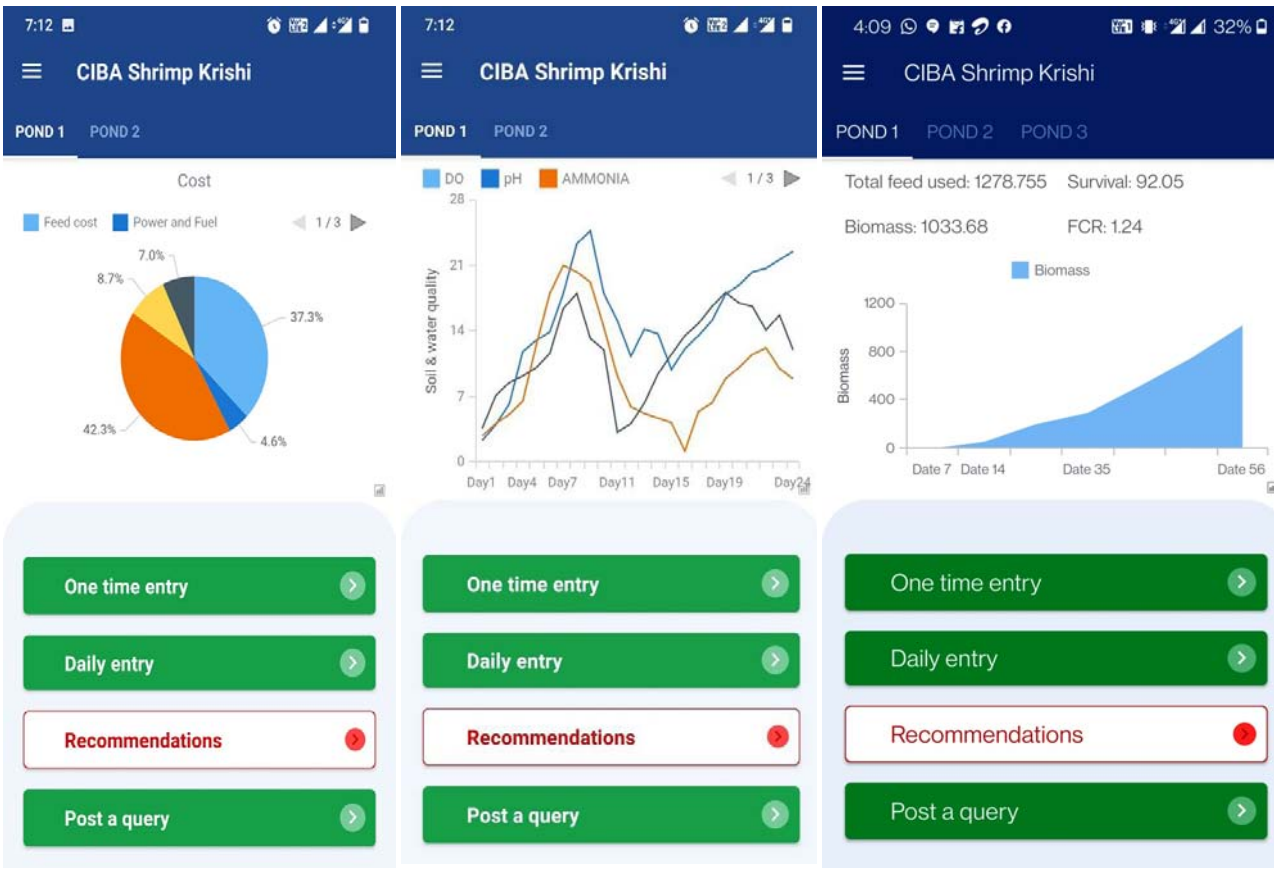
Development of CIBA Shrimp KrishiApp for shrimp farm management

An android mobile application, "CIBA ShrimpKrishiApp", was developed for handholding shrimp farmers in making real-time data based decisions at the farm level. The front end was developed using Java programming language. Linux, Apache, MySQL and PHP tools were used for designing the back-end. The app size is 8 MB and it works in Android version 5.0 and above. The app was made available in English, Hindi, Tamil and Telugu languages. The app is functional now and being placed in the Google play store for wider adoptability.



Front page and language selection in CIBA ShrimpKrishiApp

Shrimp farmers were sensitized on the ShrimpKrishiApp modules. Using this interactive mobile application, the farmer can input his farm data on day-to-day farming operations/ observations from stocking to harvest. Based on the inputs provided and inbuilt decision-making system, the app displayed pond-wise status on shrimp survival, biomass, feed conversion ratio, pond water quality, and the expenditure incurred. Three expert systems viz., shrimp feed management, water quality management and shrimp disease management were inbuilt in to the app. Based on the data fed in to the app, Shrimp Krishi alerts the end-user farmer with technical advisories whenever any deviations were noted in the pond operational and critical day-to-day parameters such as water quality, feeding and shrimp health. The app could store the entire crop data in it, and the farmer could retrieve the data for their own long-term decision-making purposes or share it with their resource person for technical advice. Moreover, it paved way for accessing real-time bulk data from the remotely located shrimp farms to monitor and extend customized technical advisories.

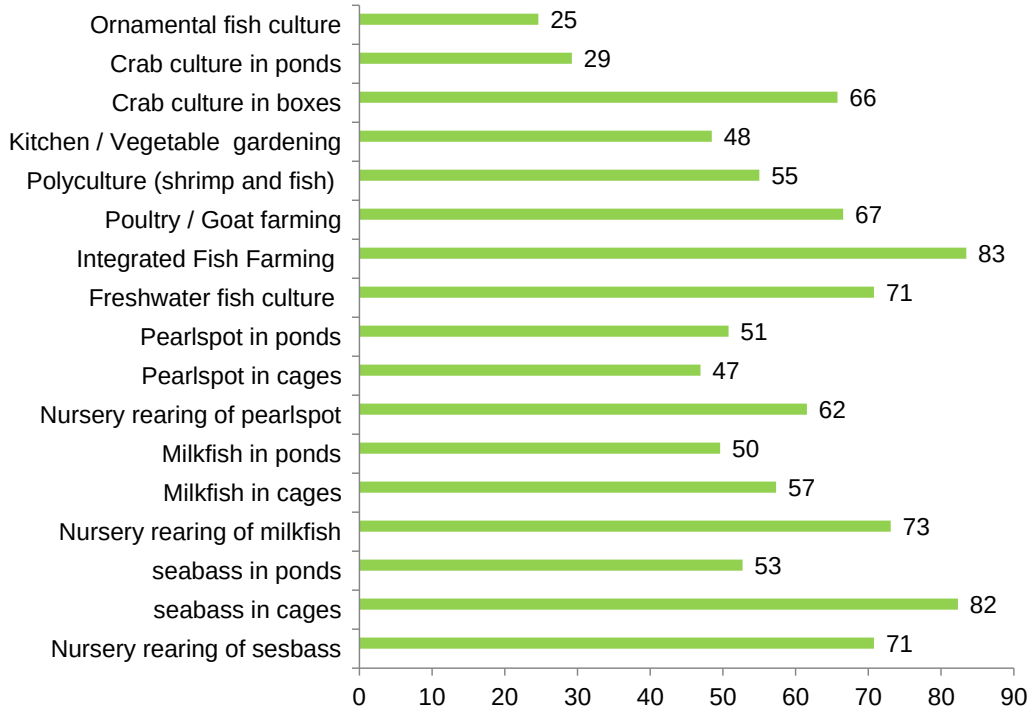


Graphical display of pond conditions in the mobileapp

Sensitization of shrimp farmers on ShrimpKrishiApp modules

Extent of influence of socio-economic parameters of tribal farmers on their adoption of aquaculture and allied technologies

Socio-economic status of the tribal farmers influences their adoption of aquaculture and allied technologies for their livelihood upliftment. Primary data on socio-economic profile of tribal farmers (n=130) of Navsari and Surat districts of South Gujarat from seven coastal villages viz, Kabilpore, Pathri, Danti, Navipardi, Onjal, Matwad, and Signod, and its impact on adoption of aquaculture were collected using a structured questionnaire. Seventeen independent variables such as age, marital status, education, family size, family type, type of house, occupation, farming experience, farm size, access to aquaculture inputs, ownership, marketing behaviour, family income, extension media contact, training exposure, knowledge in culture practices and participation in ICT activities were measured and analysed against the dependent variable adoption behaviour. Socio-economic profile of tribal farmers revealed that their extension agency contact (6.78), education level (6.18), participation in aquaculture activities (5.54), knowledge in culture practices (4.46), and farming experience (3.99) were quite high. The respondents acknowledged that their knowledge level on aquaculture was mainly through participation in the aquaculture activities and training programmes of ICAR-CIBA, Fisheries College and Krishi Vigyan Kendra, Navsari, Gujarat. The rate of adoption of technologies by the respondents ranged from 25 to 83% with a mean adoption rate of 60%. The technologies such as nursery rearing of Seabass nursery rearing in hapas, seabass culture in cages, nursery rearing of milkfish in hapas, freshwater fish culture, and Integrated Fish Farming had higher adoption rates. However, kitchen / vegetable gardening, mudcrab culture in ponds, and ornamental fish culture were adopted by few farmers.



Rate of adoption of aquaculture and allied technologies

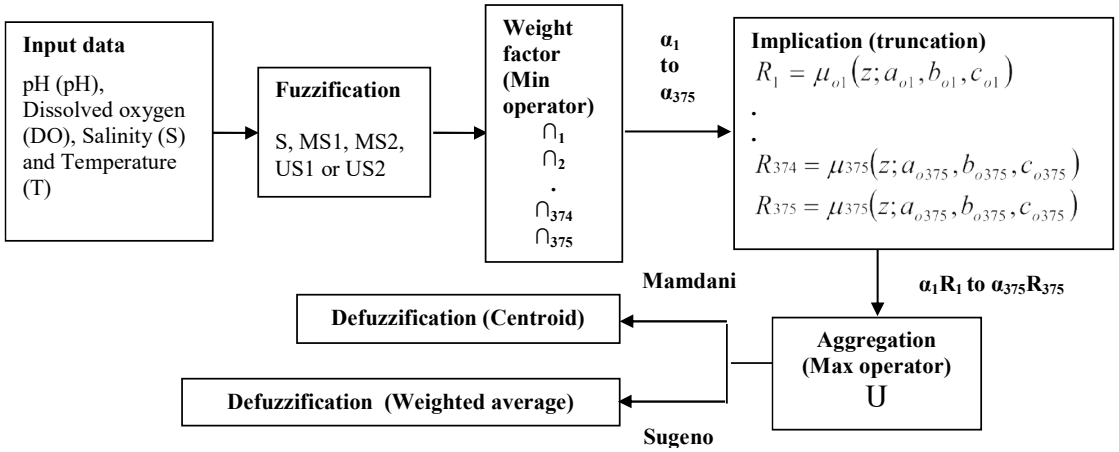
Relationships between the selected independent variables and extent of adoption were determined by Pearson's product moment correlation coefficient (r). The results showed that education, family size, farming experience, marketing behaviour, extension media contact, training exposure, knowledge in culture practices and participation in aquaculture activities had significant and positive relationship with adoption of aquaculture and allied technologies while age had a negative relationship. The higher level of training exposure and participation in aquaculture activities were useful in gaining the knowledge about aquaculture and allied technologies. The stepwise regression analysis further revealed that 86.3% of the variation in the extent of adoption of aquaculture and allied technologies was accounted by the combined effect of six independent variables Viz., knowledge in culture practices farming experience, participation in aquaculture activities, education, training exposure and extension media contact.

Stepwise multiple regression analysis showing the variation of extent of adoption score explained by different factors

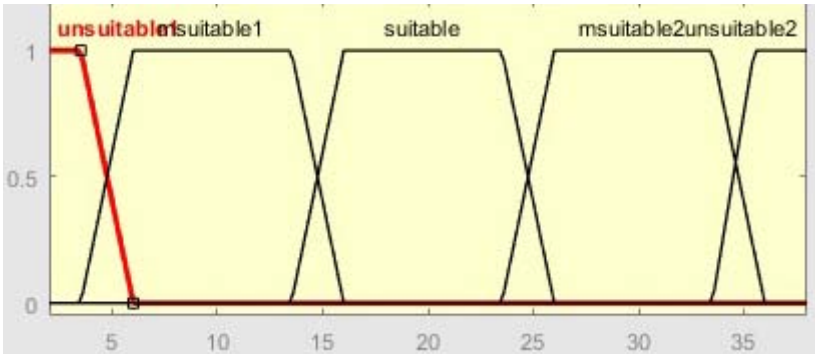
Model	Variable entered	Multiple R	Coefficient of determination R^2	Percent of variation expressed
1	Knowledge in culture	0.768	0.590	59.0
2	Farming experience	0.860	0.740	15.0
3	Participation in aquaculture activities	0.900	0.811	7.1
4	Education	0.912	0.832	2.1
5	Training exposure	0.921	0.848	1.6
6	Extension media contact	0.929	0.863	1.5

Data aggregation model using machine learning technique for the development of cage aquaculture monitoring system

Optimal environmental parameters are critical for the performance of cage / tank based aquaculture and data on water quality parameters are collected using sensor-based networking systems. However, inadequate electrical power supply and processing capabilities at the farming sites constrained its real-time application. Therefore, data aggregation process using advanced machine learning (ML) techniques such as fuzzy logic, neural networks, deep learning etc. are required to minimize the data communication lag while employing sensor based data collection at farm level. In this context, data aggregation model using Mamdani and sugeno fuzzy based ML techniques for the development of cage aquaculture monitoring system was developed which is useful to reduce traffic and enhance the performance of sensor networks. In the developed model, trapezoidal and triangular membership functions were used for defining the input variables which were most important parameters for cage aquaculture such as pH, salinity, dissolved oxygen and temperature and output variable the aggregation area. Totally, 375 fuzzy rules with logical AND operator, truncation implication, and centriod method for defuzzification were employed to develop an efficient mamdani and sugeno fuzzy model for aggregating the input values. The model classified the aggregated values of each aqua site in the datasets into one of the four classes such as excellent, good, acceptable, and not acceptable. The model was implemented in MATLAB with both mamdani and sugeno fuzzy inference systems.



Schematic representation of proposed data aggregation model for cage aquaculture



Membership function for salinity variable

Scheduled Tribe Component (STC)

Under Scheduled Tribe Component (STC), successful demonstrations (227 beneficiaries), trainings (175 beneficiaries) and awareness camps (584 beneficiaries) at Tamil Nadu, Gujarat, Maharashtra, Odisha, and West Bengal have given livelihood upliftment and income generation for tribal communities from ₹ 0.7 lakhs to ₹ 7.91 lakhs. The tribal beneficiaries are now successfully continuing the demonstrations/technologies for their livelihood support.

Front-line demonstrations of Monoangel, Asian seabass, Mud crab at Kovalam, Chengalpattu district, Tamil Nadu

As livelihood support for eight tribal farmers through brackishwater aquaculture the following front-line demonstrations were conducted at Kovalam, Chengalpattu district, Tamil Nadu.

(1) A total of 525 Monoangel, *Monodactylus argenteus,* fish with a range of 2.0-2.6 cm of length and 1.5-3.2 g of weight were stocked in 9 (2 × 1 × 1 m) hapas. After 50 days of culture, the fishes attained a growth of 5.0 – 6.9 cm of length and 5.1 – 7.0 g of weight with survival of 100%. Partial harvest of Monoangel was sold to the aquarium entrepreneurs generating an income of ₹ 4,000.

(2) A total of 184 numbers. of Asian seabass, *Lates calcarifer*, of size 12.3-17.6 cm of length and 17.0-36.0 g of weight were stocked in a pond. After 50 days, fishes attained the growth of 15-20 cm of length and 105-145 g of weight.

(3) Two hundred mud crabs were stocked individually in 200 floating boxes with initial size of 6.6-9.0 cm length and 53-109 g weight. After 50 days, crabs attained size of 10.5-15 cm of length and 156-384 g of weight with survival of 95%. Demonstrations are in progress.

Stocking of Mud crab in crab boxes by tribal farmers at Kovalam, Tamil Nadu

Sale of brackishwater ornamental fishes, Monoangel, produced by tribal farmers at Kovalam, Tamil Nadu

Sampling of Monoangel and Asian Seabass by tribal farmers and CIBA staff at Kovalam, Tamil Nadu

Integrated fish farming with agro-based farming at Kattur village, Tiruvallur district, Tamil Nadu

Aquaculture Technologies viz; two tier milkfish farming in pond and pens, seabass nursery rearing in hapas, and crab farming in pen and boxes were demonstrated by integrating with agro-based farming like duck and poultry farming, vegetable gardening. Twelve tribal families of Lakshimipuram tribal nagar, Kattur village were adopted. Two crab farming cycle was conducted at the Kattur crab farming site. The crabs stocked had a bodyweight in the range of 400-1,100 g for

the farming activity. The survival in both pen and box farming ranged from 62 to 68%. A total of 49.28 kg of crab was harvested from the first cycle realizing an income of ₹ 33,690. In the second cycle, 33.9 kg of crab was harvested realising an income of ₹ 31,858. The profit was deposited in their bank accounts and re-invested in farming.

Stocking of seabass and milkfish seeds by tribal beneficiaries at Kattur village, Tiruvallur, Tamil Nadu

Integrated Aqua-Agri-Poultry and Goat-rearing model, Singod Village, Navsari district, Gujarat

An 'Integrated Aqua-Agri-Poultry and Goat-rearing' farming system is developed for the livelihood and nutritional security of tribal communities in Singod Village, Navsari district, Gujarat. The farm is run by a tribal SHG (40 members) named as *"Singod Halpati Samaj Yuva Matsya Udhyog Juth"* which was formed by the scientific team of NGRC-CIBA. The farm is consisted of 25 low volume cages (4×4×2 m), poultry unit, goat rearing shed, seasonal vegetables and fruit bearing trees on pond dykes. SHG were provided with 18,000 pangasius (6,000 numbers: 12-15 g & 12,000 numbers: 3-5 g), 18,000 tilapia (6,000 numbers: 5-8 g & 12,000 numbers: 1-3 g), 40,000 catla (5-8 g), 20,000 roopchand (2-3 g) 4,000 rohu (5-8 g) and 3,000 pearslpot (5-8 g) seeds for cage culture in pond. The 200 seedlings each of cauliflower, brinjal, chilli, tomato along with seeds of coriander, fenugreek and spinach were sowed on dyke. In addition, six surati goats were also given to them. Three batches of 500 numbers of poultry birds were provided to SHG at interval of 60 days and poultry farming was carried out for 35-45 days till the birds grow to 1.8-2.0 kg. Within eight months the SHG earned an income of ₹ 7.91 lakhs from the sale of partial harvest of fishes, poultry birds, goats, and vegetables. The integrated system may generate a gross income of ₹ 30-32 lakhs for tribal communities of Singod, Navsari, Gujarat.

Partial harvest of Pangasius fish by tribal SHGs, Singod, Navsari, Gujarat

Integrated fish, crab, shrimp, goat, poultry and vegetable farming system, Matwad, Navsari, Gujarat

An integrated fish, crab, shrimp, goat, poultry and vegetable farming system in brackishwater pond system was developed as a livelihood model for tribal SHG at Matwad Village, Navsari, Gujarat. The selected SHG group (8 Nos) comprising of men and women of Matwad village were trained on each aspect of fish culture, livestock and vegetable farming and all required inputs were provided to them. The performance details of integrated fish, crab, shrimp, goat, poultry and vegetable farming in brackishwater pond system is summarized and given. Since 2020, SHGs have received a total of ₹ 9.10 lakhs through these demonstrations. In 2021, they generated ₹ 3.97 lakhs revenue from this farming system. The integrated agri-aqua-poultry and goat farming system in brackishwater aquaculture pond is more economical and sustainable model where farmer can get monthly income from regular sale rather than depending solely on income after sale of entire crop.

Finfish nursery units, Matwad, Navsari, Gujarat

Mud crab box culture unit, Matwad, Navsari, Gujarat

The growth performance details of integrated fish, crab, shrimp, goat, poultry and vegetable farming in brackishwater pond system

Culture	Period	Density	Achievement
Seabass nursery	75-90 days	10,000 (1.0-2.0 cm)	55% survival (2.5-4 inch)
Pearlspot nursery	60-75 days	5,000 (2.0-2.5 cm)	100% survival (3-4 inch)
Milkfish nursery	75-90 days	6,000 (2.0-2.5 cm)	100% survival (3-4 inch)
White leg shrimp nursery & grow out	120-150 days	15,000 (PL-8)	40% survival (8-20 g)
Floating crab box culture	180 days	240 (100-150 g)	75% survival (300-500 g)
Pearlspot & milkfish polyculture	180-240 days	2,000 (1,000 each; 2.0-2.5 cm)	100% survival (pearlspot 100-120 g; milkfish: 300-500 g)
Goat farming	180 days	9 Goats (6-8 kg)	100% survival with production of goat broodstock (30-50 kg) & three new goat kids (5-7 kg)
Poultry farming	35-40 days	500 Chicks (1 day old)	90% Survival (1.8-2 kg poultry)
Low salt tolerant vegetable Farming	120-150 days	Tomato, brinjal, chilly (200 each), Spinach seed	200 kg

Harvested seabass, milkfish, pearlspot fingerlings from integrated farming system, Matwad, Navsari, Gujarat

Low volume cage culture of seabass and pearlspot in creek, Visrampur village, Palghar, Maharashtra

The selected tribal SHG members (10numbers) at Visrampur, Palghar, Maharashtra were trained on fabrication of cage structure, cage structure installation and anchoring in creek, cage net fixing, fish stocking, feeding, fish grading and sampling, net cleaning, and cage culture management. Cage culture materials, solar street light for security purpose at cage culture site and boats for feeding the animals were provided to SHG. A total of 5 cages of 4×4×2 m (32 m^2) were fabricated and installed in the creek. Seabass fingerlings (4,000 number of size 50-60 g) were stocked in four cages @density of 1,000 /cage and were fed with formulated feed @ 5-6 % of body weight twice a day. Pearlspot seed (2-3 inch) were stocked in one cage @ density of 3,000/cage and are fed with formulated feed @ 6-8% of body weight twice a day. The seabass attained growth of 150-200 g with survival of 93% and pearlspot attained growth of 12-15 g with survival of 98%. The culture is in progress and all stocked fishes will be harvested in June 2022.

Low volume cage culture units and feeding boat with tribal SHGs, Visrampur, Palghar, Maharashtra

Seabass in low volume cage culture units, Visrampur, Palghar, Maharashtra

Integrated fish, crab, goat and vegetable farming model in brackishwater pond, Chinchani, Palghar, Maharashtra

The integrated farming model in brackishwater pond, 0.8 ha (1.5 m deep), was renovated at Chinchani village, Palghar district, Maharashtra, for livelihood development of tribal SHG members. It comprises of 60-90 days nursery rearing of seabass (8,500 numbers, 0.3-0.5 g), pearlspot (7,500 numbers, 0.3-0.5 g) in hapas (2×1×1 m); 180-240 days farming of green and orange mud crabs (80-150 g) in floating HDPE boxes (200 numbers); 210-240 days monoculture of seabass (2,325 numbers, 10-15 g) in the pond; 180-210 days hybrid goat farming in shed with low salt-tolerant tomato, brinjal, chilly vegetables farming (120 days) on pond dyke. In nursery rearing, the survival of 45-100 % was found in seabass (10-15 g) and pearlspot (8-10 g) fingerlings production, respectively. About 62% survival was observed in crab box culture (300-450 g) and in monoculture seabass have grown to size of 200-320 g. In goat farming, 100% survival was observed with production of goat flocks (25-40 kg) and two kids (6-8 kg). From the demonstration, the SHG generated a total income of about ₹ 2.58 lakhs from sale of seabass and pearlspot fingerlings, crabs and vegetables. The seabass monoculture, goat and vegetable farming are in progress and will be harvested in June 2022.

Distribution of seeds and harvested pearlspot and seabass fingerlings at Chinchani, Palghar

Mud crab culture unit in boxes at Chinchani, Palghar

Demonstrations of diversified species, milkfish, seabass, *Mystus gulio* and mullets, *P. vannamei*, Sahada village, Balasore district, Odisha

Nursery and grow-out demonstration and training were conducted for diversified species like milkfish, seabass, *Mystus gulio* and mullets besides nursery rearing of shrimp *P. vannamei* in Sahada village, Balasore district, Odisha. Nursery rearing of seabass (2,000 numbers) and milkfish (4,000 numbers) seeds was initiated in tank system. These seabass seeds yielded a survival of 46 % till juveniles. The seabass juveniles were sold to the local farmers and a net income of ₹ 24,800 was generated. *Mystus gulio* were stocked at the rate of 50,000/acre each weighing around 15 g. Shrimp nursery technology was demonstrated where shrimps were stocked at the stocking density of 1,000 per m^3 in single phase system which yielded higher growth (680 ± 85 mg) and survival (85.5 ± 3 %) at 25 days of culture. The juveniles were transferred to grow-out pond and culture demonstration was carried out.

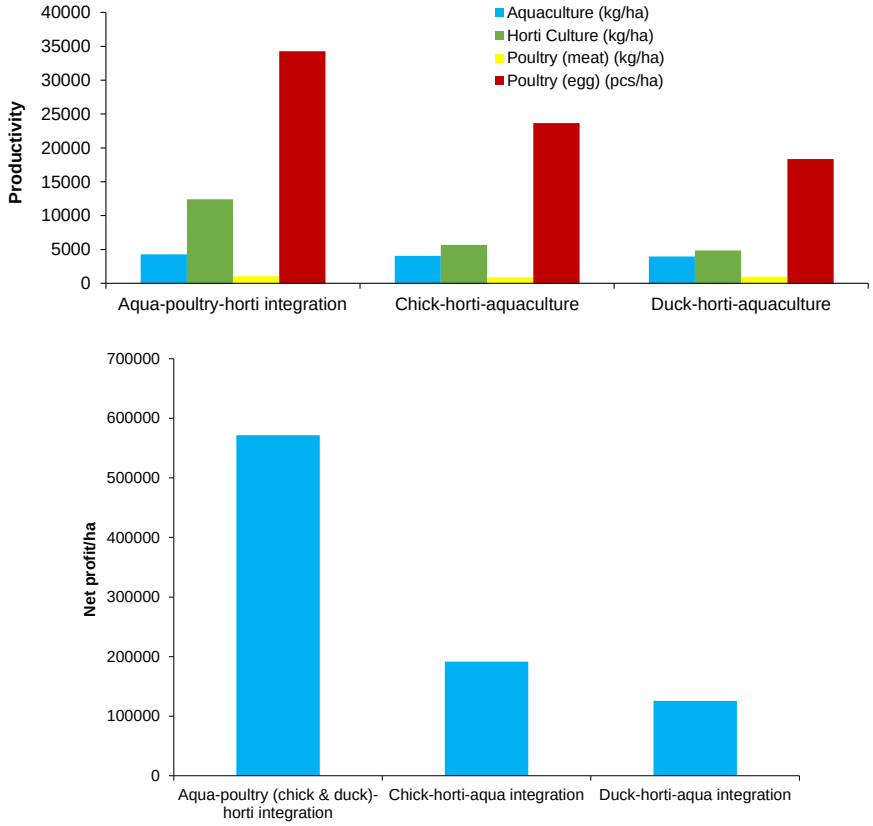
Grow-out farming of Asian seabass and milkfish are being continued in the pond culture system with supplemental feeding. The growth performance is getting better after the winter and prevailing low temperature. Seabass 1,280 numbers were harvested at an average body weight of 720 g, but during harvesting the growth rate was relatively lower after the cyclonic inundation. The produce was harvested and a gross income of ₹ 1,70,000 was generated. Harvest mela and interaction meet was conducted on 29th December, 2021 at Sahada, Balasore, Odisha. Around 400 villagers participated in the interaction meet and witnessed the harvest mela. The milkfish registered an average body weight (ABW) of 1,050 g and a production of 1,100 kg was harvested which generated an income of ₹ 1,43,000 .

Harvesting of fishes from tribal farmers pond, Sahada village, Balasore district, Odisha

Harvested fishes, Sahada village, Balasore district, Odisha

Front line demonstration of integrated aquaculture-livestock-horti- farming system, Kakdwip, 24 South Parganas, West Bengal

Front line demonstration on 'Aqua-poultry (chick & duck both)-horti integrated farming' has been conducted and compared with the performance of earlier studied 'chick-horti-aqua' and 'duck-horti-aqua integrated system. For aquaculture, *Penaeus monodon (0.02±0.01 g), Liza tade (1.04±0.09 g), Liza parsia(0.85±0.04 g)* and *Mystus gulio (3.21±0.34 g)* were stocked @1/m^2 each and *Oreochromis mossambicus (12±0.43 g)* @1.5/m^2. For poultry component chick (Rhode Island Red) and duck (Khaki Campbell) were reared in floating sheds. Spinach, water spinach, amaranthus, coriander, fenugreek, cabbage, knolkhol, cauliflower, broccoli, brinjal, beetroot, raddish, tomato, green chilli and other leafy vegetables were cultivated. CIBA-Horti^{Plus} and poultry/duck litter was applied as manure for horticulture crops. After 365 days, aquaculture and vegetable production were 4,436.43 kg/ha and 6,486.11 kg/ha, respectively. A total amount of 2,052 kg/ha poultry meat and 34,260 pcs/ha eggs were obtained. Aqua-poultry (chick & duck both)-horti integrated farming system showed a net profit of ₹ 5.73 lakhs per ha, which is higher than the individually conducted study of chick-horti-aqua (₹ 2.97 lakhs) and duck-horti-aqua (₹ 2.37 lakhs) integrated system.

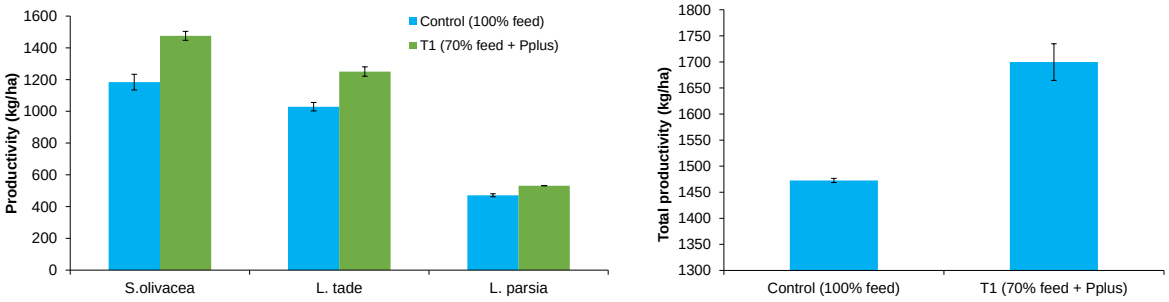


Production performance in different aquaculture-livestock-horti- farming system

Harvested fishes from integrated aquaculture-livestock-horti- farming system, Kakdwip, 24 South Parganas, West Bengal

Demonstration of Mud crab-mullet poly culture using CIBA-Plankton^{Plus}

Crab-mullet polyculture was demonstrated in farmers ponds at Manmathapur-Mundapara tribal village, Kakdwip. There were two treatments, control with Poly^{plus} feed as per requirement (100%) and T1 with Plankton^{plus} (40 ppm) and Poly^{plus} feed (70%). Crab, *Scylla olivacea* (body wt. 50.02±1.85 g) and two mullet species, i.e., *L. tade* (body wt. 1.07±0.08 g) and *L. parsia* (body wt. 0.5±0.02 g) were stocked @ 1/m^2 each. The ponds were surrounded by net to prevent the escape of crablets. After 240 days of culture, the average body weight attained by crab was 212.26±0.37, 273.33±2.23 g; *L. tade* was 150.22±0.35, 197.01±0.17 g; and *L. parsia* was 88.3±0.20, 98.4±0.30 g; in respective treatment ponds. After 240 days of culture, aquaculture production was 2,684.05±79.32 and 3,298.82±84.26 kg/ha in treatment ponds supplemented with Plankton^{plus}. The production performance was better in ponds supplemented with CIBA-Plankton^{Plus} than the control ponds even when 30% feed was reduced.

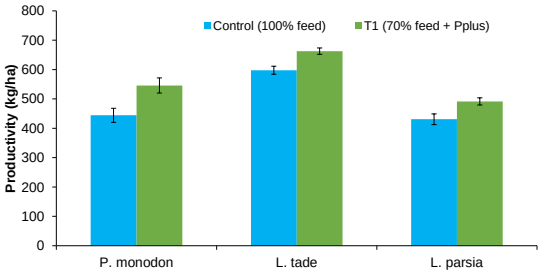


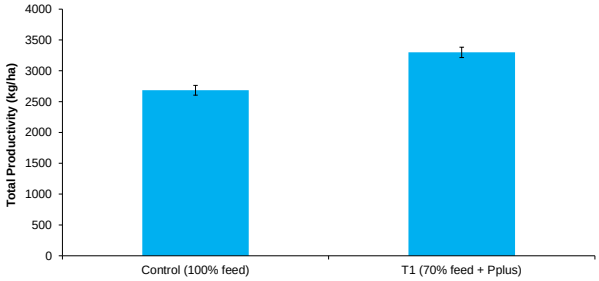
Production performance of crab-mullet polyculture system

Harvested crab and mullet

Demonstration of Tiger shrimp-mullet polyculture using CIBA-Plankton^{Plus}

Tiger shrimp-mullet polyculture demonstration was conducted in farmers ponds (each of 0.05 ha) at tribal villages adopted by KRC to evaluate the potential of CIBA-Plankton^{Plus} in reduction of feed requirement. *Penaeus monodon* (body wt- 0.03±0.02 g), *Liza tade* (body wt 1.07±0.08 g), *L. parsia* (body wt- 0.5±0.02 g) fry were stocked @ 4, 1 &1/m^2, respectively. There were two treatments, control pond (100 % Poly^{plus} feed without Plankton^{Plus}) and T1 ponds (70% Poly^{plus} feed & supplemented with 40 ppm Plankton^{Plus}). After 240 days of culture, the average body weight attained by *P. monodon* was 21.04±0.24, 24.06±0.12 g; *L. tade* was 92.08±0.55, 105.1±0.05 g; and *L. parsia* was 75.2±0.11, 83.06±0.06 g in respective treatment ponds. After 240 days of culture, aquaculture production was 1,472.66±4.07 kg/ha in control pond and 1,699.71±35.16 kg/ha in treatment pond supplemented with Plankton^{plus}. All the species performed better when CIBA-Plankton^{Plus} was supplemented in ponds with reduction of 30% feed.



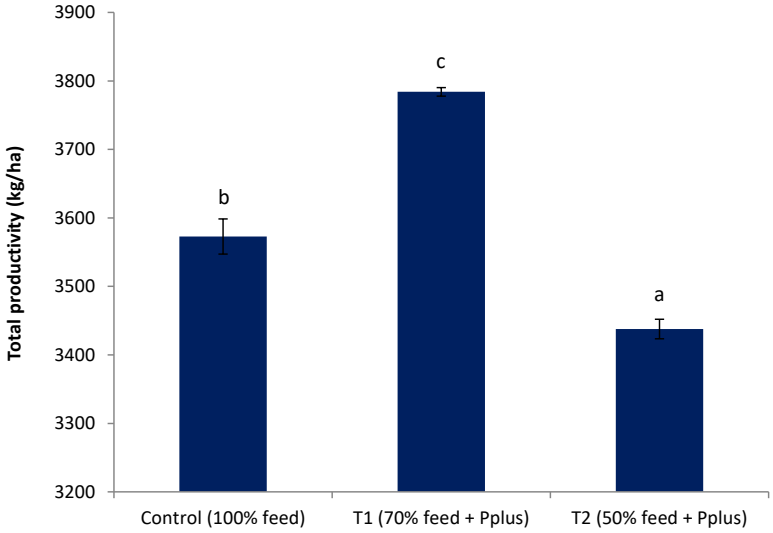


Production performance of shrimp-mullets polyculture system

Harvested tiger shrimp and mullet

Demonstration of Scampi-IMCs-mullet-tilapia polyculture using CIBA-Plankton^{Plus} in low-saline homestead ponds

To increase the income from low saline homestead ponds of tribal farmers of Sundarban, high valued fish like *L. parsia* and *L. tade* was introduced along with scampi, Indian major carp and tilapia. To make the polyculture more cost effective, use of feed was reduced to the tune of 30-50 % by using Plankton^{plus} @40 ppm. *Labeo rohita* (body wt. 12.97±0.10 g), *Catla catla* (body wt. 13.95±0.68 g), *Oreochromis niloticus* (body wt. 1.02±0.10 g), *Macrobrachium rosenbergii* (body wt. 0.03±0.02 g), *L. tade* (body wt. 1.07±0.08 g), *L. parsia* (body wt. 0.5±0.02 g) were stocked @ 0.25, 0.25, 0.5, 0.5, 0.5 and 0.5/m^2, respectively. There were three treatments, control (Poly^{plus} feed-100%), T1 (Plankton^{plus} (40 ppm) and Poly^{plus} -70%) and T2 (Plankton^{plus} (40 ppm) and Poly^{plus} -50%). The productivity was 3,572.70±25.65 kg/ha in control ponds and 3,784.17±6.20 kg/ha, 3,437.78±14.13 kg/ha in T1 and T2 ponds, respectively after 8 months of culture. The growth results showed that the species performing better in ponds supplemented with Plankton^{Plus} than the control ponds even when 30% feed was reduced.

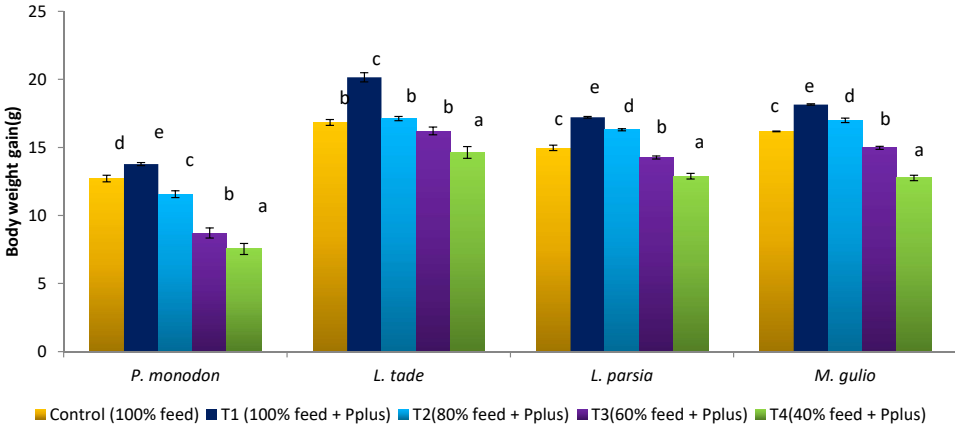


Treatment wise productivity variations in scampi-IMCs-mullet-tilapia polyculture

Haul of different species in scampi-IMCs-mullet-tilapia polyculture

Demonstration of Polyculture of tiger shrimp-mullet-gulio using CIBA-Plankton^{Plus}

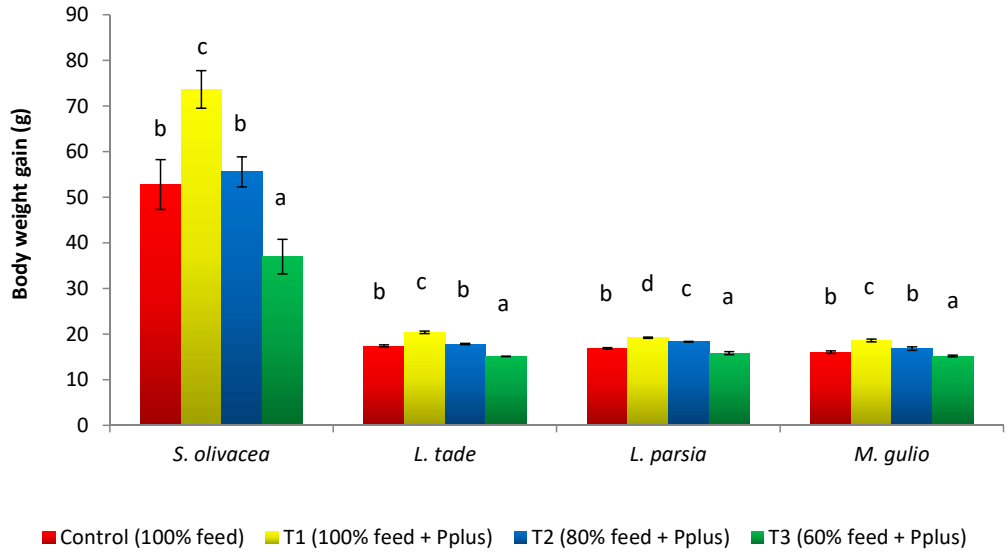
Demonstration of polyculture of tiger shrimp-mullet-gulio using CIBA-Plankton^{Plus} was conducted in 10 ponds of farmers (50 beneficiaries) in two tribal villages of South 24 Parganas, West Bengal. *P. monodon* (0.02±0.02 g), *L. tade* (1.03±0.09 g), *L. parsia* (0.85 ±0.04 g) and *Mystus gulio* (1.95 ±0.12 g) were stocked @ 1, 1.75, 1.25 and 1 number/m^2 respectively. The control ponds were supplemented with 100% feed without Plankton^{Plus} and rest 4 groups of treatment ponds were supplemented with 100% feed (T1), 80% feed (T2), 60% feed (T3) and 40% feed (T4) along with weekly dose of Plankton^{Plus}. After 90 days of culture, the average body weight attained by *P. monodon* was 12.59±0.23 g, 13.78±0.24 g, 11.35±0.20 g, 9.21±0.27 g and 7.54±0.2 g; *L. tade* was 17.97±0.24 g, 19.65±0.32 g, 18.45±0.24 g, 17.01±0.20 g and 15.87±0.23 g. *L. parsia* was 16.03±0.17 g, 18.01±0.20 g, 17.15±0.17 g, 15.35±0.21 g and 13.91±0.22 g, *Mystus gulio* was 18.09±0.16 g, 20.00±0.20 g, 19.03±0.18 g, 16.97±0.18 and 14.43±0.21 g; in control, T1, T2, T3 & T4, respectively. The growth results showed that the species performed better in ponds supplemented with CIBA-Plankton^{Plus} than the control ponds even when 40% feed was reduced.



Growth performance of polyculture of Tiger shrimp-Mullet-Gulio using CIBA-Plankton^{Plus}

Polyculture of crab-mullet-gulio using CIBA-Plankton^{Plus}

Demonstration of polyculture of crab-mullet-gulio using CIBA-Plankton^{Plus} was conducted in 8 ponds of tribal farmers (40 beneficiaries) of Sundarban, West Bengal. Orange crab,*Scylla olivacea* (54.3 ±0.87 g), *L. tade* (1.03±0.09 g), *L. parsia* (0.85 ±0.04 g) and *M. gulio* (1.95 ±0.12 g), were stocked @1, 1.75, 1.25 and 1 /m^2 respectively. The control ponds were supplemented with 100% Poly^{Plus} feed without Plankton^{Plus} and rest 3 groups of treatment ponds were supplemented with 100% feed (T1), 80% feed (T2) and 60% feed (T3) along with weekly dose of CIBA-Plankton^{Plus}. After 90 days of culture, the average body weight attained by *S. olivacea* was 98.60±0.55 g, 121.1±0.77 g, 103.9±0.58 g and 85.20±0.54 g, *L. tade* was 18.30±0.20 g, 21.19±0.22 g, 19.11±0.24 g and 16.06±0.19 g, *L. parsia* was 18.03±0.21 g, 20.34±0.22 g, 19.28±0.20 g and 16.74±0.19 g, *M. gulio* was 18.5±0.23 g, 20.96±0.21 g, 19.5±0.30 g and 16.8±0.22 g; in control, T1, T2 and T3 respectively. The growth results showed that the species performed better in ponds supplemented with CIBA-Plankton^{Plus} than the control ponds even when 20% feed was reduced. After harvesting, income from crab and fishes will be handed over to the beneficiaries.



Growth performance of polyculture of crab-mullet-gulio using CIBA-Plankton*Plus*

Harvested fishes from polyculture of crab-mullet-gulio using CIBA-Plankton*Plus*

Scheduled Caste Sub Plan Scheme (SCSP) Activities

Integrated Community Development through brackishwater aquaculture for coastal scheduled caste families

ICAR-CIBA has initiated an integrated community development for brackishwater aquaculture under SCSP scheme, various technology interventions viz., mud crab culture, milkfish farming, nursery rearing and grow-out of Asian seabass in community pond, in open pens, floating cages, for livelihood income generation. The institute has adopted 10 coastal scheduled caste families consisting of 35 beneficiaries in the Thoniveru village, Pulicat lake region in Tiruvallur district of Tamil Nadu. Under the activity, the tribal people were supported with pond development, supply of fish seed, feed and farm accessories. Crab farming was done in two pen structure made up of plastic reinforced GI mesh and also in fattening boxes. The culture period of 30-35 days of crab culture realized yield of 49.28 kg with income of ₹ 33,700/cycle. Financial and marketing linkages were created.

Distribution of crab boxes and demonstration of pen construction and rearing of mud crab (*Scylla serrata*) to SC beneficiaries at Thonirevu in Pulicat Lake

Marketing of fattened mudcrab by SC beneficiaries at Thonirevu in Pulicat Lake

ICAR-CIBA launched brackishwater aquaculture technology interventions for livelihood development in Pulicat area of Tamil Nadu

ICAR-CIBA, launched livelihood technological interventions for resource poor aqua farmers in Lakshimipuram tribal Nagar, Kattur village and Thonirevu village, Kottaikuppam Panchayat, located in Pulicat area of Tiruvallur district in Tamil Nadu on 28th August, 2021. Dr. Alby John Varghese, I.A.S, District Collector of Tiruvallur district, Tamil Nadu inaugurated the programme and distributed the critical inputs to the farmers. This programme was organized as a part of 75 years of India's Independence "Azad Ki Amrut Mahotsav" under the CIBA Tribal Sub-Plan 20/6 and CIBA – SCSP schemes. The institute adopted 10 coastal Irular tribal families and 20 coastal Scheduled Caste families in the project villages, whom are traditional fishers, crab, shrimp and clam collectors. Brackishwater aquaculture technologies viz., two tier milkfish farming in pond and pens, seabass nursery rearing in hapas, pen and low volume floating cages, crab farming in pen and boxes and fish food sales unit were inaugurated during the programme.

Distribution of critical inputs to SCSP and ST beneficiaries

Exposure visit of beneficiaries of CIBA SCSP/TSP scheme to CIBA Headquarters and Experimental Stations at Muttukadu and Kovalam

ICAR-CIBA is undertaking fisheries based livelihood development interventions for the SC-ST fisher families in Ponneri taluk of Tiruvallur district. A batch of 35 beneficiaries visited Muttukadu and Kovalam experimental stations of CIBA on 25.09.2021. They were given on-farm training and demonstration at fish, shrimp and crab hatcheries, feed mill and ongoing fish and shrimp farming demonstrations. Later at CIBA headquarters an interaction meeting was organized and farm inputs like fish nets and ₹ 50,000 the income generated by the beneficiaries through crab harvest and training certificates were distributed to them.

Amenities created at Thonirevu village in Pulicat Lake

ICAR-CIBA developed fish food sales unit and youth-cum-children study centre for the benefit of SC beneficiaries under the project and was inaugurated by Dr. K.P. Jithendran, Director, ICAR-CIBA. The beneficiaries realized a monthly income of ₹ 20,000 from fish food sales was reinvested for self-sustenance of the stall. The fish food unit operation could be an alternate source of income to the beneficiaries during the lean season.

Youth cum children study centre and Fish food unit established under SCSP plan at Thonirevu village, Pulicat, Tiruvallur district, Tamil Nadu

Asian seabass fingerling production and milkfish aquaculture in brackishwater pens at Kilarkollai village- a proven livelihood model for coastal families

Asian seabass fingerling production and milkfish farming activity in the backwaters of Kilarkollai village, Chengalpattu district of Tamil Nadu was introduced by the ICAR-CIBA team under the SCSP scheme as a means of supplementary livelihood to the villagers. Demonstration of Asian seabass nursery rearing in hapa was encouraged on participatory mode; with resources supported by the SCSP scheme. Labour input was provided by the participating farmers for cultural operations. Hatchery-produced seabass fry in the size range of 1.2-2.0 cm was stocked @ 500/hapa. The fry was fed with formulated feed (Seabass Nursery^{plus}) developed by CIBA for 57-73 days to achieve fingerling size. The net income per culture yielded about ₹ 39,500 and each family got an average income of ₹ 9,875. On the other hand, 500 milkfish fry (0.1-0.3 g) were stocked at 500/hapa and grown to fingerlings (20 g) in 60 days, subsequently, transferred to a pen enclosure (4 /m^2 in 120 m^2) to grow plate size fish for six months. Low protein (28-30%) commercial feed was fed at 3-5% body weight twice a day. A total production of 129.20 kg (280-330 g) with survival rate of 80% was obtained. The harvested fishes were sold at the rate of ₹ 180-200/kg in the local retail market. The farming realised net return of ₹ 15,596. This model proved to be ideal to supplement the livelihood activities of the villagers using the naturally available source of brackishwater, spending two hours daily in addition to their routine activities.

Demonstration of nursery rearing of Asian seabass and milkfish farming to beneficiaries at Kilarkollai, Chengalpattu district, Tamil Nadu

Demonstration of low input-based shrimp farming in Navsari, Gujarat

A low input-based shrimp farming demonstration was carried out for the benefit of SC communities under the SCSP component. Beneficiaries (8 members) from Matwad, Eroo, and Kalthan villages, were selected for the demonstration and training on scientific shrimp farming. As part of the trial, farm inputs including *P. vannamei* seed (30,000 PL_7), were provided for farming in a 0.5 acre earthen pond. The demonstration of 133 days farming resulted in a production of about 672 kg shrimp (24.97 g) generating a revenue of ₹ 216,448, which was distributed among the beneficiaries.

SC beneficiaries and ICAR-CIBA scientists during the harvest of shrimp after 133 DOC

Demonstration of cage-based breeding and seed production of pearlspot, *Etroplus suratensis* in portable RAS system to SC Self-Help Groups at NGRC-CIBA farm Matwad village, Navsari, Gujarat.

SC beneficiaries were trained for designing cages for pearlspot spawning, installation, attaching substrates, collection of eggs, disinfection, incubation and larval rearing in a portable RAS system for a period of 3 months (August – October). A total of 28 spawning were recorded from 15 pair of brooders; out of which 21 spawning were successful and resulted in production of 15,000 pearlspot fry of size 1.5 -2 cm. Subsequent demonstration of nursery rearing of pearlspot to SCSP beneficiaries resulted in production of 12,000 pearlspot fingerlings. A total of ₹ 30,000 as revenue was generated towards the sale of 2,000 pearlspot fingerlings.

Pearlspot fingerlings at the end of 60 days nursery rearing in nylon hapas

Training on nursery rearing of Asian seabass in Kottaikadu, Tamil Nadu

The scheduled caste fisher women (36 beneficiaries) from Kottaikadu village of Chengalpattu district in Tamil Nadu underwent a training and demo at Muttukadu experimental station of ICAR – CIBA for adopting nursery rearing of hatchery produced seeds of Asian seabass (*Lates calcarifer*) on 28 December, 2021.

In house pond demonstration of setting-up of hapa rearing of fish fingerglings

Inauguration of the ornamental fish breeding unit developed by CIBA at Budhakhali village, Kakdwip

ICAR-CIBA has been working for the livelihood improvement of poor and backward farmers, particularly schedule caste (SC) and scheduled tribe (ST) farmers of Sundarban, South 24 paragans under NAIP, TSP, and SCSP programmes. As a part of the CIBA initiative, a Women Self Help Group (SHG) has been formed as part of the SCSP programme with 21 members named "Budhakhali Sundari SC Fish Farmers Welfare Society" and mentored by KRC CIBA through hands-on training on fish keeping and breeding of ornamental fishes. Dr. K. K.Vijayan, Director, CIBA inaugurated the "Sundari Ornamental Fish Breeding Unit" established by CIBA on 3rd April, 2021.

An interaction programme with farmer beneficiaries was organized at KRC where in Director, CIBA handed over the cheques for the profit amount realised by farmers in different demonstration programmes implemented under TSP and SCSP. He also distributed critical inputs viz., Milkfish seed, Poly*Plus* feed and Plankton*Plus* to the farmers as part of the programme. Apart from that he also distributed chicks to women farmers of Sundarban to have an additional income to improve their livelihood status.

Handing over of cheques to the farmers by the Director, CIBA

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

TRAINING PROGRAMS ATTENDED

Scientists

S. No	Name and designation of the Person	Programme Name	Venue	Duration	Organised by
1	Dr. T. Bhuvaneswari, Scientist	Generic Online Training in Cyber Security Program	Online	5th January, 2021	ISEA, Hyderabad
2	Dr. Sherly Tomy, Principal Scientist	Training Program on "General Management Programme for Scientists"	Online	18–29th January, 2021	Administrative College of India (ASCI), Hyderabad
3	Dr. R. Ananda Raja, Senior Scientist	One-day online training programme for nominees of CPCSEA	Online	18th May, 2021	CPCSEA, New Delhi
4	Dr. S. K. Otta, Principal Scientist	Backlink WHONET training for INFAAR members	Online	05-09th July, 2021	FAO, New Delhi
5	Dr. P. K. Patil, Principal Scientist	Online Sensitization Programme on 'Entrepreneurship Development & Start-Up Ecosystem'	Online	05–09th July, 2021	ICAR-NAARM, Hyderabad,
6	Dr. J. Syama Dayal, Principal Scientist	Online Training programme on RTI Act 2005	Online	15–16th July, 2021	ICAR – NAARM, Hyderabad
7	Dr. S. K. Otta, Principal Scientist	International Virtual Regional Training Course on Anti-microbial Resistance Monitoring and Surveillance in Aquaculture	Online	26–30th July, 2021	FAO, New Delhi
8	Dr. T. Bhuvaneswari, Scientist	International Virtual Regional Training Course on Anti-microbial Resistance Monitoring and Surveillance in Aquaculture	Online	26–30th July, 2021	FAO, New Delhi
9	Dr. M. Poornima, Principal Scientist	Online training programme on Genes to Pathways	Online	2–17th August, 2021	DECODE LIFE, India
10	Dr. P. Ezhil Praveena, Senior Scientist	Fish Vaccination : Theory, Innovations and Application	Online	4th August, 2021	Bangkok, Thailand.
11	Dr. P. K. Patil, Principal Scientist	Virtual Training Workshop for Vigilance Officers of ICAR Institutes	Online	16–18th August, 2021	ICAR-NAARM, Hyderabad

12	Dr. B. Sivamani, Senior Scientist	Virtual Workshop on "Applications of Bioinformatics tools in Agricultural Research"	Online	20–30th September, 2021	ICAR – Indian agricultural Statistics Research Institute, New Delhi,
13	Dr. M. Poornima, Principal Scientist	Online training programme on Genome Editing: Introduction to CRISPR-Cas	Online	21st September – 30th November, 2021	Indian Institute of Science, Bangalore
14	Dr. P. Ezhil Praveena, Senior Scientist	Online Training Program on Transcriptomic Data Analysis	Online	28–30th September, 2021	ICAR – IASRI, New Delhi
15	Dr. Sherly Tomy, Principal Scientist	Training Programme on "Protein Structure Modelling and Dynamics"	Online	27– 29th October, 2021	ICAR –IASRI, New Delhi
16	Dr. Debasis De, Principal Scientist	Recirculatory Aquaculture System	Online	30th October – 20th November, 2021	Aquaculture Technology & Research Foundation India (AQUAFIN)
17	Dr. B. Shanthi, Principal Scientist	Emotional Intelligence at Workplace for Scientists/ Technologists	Online	29th November – 3rd December, 2021	Centre for Organization Development, Hyderabad
18	Mrs. Babita Mandal, Scientist	Online training programme on "Statistical design and analytical methods for multifactor experiments"	Online	08 –17th December, 2021	ICAR-CMFRI, Kochi
19	Dr. M. Muralidhar, Principal Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
20	Dr. C. P. Balasubramanian, Principal Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
21	Dr. M. S. Shekhar, Principal Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
22	Dr. M. Makesh, Principal Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
23	Dr. Sherly Tomy, Principal Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
24	Dr. Shyne Anand, Senior Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
25	Dr. T. Bhuvaneswari, Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
26	Shri Aravind, Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
27	Shri I. F. Biju, Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai
28	Smt. Misha Soman, Scientist	Online Training Programme on "Demystifying interactive dash board in Excel"	Online	13–15th December, 2021	Xanthus Institute, Goa and ICAR-CIBA, Chennai

Technical Staff

S. No	Name and designation of the Person	Programme Name	Venue	Duration	Organised by
1	Shri Ramesh Babu, Sr. Tech. Assistant	National Level Capacity Building Workshop for Agricultural LIS professional	Online	22-27th November, 2021	Agricultural University, Hyderabad,

Administrative Staff

S. No	Name and designation of the Person	Programme Name	Venue	Duration	Organised by
1	Shri R. K. Babu, FAO	Online Training Programme on "Budget Utilization Procedure"	Online	22-24th July, 2021	ICAR-NAARM, Hyderabad
2	Shri P. Srikanth, AFAO	Online Training Programme on "Budget Utilization Procedure"	Online	22-24th July, 2021	ICAR-NAARM, Hyderabad
3	Smt. V. Usha Rani, AO	Online Training Programme on "Budget Utilization Procedure"	Online	22-24th July, 2021	ICAR-NAARM, Hyderabad
4	Shri K. Ragavendra, AAO	Online Training Programme on "Budget Utilization Procedure"	Online	22-24th July, 2021	ICAR-NAARM, Hyderabad
5	Smt. V. Usha Rani, AO	Budget Utilization Procedure for Administrative and Finance Officers	online	09-11th August, 2021	ICAR-NAARM, Hyderabad

Trainings conducted 2021

Sl. No	Name of the Training	Duration	No. of participants
Headquarters			
1	Farmer Field Schools on "Smart shrimp farming" at Uppanar shrimp farming cluster in Cuddalore district, Tamil Nadu and Thumlapalli, Bapatla district, Andhra Pradesh.	February to June, 2021	90
2	A Special Training Programme for the Skilled Support Staff to enhance their work efficiency	3-5th March, 2021	13
3	"Hands on training on Shrimp and mud crab culture: A practical exposure"	20-25th September, 2021	8
4	On-farm training for the SC&ST beneficiaries under SCSP Scheme	25th September, 2021	35
5	Hands-on training on diagnostics and management of *Enterocytozoon hepatopenaei* (EHP) in shrimp	25-30th October, 2021	7

6	Training on Biofloc technology for nursery and growout aquaculture	9-12th November, 2021	13
7	Online Training Programme on "Demystifying interactive dash board in Excel"	13–15th December, 2021	11
Kakdwip Research Centre			
8	Online awareness programme on shrimp and mudcrab farming (Bengali language)	12th January, 2021	309
9	On-farm training on "Seed production technology of brackishwater cat fish, *Mystus gulio*" organised in Shibnagar village of Namkhana, South 24 Parganas, West Bengal (Bengali language)	29th January, 2021	50
10	Brackishwater finfish seed production and farming" (Bengali language)	28th January, 2021	116
11	Soil and water quality management in brackishwater aquaculture (Bengali language)	11th February, 2021	73
12	Disease management in shrimp farm (Bengali language)	1st March, 2021	176
13	Brackishwater polyculture of finfish and shellfish (Bengali language)	24th March, 2021	118
14	Nutrition, feed formulation and management for brackishwater shellfishes and finfishes	15-20th November, 2021	20
15	Farming and seed production technology of brackishwater fishes	18-23th December, 2021	27
Navsari Gujarat Research Centre			
16	Training programme under "Rural Fisheries Work Experience Programme (RFWEP)" for 7th Semester Students of College of Fisheries Science, Kamdhenu University, Navsari at NGRC Farm, Matwad	6 - 12th August, 2021	40

Workshops, Seminars and Meetings

ICAR CIBA celebrated nation's 72nd Republic Day on 26th January, 2021

The institute celebrated the 72nd Republic Day by unfurling the National Flag and organised sports events for the staff and their family members at CIBA headquarters, Chennai and regional centers: Kakdwip Research Centre of CIBA, Kakdwip, West Bengal; Navsari Gujarat Research Centre of CIBA (NGRC), Navsari, Gujarat and Muttukadu Experimental Station (MES), Muttukadu, Tamil Nadu.

Release of hatchery technology for grey mullet and Cephalus*Plus* brood stock and nursery feeds

In a major breakthrough, CIBA has successfully bred the grey mullet, a high-valued commercial brackishwater fish, for the first time in the country in line with Government of India's thrust on increasing fish production under blue revolution mission. The success of this long-waited breeding technology was officially announced on 28th January, 2021 by CIBA in a stakeholder meet organised at Muttukadu Experimental Station, Chennai in the presence of Dr. Joykrushna Jena, DDG (Fy), ICAR, New Delhi, through video conferencing and Dr. M. Vijayakumaran, former Principal Scientist of CMFRI, RAC member, Mr. Ramachandra Raju and Mr. S. Sathish Kumar, IMC members of CIBA and Mrs. Oliver Rachael, Deputy Director, Department of Fisheries, Tamil Nadu. As a part of this event, the first batch of hatchery produced grey mullet seeds, and species specific feeds (Cephalus*Plus* brood stock and nursery feeds) for grey mullet were distributed to the enterprising farmers from Andhra Pradesh, Tamil Nadu and Kerala.

ICAR-CIBA organised the first stakeholder meeting with insurance companies and farmers for developing insurance for shrimp aquaculture through novel insurance products

The institute organised a consultation meeting at its headquarters, Chennai on developing a pragmatic crop insurance product for shrimp aquaculture on 12.02.2021. Officials from leading insurance companies, farmers, farmer representatives, scientists and other stakeholders participated in the deliberations. ICAR-CIBA has been sensitizing insurance companies and facilitating them with scientific data that shrimp farming with adoption of better management practices is sustainable and needs institutional support, such as suitable insurance products. During the interaction moderated by CIBA, members from Allianz Insurance, Chennai, New India Assurance, Chennai and ICICI General Insurance, Chennai and farmers and aqua business personnel exchanged their views on the draft proposal on insurance products for shrimp farming.

ICAR-CIBA organised a special training programme for the skilled support staff to enhance their work efficiency

Skilled Support Staff who help the scientists in their research and development activities seldom get attention and opportunities to enhance their skill sets. It is important that they also need to be heard and supported by conducting relevant capacity enhancement programmes. In this context, ICAR-CIBA conducted the three-day special training course on "Enhancing the work efficiency of Skilled Support Staff" during 3-5, March, 2021. Fifteen skilled support staff attended the training. Dr. K. K. Vijayan, Director, CIBA who inaugurated a training programme underlined the importance of support staff and emphasized that physical health and peace of mind are important to perform better in their work place. Sessions on healthy life style, yoga and importance of balanced diet for maintaining good health were respectively handled by experienced trainers. Further, interactive sessions on work efficiency, ethics in work place, office procedures and financial rules were explained to them with practical case studies and team building games. The training programme was coordinated by Dr. Deboral Vimala, Principal Scientist & Dr. M. Makesh, Principal Scientist & Scientist-In-Charge, HRD Cell, CIBA.

International Women's Day celebrated at ICAR-CIBA

ICAR-CIBA celebrated International Women's Day with an emphasis on Women Leadership in Agriculture: Entrepreneurship, Equity & Empowerment (3E's) on 8th March, 2021. Dr. M. Bhanupriya, Consultant, Radiation Oncologist gave a special talk on 'Women's Health Care' and Mrs. Gayathri Thiagarajan, Regional Nutrition Training Manager, Nestle India, presented a talk on Role of women in changing the nutrition of households'. Dr. S. V. Alavandi, Director-In-Charge welcomed the speakers and highlighted the significant roles played by the women in the family and felt that education alone emancipates them from the socio-economic clutches. Further, as a part of the fortnight long Women's Day celebration an event was organised on 27th February for farm women folk in Muttukadu Experimental Station of CIBA about preventive measures of COVID-19 & hygienic practices. About 25 aqua farmers including 15 women aqua farmers participated in the programme. The programme was co-ordinated by Dr. D. Deboral Vimala, Principal Scientist & Chairperson, Women's Cell, CIBA.

ICAR-CIBA to promote brackishwater aquaculture as the low water foot print food production system on World Water Day – 2021

World Water Day is celebrated globally every year on 22 March to sensitize the public about the water, its availability, accessibility, depletion, use efficiency, conservation and management. Under the leadership of Dr. K. K. Vijayan, Director CIBA the institute organised a virtual seminar on "Sustaining Water for the Next Millennium". Dr. Indumathi M. Nambi, Professor, Environment & Water Resources Engineering, Indian Institute of Technology, Madras, the invited speaker, highlighted about water foot print for green, blue and grey waters, individual and national water foot prints, concept of virtual water, water foot print import and export and its impact on national trade policy.

Inauguration of State of the art 'Aqua-Climate Laboratory', by DDG (Fisheries) virtually in the presence of DDG (NRM)

Dr. J. K. Jena, DDG (Fy), ICAR virtually inaugurated the state-of-the-art laboratory on 27th April, 2021 at ICAR-CIBA, Chennai in the presence of Dr. S. K. Chaudari, DDG (NRM), ICAR, Dr. V. K. Singh, Director, ICAR-CRIDA, Hyderabad, and DR. K. K. Vijayan, Director, ICAR-CIBA. M. Muralidhar, PI of NICRA project at ICAR-CIBA briefed about the establishment of Aqua Climate Laboratory facility under the project. Dr. K. K. Vijayan highlighted the partnership of CRIDA and CIBA, on the area of climate change, and developing this facility of International standard. Dr. V. K. Singh, Director, CRIDA applauded CIBA for the achievements under the NICRA project. Dr. J. K. Jena congratulated CIBA for this excellent facility in the region and emphasised the importance of aquaculture for food security in the scenario of climate change.

Release of ICAR-CIBA technologies: Nodavac-R, vaccine for Viral Nervous Necrosis and Oxy^{plus}, Dissolved Oxygen Enhancer

Two products developed by the ICAR-CIBA viz., CIBA Oxy^{plus}, Dissolved Oxygen Enhancer and CIBA-Nodavac- R, Recombinant Viral Nervous Necrosis Vaccine were virtually released by Dr. J. K. Jena on 27th April, 2021 at ICAR-CIBA. Dr. P. Kumar Raja, Scientist who led the team in the development of cost-effective Oxy^{plus} explained the advantages of the indigenously developed product, in addressing the emergency oxygen depletion in aquaculture ponds. CIBA-Nodavac-R, a Recombinant Vaccine was developed indigenously to prevent the Viral Nervous Necrosis (VNN). Dr. M. Makesh, Principal Investigator and the team leader highlighted need of vaccination of fishes to prevent disease outbreak in multiple fish species such as Asian seabass, mangrove red snapper, milkfish, grey mullet etc that are commercially important food fishes.

ICAR-CIBA launched the online version of AQUASTAT

ICAR-CIBA developed and launched an online version of brackishwater aquaculture database (online Aquastat) through collection and collation of major data components on various aspects of brackishwater aquaculture viz., Global and Indian scenario of brackishwater aquaculture, production and trade statistics etc. Dr. K. K. Vijayan, Director, ICAR-CIBA inaugurated online Aquastat in ICAR-CIBA website (www.ciba.res.in/aquastat) on 27th April, 2021. The data will be updated on yearly basis with a hard copy version, and every six months in online version. Online Aquastat is created using MYSQL and PHP scripting language. Data on brackishwater aquaculture and allied sectors can be retrieved based on the user's keywords in the form of country wise, state wise, species wise etc. and also in its combination which will be displayed as table and graphical format. This is useful to the planners, policy makers, researchers, state officials, academicians and other stakeholders in aquaculture as ready reference. Dr. R. Geetha, Dr. T. Ravisankar and Dr. C. V. Sairam, Economics Scientists of Social Sciences Division, CIBA developed this data base.

ICAR-CIBA inaugurated Kovalam Experimental Station (KES), Farmer Facilitation Centre, Brackishwater Ornamental Fish Hatchery and Finfish Seed Rearing Unit on 22nd May, 2021

ICAR-CIBA, Chennai officially inaugurated three additional infrastructure viz., CIBA's Kovalam experimental station, Farmer facilitation centre, Brackishwater ornamental fish hatchery and Finfish seed rearing unit on 22.05.2021. Dr. J.

K. Jena, Deputy Director General (Fisheries), ICAR, New Delhi, inaugurated the new Kovalam Experimental Station (KES), by on-line mode, in the presence Chief Guest Shri J. Jayakanthan, IAS, Commissioner of Fisheries. Dr. K. K. Vijayan, Director, CIBA, presided over the function. Kovalam experimental station is having 65 acres of land and have potential for future expansion for R&D, harmonizing with the Muttukkadu experimental station of CIBA.

Declaration of seed production technology for mangrove red snapper (*Lutjanus argentimaculatus*) and distribution of fingerlings

In a major breakthrough that would give a fillip to diversification of brackishwater aquaculture, the ICAR- CIBA, Chennai has succeeded in developing captive broodstock and seed production technology of an another marine fish Mangrove Red Snapper (*L. argentimaculatus*) for the first time in India. As a result of concerted efforts, successful breeding and larval production of Mangrove Red Snapper (MRS) was achieved using captive stock in 2019 and repeated the breeding consecutively in the next year and produced fingerlings. A function was organised at CIBA on 25 May, 2021 to announce the development of hatchery technology and distribute the first batch of red snapper fingerlings to potential farmers. Dr. J. K. Jena, DDG (Fy), ICAR, New Delhi who presided over the function through online mode, described that CIBA achieved an another milestone by developing the hatchery seed production technology for MRS and it is a significant step towards diversification of brackishwater aquaculture.

New annex building "ICAR-CIBA Headquarters Block II" opened on 28th May, 2021

New annex building "ICAR-CIBA headquarters Block II" was opened on May 28, 2021 at ICAR-CIBA headquarters by Dr. K. K. Vijayan, Director, ICAR-CIBA. The building will add an additional area of 8000 square feet to the CIBA headquarters. During the occasion Dr. K. K.Vijayan, highlighted the scope of the block and stated that the building is presently constructed at ground floor only which has the provision of additional nine floors. He had also conveyed his appreciation to the CPWD Department for their cooperation during the execution of construction work. Dr. P. Mahalakshmi, Principal Scientist & OIC of Engineering Cell, CIBA, who facilitated the work with central PWD, presented that the ground floor houses the office for Institute Technology Management Unit (ITMU), laboratories for ITMU/ABI for pilot scale production of new technologies for commercialization, and auditorium/meeting hall for 300 people and pantry room.

Inauguration of brackishwater aquaculture research and development farm, NGRC of ICAR-CIBA

ICAR-Navsari Gujarat Research Centre of CIBA, Navsari, Gujarat has been established in the year 2018 to evolve in to a nodal centre for development of brackishwater aquaculture in the west coast. On 31st May, 2021 Dr. K. K. Vijayan, Director, CIBA, inaugurated the 10 ha Brackishwater Aquaculture Research and Development farm of NGRC of CIBA, through a virtual platform. The land was transferred on lease for 25 years to ICAR-CIBA by Department of Fisheries, Govt. of Gujarat for research and development on brackishwater aquaculture in the region.

KRC OF ICAR-CIBA organised Covid-19 vaccination camp on 4th June, 2021 at KRC campus

Kakdwip Research Centre of ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Kakdwip, West Bengal organised COVID-19 vaccination camp at KRC campus for office staff and their family members. Total 102 persons of KRC family members have been administered 1st dose of COVID-19 vaccine. Awareness was created on preventive and safety measures like use of face mask and importance of social distancing to the staff and their family members during the camp.

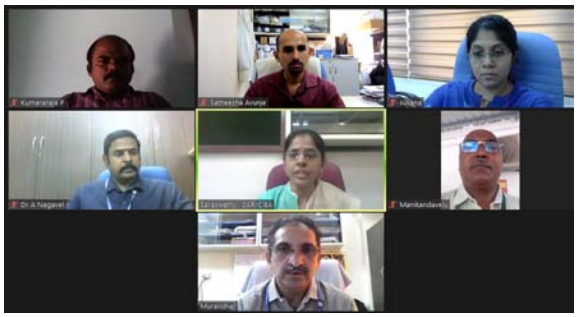
Kakdwip Research Centre of ICAR-CIBA distributed food materials to the "YAAS" cyclone triggered flood affected farmers

Super cyclone 'Yaas' aligned with full moon tide caused devastating flood at Kakdwip block of South 24 Parganas district, West Bengal on 26th May, 2021. The tidal waters rose to unprecedented levels of 8-10 m and caused severe damage to farms and properties at Kakdwip and adjoining areas. Kakdwip Research Centre of ICAR-CIBA has taken initiative to help the people by distributing food materials to the affected people in the vicinity at Buddhapur, Kakdwip on 4th June, 2021. The people expressed their happiness and appreciation for this timely help during this inadvertent situation.

Celebration of World Environment Day – 2021

World Environment Day was celebrated under the leadership of Dr. K. P. Jithendran, Director, CIBA on 5th June, 2021 by ICAR-CIBA on digital platform with an invited talk by Dr. Himanshu Pathak, Director of Deemed Institute of ICAR-National Institute of Abiotic Stress Management, Baramati, on 'Economy or Environment? Solving the Eternal conflict' aligning to the theme of the environment day "Reimagine-Recreate-Restore". Dr. Pathak described Indian food revolution and need of sustained development. The programme was witnessed by more than 100 participants including researchers, academicians and students participated and the queries posted were discussed during interaction session.

On-line farmers' awareness campaign on Balanced Use of Minerals/Fertilizers in Shrimp Aquaculture



ICAR-CIBA organised the Farmers' Awareness Campaign on "Balanced Use of Minerals/ Fertilizers in Shrimp Aquaculture" in Tamil language on 18th June, 2021 in a virtual platform on the occasion of celebrating 75 years of Indian Independence. The Chief Guest Dr. D. Manikandavelu, Professor and Head, Department of Aquatic Environment Management, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, emphasized the importance of water quality management in aquaculture with special reference to fertilizer nutrients and minerals. About 310 persons participated in the campaign including farmers, aqua consultants, scientists and research students.

ICAR-CIBA celebrated 7th International Yoga Day on 21st June, 2021

CIBA celebrated the 7th International Yoga Day on 21st June, 2021 on digital mode. Ms. Janani Subburaj, Yoga Expert gave a lecture-cum-demonstration on "Significance of Yoga in the Present Pandemic Situation and Simple Yoga Techniques for improving the physical and mental wellbeing". The practices included Yogic Breathing techniques, Bhraamari, simple stretching

techniques for activation of lymphatic system etc. Dr. K. P. Jithendran, Director (Acting) has stressed the significance of Yoga for holistic wellbeing of physical, mental and spiritual health of individual. Dr. J. Syama Dayal, Principal Scientist and Nodal Officer, International Day of Yoga celebrations and Dr. K. Ambasankar, Principal Scientist & Secretary, CIBA Recreation Club coordinated the event.

ICAR CIBA organised National Fish Farmers Day 2021 and National Campaign on Ecosystem Management for Sustainable Fisheries

ICAR-CIBA and its Research Centres at Kakdwip, West Bengal and Navsari, Gujarat organised the National Campaign on 'Ecosystem Management for Sustainable Fisheries' on 10th July, 2021. About 100 aquafarmers, fishers and SHG women participated in the programmes. Technical discussions on aquaculture species and systems, pond management, health and ecosystem management aspects of shellfish and finfish farming were held during the event.

ICAR-CIBA, Chennai organised 'one student-one tree' initiative as part of the Nation-Wide Campaign on Plantation and Awareness on the eve of ICAR's Foundation Day

ICAR-Central Institute of Brackishwater Aquaculture, Chennai launched a novel initiative of 'student custodian' for the trees planted in the office campus in connection with the nation-wide campaign on plantation and awareness on the eve of ICAR's Foundation Day on 16th July, 2021.

The programme was organised with the theme, "Har Med Par Ped" as part of the *"Bharat Ka Amrut Mahotsav"* to commemorate *75 Years of India's Independence*. Dr. K. P. Jithendran, Director, ICAR-CIBA inaugurated the function and urged the staff and scholars on 'green campus' and conservation of natural resources and ecosystem.

ICAR-CIBA organises Industry Day

ITMU, ICAR-CIBA organised a virtual stakeholders meet on 17th July, 2021 on mark of ICAR foundation Day. The Entrepreneurs of CIBA attended the virtual interaction and shared their experience and expectations of technologies services of CIBA, Chennai.

1. Mr. Sudhakar, Vice-President, Rajshree Biosolutions, Theni, TN
2. Mr. Dinesh, Director, New Bio Scientific Company, Mysore
3. Mr. Sachin, CEO, Canares Aquaculture LLP, Yeshwanthpur, Bangalore
4. Mr. Vinod Poonia, Director, Dr. Attar Aqua Feed, Haryana

ICAR-CIBA, organised an international webinar on the scope of reintroduction of shrimp crop insurance in India

ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai, in association with a leading world re-insurance company the Willis Towers Watson organised an international webinar on the reintroduction of shrimp crop insurance in India on 10th August, 2021. The scope for introducing 'affinity insurance' with the involvement of hatchery and feed mill industry partners and merits and demerits of 'indemnity' and 'parametric' insurance schemes were discussed in detail. Industry presentations were made by Willis Tower Watson and Aquaconnect group. A panel discussion on "Indian aquaculture insurance from a reinsurance perspective" was conducted as a plenary. Panelists from the insurance sector representing M/s. Swiss Re, Hannover Rück SE – India Branch, AXA Climate, Qatar Reinsurance Company Limited, and Liberty Mutual participated.

ICAR-CIBA celebrated 75th Independence Day

ICAR-Central Institute of Brackishwater Aquaculture, Chennai and its 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 celebrated the 75th year of Independence Day on 15th August, 2021. Unfurling the National Flag and sports events for the staff and their family members were organised on the eve of Independence Day at CIBA headquarters, Chennai and other regional centers.

ICAR-CIBA conducted virtual farmers-scientists-industry interaction meet on brackishwater aquaculture species and systems diversification

ICAR-CIBA organised a Farmers-Scientists-Industry interaction meet titled "Brackishwater aquaculture species and system diversification" in virtual mode on 1st September, 2021 to commemorate the 75th Anniversary of India's Independence (Bharat Ki Azadi Ka Amrut Mahotsav 2021-22).

The event had about 124 participants, including aqua farmers, technicians, entrepreneurs, researchers, students etc., Dr. K. P. Jithendran, Director, ICAR-CIBA inaugurated the function and emphasized the importance of species and system diversification in brackishwater aquaculture as a strategy for sustainable production. He underlined that the Bio-Diversity Index (BDI) of aquaculture in India is relatively low (0.13) vis-à-vis other Asian countries (0.5). The interaction meet had three technical sessions viz., species diversification in crustacean aquaculture, species diversification in finfish aquaculture and system diversification in brackishwater aquaculture. Dr. T. Ravisankar, Dr. K. P. Kumaraguru Vasagam and Dr. P. K. Patil Principal Scientists moderated the deliberations.

ICAR-CIBA organised 'one student-one tree' and 'one farmer-one tree' initiative as a part of the International Year of Millets 2023 campaign.

ICAR-CIBA launched a novel initiative of 'student and farmer custodian' for the trees planted in the office campus in connection with the nation-wide campaign on Poshan Vatika and tree plantation to celebrate the India sponsored UN declaration of International Year of Millets 2023 on nutri-garden and tree plantation on 17th September, 2021. The programme was conducted at CIBA headquarters and research centres of CIBA (KRC, Kakdwip and NGRC, Navsari). Tree plantation activity was also organised at experimental stations of CIBA (MES and KES). A total of 191 tree saplings were planted with active participation of 171 farmers including 71 kanyas/women participants.

Dr. L. Murugan, Hon'ble Minister of State for Fisheries, Animal Husbandry and Dairying and Information and Broadcasting, Govt. of India, visited Crab Harvest Mela at ICAR-CIBA demonstration site

Dr. L. Murugan, Hon'ble Minister of State for Fisheries, Animal Husbandry and Dairying and Information and Broadcasting, visited the crab harvest mela at ICAR-CIBA demonstration site, Pulicat Lake in Tiruvallur district, Tamil Nadu on 18.09.2021. ICAR-CIBA had initiated mud crab

farming demonstration under SCSP scheme for the coastal SC families of Thonirevu village for livelihood enhancement. Mud crabs were harvested from the fattening crab boxes as well as from the pens at the demonstration site. The minister interacted with the beneficiary families about the livelihood activities taken up by CIBA and appreciated the work done by the scientists of CIBA for enhancing the social status of coastal families.

KRC-CIBA-Kakdwip organised CIBA exhibition stall in the 24th National Agriculture Exhibition, Kolkata

ICAR-CIBA Exhibition stall was organised in the "24th National Agriculture Exhibition" held at Science City, Kolkata during 28-31 October, 2021. The Exhibition was organised by the Central Calcutta Science & Culture Organisation for Youth and 28 organisations of Central and State Governments participated in the event.

ICAR-CIBA, Chennai organised Vigilance Awareness Week 2021

ICAR-CIBA organised Vigilance Awareness Week 2021 during 26th October to 1st November, 2021 with the theme '*Independent India @ 75, self-reliance with integrity*'. The one week programme included: pledge on the first day followed by competitions on essay writing, elocution, quiz and drawing for the staff, students and their children. On the first day, Director In-charge, CIBA pronounced the pledge to all the staff of the institute. Participants were also encouraged to take e-pledge by directly logging on to Central Vigilance Commission (CVC) website. A drive was undertaken to spread awareness regarding the provisions under the PIDPI (Public Interest Disclosure and Protection of Informers) resolution as well as all related information. The valedictory programme was held on 1st November, 2021. The programs of the awareness week were coordinated by Dr. P. K. Patil, Vigilance Officer, ICAR-CIBA, Chennai.

Webinar on "Antimicrobial Resistance in Aquaculture – Who is Responsible?"

Considering the importance of Antimicrobial Resistance (AMR) and its significance in the aquaculture sector at present a webinar-cum-awareness programme on "Antimicrobial Resistance in Aquaculture – Who is responsible?" was organised by ICAR-CIBA, Chennai on 9th November, 2021. Internationally renowned scientist Prof. (Dr.) Iddya Karunasagar, the Expert Member, World Health Organization (WHO) advisory group on critically important antimicrobials for human use was the speaker. About 106 participants including scientists, aqua-professionals, stakeholders, academicians and students both from India and abroad participated in the webinar.

Indigenous feed mill established at Haryana with ICAR-CIBA technology received appreciation for excellent performance from Government of Haryana on the occasion of World Fisheries Day

World Fisheries Day is celebrated every year on 21st November to highlight the importance of fisheries and aquaculture and to ensure sustainability in this sector. On this occasion, the fisheries department, Govt. of Haryana organised a meeting at Siwani, Bhiwani district and presented the awards to the best farmers and entrepreneurs. In yet another recognition for the research initiatives of Chennai-based institute, a start-up company from Charkhi Dadri district, Haryana, adopted the technology of CIBA in formulating *desi* shrimp feeds and won the accolades as best entrepreneur for excellent performance. Shri J. P. Dalal, Senior Cabinet Minister presented the award to Mr. Anil Kumar, Managing Director, M/s. Dr. Attar Aqua

Feeds for the best entrepreneur under large feed mill category. Formulation of this feed on a commercial scale by the Haryana-based company helped reducing the production cost in shrimp aquaculture in north India, particularly inland states like Haryana, Punjab and Rajasthan and effectively contributing towards doubling of farmers' income. The company started operation in 2018 and currently having a installed capacity of 20 tonnes per day. Hundreds of shrimp farmers are still getting the benefits of this feed in their aquaculture ventures. It is estimated that the production cost could be reduced by 20% with the commercialization of ICAR-CIBA's *desi* feed technology.

ICAR-CIBA celebrated World Antimicrobial Awareness Week

ICAR- CIBA, celebrated the World Antimicrobial Awareness Week (18th to 24th November) and World Fisheries day (21st November, 2021) as a part of ICAR Azadi ka Amrit Mahotsav adopting the theme designed by the Fisheries Division of ICAR campaign on 'Antimicrobial Resistance in Fish' (22nd to 24th November) during 18th to 24th November, 2021. On this occasion, essay and elocution competitions related to awareness on antimicrobials were conducted among the staff and students. During the webinar, Dr. K. P. Jithendran, Director, CIBA, opined importance of the awareness creation on AMR towards the sustainable fisheries. During the valedictory session, Dr. S. K. Otta presented a consolidated report and certificates and prizes to the winners of competitions were distributed.

Celebration of World Soil Day with aqua farmers of coastal Karnataka and distribution of soil and water health cards

ICAR-CIBA celebrated the World Soil Day in consort with the aqua farmers of Udupi and Uttara Kannada Districts, Karnataka under the guidance of Dr. K. P. Jithendran, Director, CIBA on 4th December, 2021 at Kundapura, Udupi district, Karnataka. Dr. M. Muralidhar, Principal Scientist, Scientist-in-Charge, Environment Group & Principal Investigator, NICRA project narrated the importance of conserving the soil health and sensitised the farmers on soil and water quality issues of brackishwater farms in coastal Karnataka and BMPs for sustainable aquaculture. Mr. K. Ganesh, Joint Director of Fisheries, Udupi District, who inaugurated the farmer's meet explained the potential of cage culture in coastal Karnataka, and outlined the scope for future collaborations of Fisheries Department with ICAR-CIBA in utilising the resources of Karnataka state for sustainable brackishwater aquaculture development. Dr. M. Ganapathi Naik, Professor and Head, Dept. of Aquaculture, College of Fisheries, Mangalore, Dr P. P. Suresh Babu, Senior Scientist & SIC, ICAR-CMFRI, Karwar, Dr. Vishnudas Gunaga, Assistant Director, MPEDA Sub Regional Division, Mangalore and Mr. Shrinivas H. Hulkoti, Scientist, KVK Brahmavara briefed the farmers about the roles played by their agencies in sustaining the ecosystem based aquaculture in Karnataka. During the meeting Soil and water health cards (SWHC) were issued to 148 farmers by the dignitaries.

ICAR-CIBA celebrated National Farmers Day on 23rd December, 2021

ICAR-CIBA celebrated the National Farmers Day with the fishers, tribal farmers and fisheries students at Muttukadu Experimental Station, Muttukadu, Chengalpattu district, Tamil Nadu. National Farmers Day (Rastriya Kisan Diwas) is celebrated on 23rd December every year in the honour of Chaudhary Charan Singh who was a popular kisan leader and former Prime Minister of India. About 120 farmers, students, scientists and staff of CIBA participated in the programme.

Awards and Recognitions

- Dr. Akshaya Panigrahi, Principal Scientist, CCD has been awarded "K. Chidambaram Memorial Annual Award" for "Developing technology in organic shrimp production and demonstration of native penaeid shrimp for higher production in different ecological and climatological conditions of Indian coastal areas" by The Fisheries Technocrats Forum, Chennai, Tamil Nadu.
- Dr. Akshaya Panigrahi, Principal Scientist, CCD has been awarded with "Outstanding Aquaculture Scientist Award" for "Commendable contribution to better farming systems, Management and propagation of native species in Aquaculture" by Dr. B. Vasantharaj David Foundation, Chennai, Tamil Nadu
- Dr. P. Ezhil Praveena, Senior Scientist, AAHED has been awarded for the oral presentation with 1st position for the oral presentation of the abstract Pathology of white muscle syndrome in shrimp in the 4th central zone conference of IAVP-2021 & National symposium organised by Department of Veterinary Pathology, College of Veterinary Science & A. H., Rewa, NDVSU, Madhya Pradesh during 5 - 6th Oct, 2021 through virtual mode.
- Dr. Ananda Raja, Senior Scientist, AAHED has been awarded Outstanding Scientist in the International Conference on Engineering, Science and Medicine organised by the VDGOOD Professional Association held on 12th November 2021.

ICAR-CIBA bagged the ICAR's Best Annual Report Award 2019-20

ICAR-CIBA, Chennai has been awarded the 'Best Annual Report Award 2019-20' under large institute category of all the ICAR Institutes. The institute received the award from Shri Narendra Singh Tomar, Honourable Union Minister of Agriculture and Farmers Welfare, in the presence of Shri Parshottam Rupala, Union Minister of Fisheries, Animal Husbandry & Dairying & Vice-President, ICAR, Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR), and other dignitaries, on virtual mode during the 93rd ICAR Annual Foundation Day & Award Ceremony held on 16th July, 2021.

List of PhD awardees during 2021

Name of the Student	Thesis Title	Supervisor	Date of award
Shri P. R. Anand	Development and validation of Technology Information Communication Modules as Mobile Application for sustainable shrimp aquaculture	Dr. M. Kumaran	24.03.2021
Mrs. Sreekakula Kathyayani	Effect of multiple combinations of environment and climatic stressors on shrimp growth and biochemical parameters	Dr. M. Muralidhar	28.04.2021
Shri C. P. Binesh	Betanodavirus in fishes: Molecular surveillance, phylogenetic and development of a diagnostic assay	Dr. K. P. Jithendran	30.09.2021
Mrs. P. Sai Krithi	Insights into molecular pathways associated with ovarian development in *Penaeus monodon*	Dr. Sherly Tomy	01.12.2021
Shri C. Bala Amarnath	Possibility of combined silencing of host and viral genes as a strategy for better survivability of tiger shrimp, *Penaeus monodon*, against WSSV infection	Dr. Subhendu Kumar Otta	23.12.2021

Linkage and Collaborations

The institute maintained linkages with the following national and international organisations

ICAR INSTITUTES
ICAR - Central Marine Fisheries Research Institute, Kochi, Kerala
ICAR - Central Inland Fisheries Research Institute, Barrackpore, West Bengal
ICAR - Central Institute of Fisheries Technology, Kochi, Kerala
ICAR – Central Institute of Fisheries Education, Mumbai, Maharashtra
ICAR – National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh
ICAR - Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha
ICAR – Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand
ICAR – Central Island Agricultural Research Institute, Port Blair
ICAR – Central Research Institute for Dryland Agriculture, Hyderabad
ICAR – Directorate of Seed Research, Mau, Uttar Pradesh
ICAR – Central Institute for Women in Agriculture, Bhubaneswar
ICAR – National Academy of Agricultural Research Managment, Hyderabad

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 Sciences, 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 institute, 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 Fisheries 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 Dr. J. Jayalalithaa Fisheries University, Nagapattinam
University of Madras, Chennai
West Bengal University of Animal and Fisheries Science, Kolkata
Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai
Indian Institute of Technology, Kharagpur, West Bengal
University of Southampton, UK and The Pirbright Institute, United Kingdom
Centre for Environment Fisheries and Aquaculture Science (CEFAS), Weymouth, Dorset, United Kingdom
Guru Nanak College (Autonomous), Velachery, Chennai, Tamil Nadu
Sathyabama University of Science and Technology, Semmancheri, Chennai, Tamil Nadu

State Fisheries Departments
The institute has well established linkage with state fisheries departments mainly for transfer of technologies

Consultancies and Technology Transfer

Startup initiative for production of 'Black Soldier Fly Meal (BSF) as fishmeal replacement

ICAR-CIBA joined hands with a team of young entrepreneurs led by Mr. C. Bhanu Prashanth to explore the possibilities of using black soldier fly meal (BSF meal) as a sustainable ingredient in aquafeed through an MoU signed on 20th January, 2021. The startup plan to collect all the kitchen waste which is rich in nutrients from multi-storied residential apartments, available for free of cost, and subject them for biological processing by black soldier flies (*Hermetia illucens*), which will yield high-quality protein and lipid-rich meal, while the residual material rich in inorganic nutrients available as a by- product can be used as an organic fertilizer for agriculture and horticulture.

ICAR-CIBA partners with farmer-entrepreneur for establishing a multispecies integrated feed mill to facilitate diversification of brackishwater aquaculture in Andhra Pradesh

Technology support for diversification of brackishwater aquaculture by having species choices of different feeding habits and farming requirements to utilize the resources sustainably is one of the mandates of ICAR-CIBA. In any aquafarming, success depends on quality seed and feed which in turn determine the economic returns and profitability. CIBA has successfully contributed to the critical nodes of this farming value chain of candidate shellfish and finfish with seed, feed, health care and region-specific farming technologies. In this setting, CIBA formed a strategic alliance with an enterprising brackishwater farmer, Mr. Mandava Venkata Naveen from Nagayalanka region of Andhra Pradesh, for an integrated feed mill to produce indigenous formulated grow-out feeds used for candidate brackishwater fish species by signing an MoU on 17th Feb, 2021. CIBA has developed cost-effective and quality 'desi feeds' using indigenous feed ingredients for all the candidate species farmed in brackishwater. The integrated feed mill envisages to produce species-specific formulations with the technical collaboration of CIBA, for their own use and subsequent sales to nearby farmers.

During the event, Dr. K.K. Vijayan, Director, ICAR-CIBA, impressed upon the quality of feed vis-a-vis the cost of production and emphasized that this integrated feed mill initiative is the first of its kind in this region and would be a boon for aqua farmers in the future.

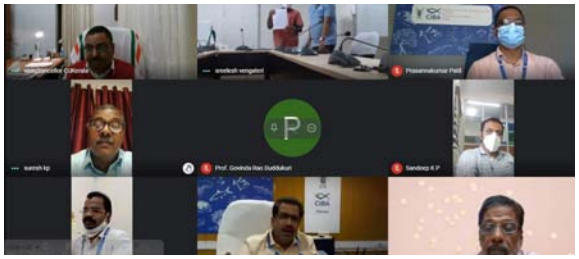
Small scale integrated feed mill for production of fish & shrimp feed

In association with 'Wellgrow Feeds' under the start-up initiative, the institute plans to establish a small scale integrated feed mill at Kannur, Kerala through an MoU signed on 24th March, 2021. The major bottleneck for the large scale propagation of brackishwater aquaculture is the availability of cost effective & quality feeds. It is planned to establish an integrated feed mill to process indigenous formulated, functional and grow-out feeds used for farmed species in the West coast.

MoU signing for CIBA-Plankton *Plus* technology transfer

Director, CIBA, signed a Memorandum of Understanding (MoU) with M/s T. K. Enterprise, Kakdwip, West Bengal for technology transfer of CIBA-Plankton Plus developed by CIBA on 2nd April, 2021. He highlighted the importance of this technology by converting the fish trimmings/waste to value-added products, on a 'waste to wealth' platform. He articulated that the CIBA-Plankton Plus is capable of enhancing aquaculture production in various salinity regimes. He complimented M/s T. K. Enterprise for recognizing the potential of CIBA in R&D backstopping in brackishwater aquaculture and coming forward to sign the MoU. He also stressed the requirement of continued research in refining and fine-tuning the products from fish waste.

Promoting brackishwater aquaculture in North Kerala



In association with Central University of Kerala (CUK) the institute is planning to promote brackishwater aquaculture in the north Kerala through an MoU signed on 25th May, 2021. It is proposed to undertake awareness and capacity development programs to educate people about the potential of brackishwater aquaculture and scope for societal development through entrepreneurship development, employment generation and rural development. In the first phase, CIBA will provide critical inputs like seed and feed for the experiments and the CUK conducts the field level demonstrations with technical inputs from CIBA.

Commercialization of multi-parameter water quality analysis kit to W S Telematics Pvt. Ltd., New Delhi

Multi-parameter water quality kit was commercialized to W S Telematics Pvt. Ltd., Delhi for on-farm assessment of pH, dissolved oxygen, carbonate, bicarbonate, total alkalinity, calcium, magnesium, total hardness, total ammonia-N and nitrite-N through an MoU signed on 23rd July, 2021. This kit is expected to help farmers in rapid measurement of parameters and immediate decision making at the farm level for successful culture in the inland saline aquaculture region of the North Western India.

Transfer of fish feed processing technology to Betterwell Pvt. Ltd., Cochin, Kerala

A customized fish feed formulation and feed processing technology was transferred to Betterwell Pvt. Ltd., to cater to the pressing demands of poor and marginal farmers of Kerala through an MoU signed on 3rd August, 2021. The partners are group of farmers from Kerala who are directly associated with Fish Farmers Association of Kerala. This technology is expected to promote the production of cost-effective finfish feeds which is a long waited input element for expanding fish farming in neighboring Kerala. The company aims to provide cost effective feed to farmers, through the concept of Factory to Farm and thus avoiding the middle men and dealers. This would be huge savings for the farmers.

ICAR-CIBA transfers breeding and seed production technology of *Mystus gulio* to Department of Fisheries, Government of Andhra Pradesh

Nona tengra, *Mystus gulio* is a commercially important brackishwater catfish for aquaculture. They are very hardy with excellent nutritional value and high market demand. To reduce the seed exploitation from the wild and to meet high seed demand, the KRC-CIBA has standardized seed production and farming of Nona tengra. An MoU was signed between ICAR-CIBA and Department of Fisheries, Government of Andhra Pradesh for technology transfer on consultancy mode for hatchery design, construction, breeding and seed production of Nona tengra. The first batch of hatchery produced seeds of Nona tengra was distributed to the farmers by Hon'ble Sri. Simhadri Ramesh Babu, MLA, Avanigadda, Krishna District on 25th August, 2021.

Promoting fisherwomen micro-level entrepreneurship through fish waste to wealth technology

Fish wastes are a concern of public health and to be managed effectively for the economic gain and the environmental safety. This is addressed by the institute by developing technology for recycling of fish waste to value added products, CIBA-Plankton^{Plus}, a product for boosting plankton production in aquaculture rearing systems, and CIBA-Horti^{Plus}, manure for horticulture. Nambikkai Fish Farmers Group, trained by the institute has started a micro-level enterprise, V.S. Fish Waste Hydrolysate. This model is expected to promote sustainable model for converting the fish waste to value added products, which can provide ancillary income to the fisherfolk and will also help for making the fish market clean. An MoU was signed to transfer the technology to the entrepreneur on 22nd September, 2021.

Consultancy to Coastal Corporation Ltd., for breeding and production of Specific Pathogen Free (SPF) polychaete worms

ICAR-CIBA signed an MoU with Coastal Corporation Ltd., Andhra Pradesh on 2nd November, 2021 to provide consultancy services for breeding and production of SPF polychaete worms (*Perinereis* spp.). Polychetes are the maturation diet in hatcheries, presently sourced from wild and may potentially transfer pathogens to shrimp brooders. Scientific production of SPF polychaete worms is the key for pathogen free quality shrimp seed production. Through this collaboration the Coastal Corporation Ltd., will invest on infrastructure for holding domestication, mass scale production of the selected species, while ICAR-CIBA will facilitate research and development for quality production of sandworms.

Consultancy to Naturalle Herbal Remedies Pvt. Ltd., Nellore, Andhra Pradesh on grow-out culture of polychaete worms

ICAR-CIBA signed an MoU to provide consultancy to Naturalle Herbal Remedies Pvt. Ltd., Nellore, Andhra Pradesh on 17th November, 2021 for the development of grow-out technology for polychaete worms such as sand (*Perinereis* spp.) and mud worms (*Marphysa* spp.). The polychaete worms forms an important component in the marine food chain as they became an essential source of food for brood fish/shrimp. Polychaetes are indispensable maturation diet for broodstock shrimps accelerating maturity and enhance fecundity among the Penaeid shrimps due to presence of polyunsaturated fatty acids (PUFA).

Transfer of eco-friendly biofloc based multi-phased nursery/grow-out shrimp farming technology to Shree Rudra Animal Health Pvt. Ltd., Andhra Pradesh

Considering the importance of biofloc technology in promoting eco-friendly and sustainable farming practices to the Indian shrimp industry, CIBA signed an agreement with Shree Rudra Animal Health Pvt. Ltd., Andhra Pradesh on 27th November, 2021. The biofloc technology has the potential to support intensification and high-density farming to achieve higher productivity in shrimp production systems. Manipulating the carbon to nitrogen (C: N) ratio in the culture system facilitates the production of beneficial microbial biomass that absorbs the nitrogenous wastes in addition to *in situ* feed source for the growing shrimp. The technology facilitates the improved water quality and reduces the external application of feed thereby reducing the cost of production.

Developing aqua-feed manufacturing facility to Nation's leading fertilizer conglomerate, Indian Potash Limited (IPL)

India's largest fertilizer company, Indian Potash Limited (IPL) signed MoU with CIBA for technical support on aquafeed formulation and manufacturing on 9th December, 2021. Based on the nutrient requirements of culture species, price and seasonality of locally available ingredients, institute has developed scientific feed formulations which is eco-friendly and cost-effective. The IPL plans to produce aqua feeds using advanced indigenous feed processing technology developed by the institute.

Agreement for transfer of fish farm land to ICAR-CIBA, NGRC

An MoU to transfer 10 ha fish farmland to Navsari Gujarat Research Centre of CIBA (NGRC), for research and demonstration of brackishwater aquaculture was signed during the Pre-Vibrant Gujarat Summit 2021 (14th-16th December, 2021) with the Department of Fisheries, Gujarat State Government. The agreement was signed by Mr. Satish Patel, IAS, Commissioner of Fisheries, Department of Fisheries, Govt. of Gujarat and Dr. K.P. Jithendran, Director, ICAR-CIBA.

The institute also signed another MoU with Gujarat Fish Farmers Producers Co-Op. Society Ltd., to provide technical support and critical inputs in brackishwater farming demonstrations in Gujarat to boost fish production and livelihood. This is the first FFPO in the co-operative sector in the country, working on areas of skill development, self-reliance and employment generation of fish farmers and tribal communities. Dr. K.P.Jithendran, Director, ICAR-CIBA and Shri Jayantilal P. Kewat, President, Gujarat Fish Farmers Producer Co-Op. Society Ltd., signed the documents.

Revenue generated

Services offered and name of the firm	₹ (Lakhs)
CMH mineral, ammonia, nitrite, CBA, pH & DO kits technology to Information and Inputs For Sustainable Aquaculture (IIFSA), Nellore, Andhra Pradesh	2.50
Collaborative partnership and consultancy service for eco-friendly biofloc based multi-phased nursery/grow-out farming technology to AUSSCO India Marine Products Pvt. Ltd., Surat, Gujarat	0.70
Characterization and feed formulation of Black Solider Fly Larvae (BSFL) based shrimp larval feed with Mr.C. Bhanu Prashanth, Anna Nagar West, Chennai.	0.59
Knowledge partnership for brackishwater aquaculture technology demonstration and training with Nature Environment & Wildlife Society, Kolkata	2.50
Transfer of technology on plankton^{Plus} to T.K.Enterprise, South 24 Parganas, WB	3.54
Transfer of technology on small scale integrated feed mill for production of fish & shrimp feed to M/s Wellgrow, Kannur, Kerala	0.59
Establishing seabass hatchery to Department of Fisheries, Govt. of Maharashtra and Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra, Mumbai	7.08
Transfer of "CIBAMOX" - Water Probiotic Technology to M/s Alpha Biologicals, Nellore, Andhra Pradesh	2.36
Formulation to control parasitic infestations in fish to M/s Alpha Biologicals, Nellore, Andhra Pradesh	2.36
Royalty for CIBASTIM technology from M/s Rajshree Biosolutions, Chennai	2.30
Transfer of CMH, Mineral, Ammonia, Nitrite, CBA, pH & & DO kits to WS Telematics, New Delhi	5.40
Fish feed production technology to M/s John James, Betterwell Pvt. Ltd., Kerala	3.54
Transfer of Plankton^{Plus} and Horti ^{Plus} to V.S. Fish Waste Hydrolysate, Chennai	1.18
Consultancy services for breeding and production of polychaete worms as live feed for aquaculture to Coastal Corporation Ltd., Vishakapatnam, Andhra Pradesh	1.08
Consultancy services for breeding and production of polychaete worms to Naturalle Herbal Remedies Pvt. Ltd., Nellore, Andhra Pradesh	0.29
Consultancy services for eco-friendly biofloc based multi-phased nursery/ grow-out farming technology to Shree Rudra animal health Pvt. Ltd., East Godavari District, Andhra Pradesh	1.77
Transfer of technology on integrated shrimp & fish feed processing and production to Indian Potash Limited, Chennai	10.80
Total	**48.58**

Official Language Implementation

आईसीएआर-सीबा, मुख्यालय में दनिांक 14 से 20 सतिंबर, 2021 के दौरान हदिंी सप्ताह मनाया गया

आईसीएआर-सीबा, चेन्नई ने राजभाषा के रूप में हदिंी के उपयोग को बढ़ावा देने के लिए 14-20 सतिंबर, 2021 के दौरान हदिंी सप्ताह मनाया। सप्ताह के दौरान हदिंी नोटगि, ड्राफ्टगि, अनुवाद, गायन और प्रश्नोत्तरी प्रतयिोगतिाओं का आयोजन कयिा गया। सीबा के नदिेशक डॉ. के.पी. जतिेंद्रन ने वार्षकि हदिंी पत्रकिा "जल तरंग" के 7वें अंक का वमिोचन कयिा, हदिंी शब्द के प्रदर्शन के लिए समर्पति टेलीवजिन के साथ सारांश डजिटिल नोटसि बोर्ड का उद्घाटन कयिा और 20 सतिंबर, 2021 को आयोजति समापन समारोह के दौरान हदिंी प्रोत्साहन योजनाओं के तहत वजिेताओं को पुरस्कार वतिरति कयि। अपने संबोधन में, सीबा के नदिेशक ने भारत की भाषाई ववििधिता और पूरे देश में संचार करने में हदिंी के महत्व पर टप्पिणी की। उन्होंने उल्लेख कयिा कि हदिंी एकक सीबा के वार्षकि प्रतविेदन का हदिंी संस्करण प्रकाशति कर रहा है जसिने वर्ष 2019 का आईसीएआर सर्वश्रेष्ठ वार्षकि प्रतविेदन पुरस्कार जीतने में योगदान दयिा है। डॉ. सुजीत कुमार, वैज्ञानकि और राजभाषा कार्यान्वयन समति (ओएलआईसी) के प्रभारी अधकिारी ने हदिंी एकक द्वारा संस्थानों में कयि गए कार्यों को प्रस्तुत कयिा। वति एवं लेखा अधकिारी और सदस्य ओएलआईसी श्री आर.के. बाबू ने संस्थान में हदिंी प्रतयिोगति में वैज्ञानकिों, अधकिारयिों और छात्रों की बढ़ती हुई प्रतभिागति पर प्रसन्नता व्यक्त की। कार्यक्रम का समन्वय संस्थान की वैज्ञानकिों डॉ. ए.के. पाणग्रिही, डॉ. सुवाना सुकुमारन और श्रीमती मशिा सोमन ने कयिा।

आईसीएआर-सीबा के काकद्वीप अनुसंधान केंद्र में दनिांक 08 से 22 सतिंबर, 2021 के दौरान हदिंी पखवाड़ा मनाया गया

कार्यालयी और वैज्ञानकि कार्यों में हदिंी के उपयोग को प्रोत्साहति करने के लिए दनिांक 08-22 सतिंबर, 2021 के दौरान काकद्वीप अनुसंधान केंद्र में हदिंी पखवाड़ा मनाया गया। इस संबंध में, केआरसी-कर्मचारयिों के बीच गायन, प्रश्नोत्तरी, आशुभाषण जैसी वभिन्नि प्रतयिोगतिाएं आयोजति की गई थीं। ओएलआईसी समति के सदस्य डॉ. प्रेम कुमार ने सीबा के केआरसी में हदिंी के कार्यालयी उपयोग पर प्रकाश डाला। सीबा के केआरसी के कार्यालय प्रभारी डॉ. देबाससि डे ने कार्यालयी कार्यों में हदिंी का उपयोग करने के लाभों को सूचीबद्ध कयिा और सभी कर्मचारयिों को कार्यालय और अन्य कार्यकलापों के लिए राजभाषा हदिंी का उपयोग करने के लिए प्रोत्साहति कयि। अंत में केआरसी सीबा के कार्यालय प्रभारी ने सभी वजिेताओं को पुरस्कार वतिरति कयि। श्रीमती बबीता मंडल, वैज्ञानकि ने धन्यवाद ज्ञापन प्रस्तुत कयिा।

Release of 7th issue of Hindi magazine Jal Tarang by Director, CIBA

Hindi week celebrated at ICAR-CIBA, Headquarter during 14 – 20 September, 2021

ICAR-CIBA, Chennai celebrated Hindi Week during 14 – 20 September, 2021 to promote use of Hindi as official language. During the week, Hindi noting, drafting, translation, singing and quiz competitions were organised. Dr. K.P. Jithendran, Director, CIBA, released the 7th issue of annual Hindi magazine "Jal Tarang", inaugurated Saransh digital notice board with dedicated television for display of Hindi word and distributed the prizes to the winners under Hindi incentive schemes during valedictory function held on 20th September, 2021. In his address, Director, CIBA, remarked the linguistic diversity of India and importance of Hindi in communicating across Nation. He mentioned that Hindi cell is publishing Hindi version of CIBA annual Report which has contributed in winning the ICAR best annual report award for the year 2019. Dr. Sujeet Kumar, Scientist and Officer In-Charge of Official language implementation committee (OLIC) presented the work carried out at the institute by the Hindi cell. Shri R.K. Babu, Finance and Account officer and member OLIC expressed happiness in increasing participation at the institute by the scientists, officers and students in Hindi competition. The program was coordinated by Dr. A.K. Panigrahi, Dr. Suvana Sukumaran and Mrs. Misha Soman, Scientists of the institute.

Dr. Vidya Rajendran receiving award under noting and drafting competition at the valedictory ceremony of Hindi week

Hindi pakhwada celebrated at Kakdwip Research Centre of ICAR-CIBA during 08 – 22 September, 2021

Hindi Pakhwada was celebrated at Kakdwip Research Center during 8-22 September, 2021 to encourage the use of Hindi in official and scientific works. In this connection, various competition such as singing, quiz, extempore were conducted among the KRC-staff. Dr. Prem Kumar, member OLIC committee highlighted the official uses of Hindi at KRC of CIBA. Dr. Debasis De, OIC, KRC of CIBA listed the benefits of using Hindi in official work and encourage all the staff to use official language, Hindi for official as well as other activities. At the end prizes were distributed to all the winners by OIC, KRC of CIBA. Mrs. Babita Mandal, Scientist proposed the vote of thanks.

Participants receiving award at valedictory function of Hindi pakhwada held at Kakdwip Research Centre of CIBA, Kakdwip, West Bengal on 22.09.2021

Research and 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	**Dr. Madhusoodana Kurup**
Members	Dr. M.Vijakumaran
	Dr. Lalit C. Garg
	Dr. Asim K.Pal
	Dr. Santhana Krishnan
	Dr. Pravin Puthra
	Dr. K.K. Vijayan
Member Secretary	Dr. Subhendu Kumar Otta

The 26th meeting of the Research Advisory Committee (RAC) of CIBA was held during 25-26th February, 2021 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 Puthra, Assistant Director General (M.Fy.), ICAR, New Delhi
	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. Kumaraguru Vasagam, Principal Scientist & OIC, PME cell

The 38th IRC Meeting was held on 27-28th April, 2021 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.P.Jithendran**
Members	
	Dr. Pravin Puthra, ADG (M.Fy.), ICAR
	Dr. Sudhansu Sekhar Mishra, Principal Scientist, ICAR- CIFA, Bhubaneswar

	Dr. V.R. Suresh, Principal Scientist, ICAR-CIFRI, Barrackpore, West Bengal
	Dr. Vindhya 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, Kolkata (WB)
	FAO, IIHR, Bangalore
Member Secretary	Smt. V. Usharani, Administrative Officer
Co-opted Members	
	Dr. M. Kumaran, Principal Scientist & Head of Office
	Dr. Kumaraguru Vasagam, 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 53rd IMC meeting was held on 14th July, 2021.

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:

Chairman	**Dr. K.P. Jithendran**
Member Secretary	Dr. T. Ravisankar, Principal Scientist
Official Side	
Members	Dr. K. Ambasankar, Principal Scientist
	Dr. M. Kailasam, Principal Scientist
	Dr. M. Kumaran, Principal Scientist
	Dr. P. Mahalakshmi, Principal Scientist
	Shri R. K. Babu, Finance & Accounts Officer
Staff Side	
Secretary	Shri N. Jagan Mohan Raj, Technical Officer
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

The IJSC Meeting was held on 28th September, 2021 at the Headquarters, ICAR-CIBA, Chennai.

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. Ambasankar, Principal Scientist**
Elected Members	
Scientific Members	Dr. Nila Rekha, Principal Scientist
Technical Member	Dr. Joseph Sahaya Rajan, Asst. Chief Technical Officer
Administrative Members	Smt. Usha Rani, 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 Assistant
	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 on 28.06.2021 as follows:

Chairman	**Dr. Sherly Tomy, Principal Scientist**
Members	Dr. P. Mahalakshmi, Principal Scientist
	Smt. K. Jacquline, ACTO
	Smt. S. Nalini, Private Secretary
	Smt. K. Subhashini, Personal Assistant
	Smt. E. Mary Desouza, Assistant
Member Secretary	Smt. V. Usha Rani, AO

LIAISONING COMMITTEE

The composition of the Liaisoning Committee 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 and Assignments 2021

Services in Committees

Dr. K.K. Vijayan, Director (upto 31.05.2021)

- Member - Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai
- Member -ICAR Regional Committee No.VIII
- Executive Committee Member - National Centre for Sustainable Aquaculture (NaCSA)
- Member - Coastal Aquaculture Authority
- Member - Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur
- Member - Scientific Advisory Committee for Dr. Perumal Krishi Vigyan Kendra
- Member - State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Department of Animal Husbandry & Veterinary Services, Government of Tamil Nadu, Chennai
- Member - Board of Management of Tamil Nadu Fisheries University, Nagapattinam
- Member -Board of Management of Tamil Nadu Veterinary and Animal Sciences University, Chennai
- Member -Academic Council of Central Institute of Fisheries Education, Mumbai
- Member -Board of Management of Central Institute of Fisheries Education, Mumbai
- Member - National Committee on Introduction of Exotic Aquatic Organisms into Indian waters, constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi
- Member - Advisory Committee on Hilsa Conservation and Research
- Member - Governing Body of State Fisheries Resource Management Society (FIRMA), Thiruvananthapuram
- Member - Advisory Board for Fisheries Sector Development, constituted by Special Chief Member - Secretary (Planning), Planning Department, Govt. of Andhra Pradesh
- Member - Society of Coastal Aquaculture and Fisheries
- Member - Society for Fisheries Technologists
- Member - Marine Biological Association of India
- Member - Faculty in the Board of Studies of Cochin University of Science and Technology (CUSAT), Kochi
- Member - Tamil Nadu State Council for Science and Technology, Chennai.
- Member - Selection Committee – Tamil Nadu Scientist Award (TANSA) constituted by Tamil Nadu State Council for Science and Technology
- Member - High Power Society "Society for Promotion of Shrimp Farming in Punjab", headed by Additional Chief Secretary, Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, constituted by Department of Fisheries, Punjab

- Member - Selection Committee for the selection of the University Officers of the Tamil Nadu Dr J Jayalalitha Fisheries University, Nagapattinam
- Member - State-wise Coordination Committees for doubling Farmer's income by March, 2022, constituted by Secretary, DARE & Director General, ICAR, New Delhi.
- Member - Kerala State Council for Science Technology and Environment, Thiruvananthapuram.
- Member - Expert committee to study on Vembanad, Astamudi and Sasthamkotta lakes, constituted by Office of the Director of Fisheries, Govt. of Kerala, Thiruvananthapuram
- Member - Sub-Committee to work out modalities for engaging Consultants in Coastal Aquaculture Authority
- Member - Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) for formulation of unit cost norms, unit costs and guidelines in respect of all the components and sub-components of the PMMSY
- Member - Committee for reviewing financial elements of programmes under the Deep Ocean Mission Proposal, constituted by NIOT, Chennai.
- Member - Committee for fixation of fee in respect of private colleges of Agriculture and allied subjects affiliated with TNAU, constituted by the Govt. of Tamil Nadu.
- Member - Committee to review the Establishment and Operation of Shrimp Nucleus Breeding Centre (NBCs) and Broodstock Multiplication Centres (BMCs) in the country, constituted by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India.

Dr. K.P. Jithendran, Director (from 01.06.2021)

- Member - Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai
- Member -ICAR Regional Committee No.VIII
- Executive Committee Member - National Centre for Sustainable Aquaculture (NaCSA)
- Member - Coastal Aquaculture Authority
- Member - Board of Tamil Nadu Fisheries Development Corporation Limited, Chennai
- Member - Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur
- Member - Scientific Advisory Committee for Dr. Perumal Krishi Vigyan Kendra
- Member - National Committee on Introduction of Exotic Aquatic Organisms into Indian waters, constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi.
- Member - Advisory Committee on Hilsa Conservation and Research
- Member - High Power Society "Society for Promotion of Shrimp Farming in Punjab", headed by Additional Chief Secretary, Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, constituted by Department of Fisheries, Punjab.
- Member - Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) for formulation of unit cost norms, unit costs and guidelines in respect of all the components and sub-components of the PMMSY
- Member - Committee to review the Establishment and Operation of Shrimp Nucleus Breeding Centre (NBCs) and Broodstock Multiplication Centres (BMCs) in the country, constituted by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India.
- Member - Expert Committee to draft the Coastal Aquaculture Authority (CAA) Amendment Bill, 2021, constituted by the Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India.
- Member - Technical Advisory Committee for the GNF-BMZ Project "Building a transnational, civil society partnership to increase the resilience of coastal population in South Asia", constituted by the Governing Board of Centre for Research on New International Economic Order (CReNIEO), Chennai

Scientists

- Site Inspection of the proposed Broodstock Multiplication Centre (BMC) facility for SPF *Penaeus vannamei* at Kotapalem Village, Srikakulam District, Andhra Pradesh by Kona Bay India Private Limited on 3rd September, 2021- Dr. M. Muralidhar.
- External examiner for evaluation of B.V.Sc. & A.H. papers during 6-7th January, 2021 at Madras Veterinary College, Chennai - Dr. Ananda Raja
- Invited as Examiner by NITTE University, Mangalore to conduct PhD viva on 22nd January, 2021 - Dr. S. K. Otta
- Evaluation of PhD thesis from Orissa University of Agriculture and Technology, Bhubaneswar-July, 2021- Dr. S. K. Otta
- Technical expert for the selection of Consultants (Monitoring Assistant and Admin) in CAA, Chennai held on 17th August, 2021- Dr. M. Poornima
- Conducted PhD comprehensive examination and MFSc viva (virtual mode) CIFE, Mumbai on 22nd October, 2021- Dr. S. K. Otta
- Conducted M.F.Sc viva examination of CIFE, Mumbai (virtual mode) on 26th October, 2021 - Dr. S. K. Otta
- Invited as Examiner by Mangalore University, Mangalore to conduct PhD viva on 7th December, 2021 - Dr. S. K. Otta
- Outside expert nominated by ASRB for five year assessment of technical officers under the workshop group (Group III) for considering for next higher grade/ promotion of technical officers of CIFE, Mumbai - Dr. M. Makesh
- Nominee CPCSEA by the Ministry of Fisheries, Animal Husbandry and Dairying, Department of Animal Husbandry and Dairying, Govt. of India - Dr. Ananda Raja
- Member of Expert panel for EIA, Chennai - Assessment Panel of Expert for renewal of approval of Softgel Health care Pvt. Ltd., Kancheepuram district, TN - Dr. T. Bhuvaneswari
- Member of Expert panel for CAA, Chennai- Inspection committee for inspection of Hatchery Renewal and Registration of hatcheries in Chengalpattu district - Dr. T. Bhuvaneswari
- Member of Expert panel for AQCS, Chennai- Inspection of Aquatic Quarantine Facility for import of live SPF polychaetes by M/s NSR traders at the facility located at SY NO 290/2, Kona Forest Village, Vemavaram gram panchayat, Thondangi mandal, East Godavari District, Andhra Pradesh - Dr. T. Bhuvaneswari
- 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. Vinay Kumar Katneni
- Editorial Board Member for Journal of Modern Agriculture and Biotechnology, Innovation Forever Publishing Group – Dr. Debasis De
- Member for the Board of Studies, Department of Zoology (PG) Gurunanak College, Chennai from 2021-2023 - Dr. D. Deboral Vimala
- Member of CAA inspection committee for renewal of registration of shrimp hatcheries in Navsari, Valsad and Gir Somnath districts of Gujarat during 10th to 12th February, 2021 - Mr. Jose Antony
- Convener for Sub-Session II-I-II: Brackishwater fishery & fish health management in coastal ecosystem of the International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 – 19th March, 2021 at Regional Research Station, Canning Town, West Bengal – Dr. T.K. Ghoshal
- Member of Assessment Committee for assessment of two staff of the RAKVK, Nimpith, South 24 Parganas, West Bengal on 29th June, 2021 – Dr. Debasis De

- Member of CAA inspection committee for renewal of registration of shrimp hatcheries at East Godavari, Guntur, Prakasham and Nellore district of Andhra Pradesh during 6-8th July, 2021 - Mr. Biju Francis
- Expert in the live phone in programme "Hello DD Career Plus" on "Career in Fisheries Science" on 12th August, 2021 in Doordarshan Kendra, Kolkata – Dr. T.K. Ghoshal
- Member of Selection Committee for selection of SRF under ARYA project in the RAKVK, Nimpith, South 24 Parganas, West Bengal on 8th November, 2021 – Dr. Debasis De
- Member of Selection Committee for selection of Subject Matter Specialist (Animal Husbandry) in RAKVK, Nimpith, South 24 Parganas, West Bengal on 21st December, 2021 – Dr. Debasis De
- Member of Expert Committee for the B.F.Sc programme under the School of Agriculture & Allied Sciences of The Neotia University, West Bengal – Dr. T.K. Ghoshal

Mera Gaon Mera Gaurav

Mera Gaon Mera Gaurav (MGMG) programme or "My Village My Pride" is a farm - centric mission that, targets to translate knowledge from research labs to farmers' field to address farm-related problems in a wholesome manner to provide livelihood security to the villagers. In this programme, scientists regularly visit the assigned villages and take the latest technologies from the lab to the doorstep of the farming community. The major activities under this programme includes front line demonstration of culture technologies, best management practices, disease diagnosis, etc. The regular programme also includes field visits, stakeholder interaction, meetings and providing advisories to create social awareness. Under this program 13 villages in three districts viz., Chengalpattu, Thriruvallur and Chennai in Tamil Nadu were adopted and 13 teams of scientists was constituted to work in each village. For demonstration of technologies, shrimp seed, crab juveniles and fish fry/fingerlings of selected finfishes along with suitable package of practices was distributed under MGMG programme of ICAR-CIBA. Other inputs such as fencing net, hapas, small aerators, fishing nets, and other items required for the demonstration were also provided to the fish farmers. Regular visits were made to monitor the progress and to provide technical inputs and guidance.

During the present reporting period, scientists of ICAR-CIBA had undertaken 59 visits, 31 meetings and 8 training programmes for the beneficiaries under the MGMG programme. As a part of the programme, 24 demonstrations were conducted, 239 mobile advisories had been extended and 19 literatures were distributed under various thematic areas. Five campaigns were also conducted under the same programme. The total number of field activities conducted was 156 and 2923 fish/aqua farmers were benefitted from this MGMG programme.

Swachh Bharat Mission 2021 Programmes

ICAR-CIBA has conducted Swachh Bharat Mission programmes such as disposal of unwanted things in workplace and conducted swachhata awareness programmes through a special campaign and Swachhata Pakhwada during 2-31 October, 2021 and 15-31 December, 2021 respectively at ICAR-CIBA headquarters, Chennai, two experimental stations at Muttukadu and Kovalam, and the two regional centres viz., Kakdwip Research Centre (KRC), West Bengal, and Navsari-Gujarat Research Centre (NGRC), Gujarat.

ICAR-CIBA, Chennai has bagged the second prize in the Swachhata Pakhwada Award, 2021 for its Swachh Bharat activities during 2021, among all the ICAR Institutes / ARARI in the country. The award is given based on the activities like organising innovative events, documentation and dissemination of the Swachhata Pakhwada activities. As a part of the Swachhata Pakhwada, ICAR - CIBA scientists, staff and students has organised various activities at institute campuses and adopted villages. Weeding of old files, disposal of office scrap materials, and outdoor special swachhata programmes in the adopted villages on 'waste to wealth', cleanliness drives, rallies, tree planation etc. were organised. More than 830 participants including staff of CIBA, farmers and school students participated in the various activities.

Swachhata pledge

Swachhata Pledge was taken by the scientists, officers, staff and students at CIBA headquarters, experimental stations, and research centres. Around 137 participants attended the Swachhata Pledge. After the pledge, awareness drive about cleanliness of campus and work place, importance of weeding out of files, ensuring COVID-19 protocols were emphasized to the participants.

Swachhata pledge at ICAR-CIBA headquarters, Chennai

Cleaning of office premises and weeding out of the files and records

The weeding out of the old files and records from stores, administration, audit and accounts section and library and cleanliness drive in various laboratories and common places in the institute premises including research centres at Gujarat and Kakdwip were undertaken. Out of 1,700 old files/ records 1,215 files were weeded out from various divisions, and administration, stores and audit sections. Totally 17 quintal of unserviceable/scrap items were identified, condemned and disposed as per the procedure and a revenue of ₹ 12.0 lakhs was generated through the disposal. Due to disposal of materials, nearly 1,900 sq ft space was freed and utilised as storage facility. In addition, the processing of files by the administration, audit & accounts and stores sections were carried out through e-office, with 100% implementation of e-office, thus enabling paperless office.

Disposal of e-waste materials from the campus, ICAR-CIBA, headquarters, Chennai

Awareness programme with adopted village farmers

ICAR-CIBA organised the Swachhata Pakhwada at Muttukadu Experimental Station to create awareness on cleanliness, hygiene and sanitation among the Women Self Help Group (SHG) members and villagers, Kottaikadu village, Chengalpattu district, Tamil Nadu. ICAR - CIBA staff explained about Swachh Bharat Mission aim and objectives; importance of self-help principles; safe disposal of wastes from village premises including domestic wastes; and the necessity to maintain hygiene and sanitation. They also highlighted the importance of kitchen garden and organic farming for healthy living. Around 60 participants including

SHG members, scientists and staff of CIBA attended the programme. The cleaning materials and vegetable seeds were distributed to the SHG members for cleaning and kitchen gardening respectively.

Awareness meeting with Women Self Help Group from Kottaikadu village, Chengalpattu district, Tamil Nadu

Waste to wealth programme

ICAR-CIBA organised a sensitization programme on '*Waste to Wealth*' as a part of the Special National Swachhata Campaign at Kasimedu Fishing Harbour, Chennai. On that occasion, Dr. K.P. Jithendran, Director, ICAR-CIBA inaugurated M/s the fish waste (trimmings) processing unit built by V.S. Fish Waste Hydrolysate with the technology support of ICAR - CIBA. This plant is expected to produce two value-added products (CIBA Plankton^{Plus} and Horti^{Plus}) using the fish trimmings accumulated from more than 40 fish landing centers in and around Chennai. More than 120 participants attended the programme, including farmers, entrepreneurs, scientists, students, staff, press and media.

Distribution of swachh materials to fisherwomen, Kasimedu, Chennai

ICAR-CIBA has conducted demonstration on "*Waste to Wealth*" programme by recycling of fish waste to value added products under Swachhata Pakhwada on 20th December, 2021 at ICAR-CIBA, Chennai. The SHG members trained earlier by the institute demonstrated the protocol for recycling of fish waste to value added products. CIBA scientists highlighted the importance of cleanliness in the villages and recycling of fish waste to avoid infections and diseases. Recycling will not only help in cleaning and hygienic disposal of fish market waste which is abundantly available in the village cluster but will also help to produce wealth from waste. Around 20 participants including fishermen, women, and officials from ICAR-CIBA, Chennai, actively participated in the programme.

Demonstration of recycling of fish waste to value added products at ICAR - CIBA headquarters, Chennai

Special swachhata campaign

Special Swachhata Campaign was organised in Koovathur village of Chengalpattu district in Tamil Nadu. About 112 participants comprised of aqua farmers and farm women, fishers, school children and villagers participated in the campaign. Dr. K.P. Jithendran, Director, ICAR-CIBA, stressed that coastal water bodies need to be maintained well without pollution for realizing higher yield and income from aquaculture. As a part of the campaign, the school children from the village gave scintillating speeches on importance and methods of maintaining cleanliness of self and the environment for a healthy living.

School students scintillating speeches in Koovathur village, Chengalpattu, Tamil Nadu

Kakdwip Research Centre (KRC) of ICAR-CIBA organised a special swachhata campaign in Manmathpur, Mundapara tribal village. About 100 women, aqua farmers and children participated in the programme. Masks and sanitizers were distributed to all the villagers. Later, cleaning of degradable and non-degradable items was carried out in the village by KRC scientists and staff with the assistance of local villagers. Fish feed prepared by feed mill of KRC was also distributed to farmers adopted by tribal sub plan of KRC, Kakdwip.

ICAR-CIBA organised a Special Swachhata Campaign at Kovalam Experimental Station (KES), Kovalam, Tamil Nadu. About 50 participants including Irular tribal aqua farmers, farm women, fishers and CIBA scientists and staff participated in the event. Masks, sanitizers, soap and other swachh materials were distributed to the tribal farmers.

Awareness cum tree planation programmes

ICAR-CIBA has organised an awareness program on 'shun single use plastics', and importance of cleanliness, sanitation and hygiene practices related to health aspects among farmers, students and scientist and staff of ICAR - CIBA at Muttukadu, Chengalpattu, Tamil Nadu. Subsequently, tree planation and a rally were conducted. Around 100 participants attended in both the programmes. CIBA scientists narrated about the reason behind conducting this programme and also explained various means to avoid plastic waste and a pledge in this regard was administered to the participants. The participants understood the importance on the call on 'Shun Single Use Plastics' and affirmed solemnly on avoidance of single use plastics to make our country greener and plastic free.

Fruit bearing tree plantation at MES of CIBA, Muttukadu, Tamil Nadu

Awareness programmes cum rallies

ICAR-CIBA has organised the following two awareness-cum rallies under this programme:

- More than 50 scientists and staff of ICAR-CIBA and students from Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Tamil Nadu took part in a rally on the Highway Road followed by an awareness programme at Muttukadu, Chengalpattu, Tamil Nadu. ICAR - CIBA staff explained various ways to avoid plastic waste and a pledge in this regard was administered to the participants. Various placards explaining about different methods to avoid plastic waste were also displayed. The participants understood the importance on the call on "shun single use plastics" and vowed to avoid single use plastics.

Rallies on shun single use plastics at MES of CIBA, Muttukadu, Tamil Nadu

- Awareness cum rallies on shun single use plastics, and importance of cleanliness, sanitation and hygiene practices related to health aspects among students, farmers and scientist and staff of CIBA at Muttukadu, Chengalpattu, Tamil Nadu were conducted. Around 100 participants attended the programme. Director, CIBA, highlighted the importance of cleanliness, sanitation and hygiene among students. Nodal officer of CIBA-Swachh Bharat Mission narrated about the reason behind conducting this programme and briefed about Swachhata Pakhwada theme and explained various means to avoid plastic waste and a pledge in this regard was administered to the participants.

Awareness cum rallies on shun single use plastics at CIBA hatchery road of MES, Muttukadu, Chennai, Tamil Nadu

Water harvesting for agriculture / horticulture

Navsari Gujarat Research Centre of CIBA organised Swachhata Pakhwada at its adopted tribal village Signod, Navsari, Gujarat. Around 25 farmers including scientists participated in the program. Scientists and students of the centre demonstrated water harvesting through excavation of pond and utilization of the harvested rain water for round the year horticultural crop and fish cultivation. Scientists explained the importance of recycling of waste water and water harvesting for horticulture applications. As a part of the Swachhata Pakhwada programme, villagers participated in the horticulture activity and cultivated crops on the pond dykes with irrigation from harvested pond water.

Cultivation of crops on the pond dykes by tribal villagers at Signod, Navsari, Gujarat

Cleaning of degradable and non-degradable items

Kakdwip Research Centre of ICAR-CIBA organised an awareness programme on cleanliness, hygiene and sanitation under Swachhata Pakhwada at Buddhapur village, Kakdwip, South 24 Parganas, West Bengal. About 100 villagers including farmers, scientists, students and staff participated in the programme. CIBA scientists sensitized the villagers about climate change and importance of cleanliness. They were also apprised about the deleterious effect of various harmful anthropogenic activities like dumping of single use plastic in natural ecosystem, deforestation of mangroves, illegal fishing, etc. Masks and sanitizers were distributed to the villagers in the programme. Later, cleaning of degradable and non-degradable items was carried out at one part of the village by KRC scientists and staffs with the assistance of the villagers. They were also briefed about judicious use and safe disposal of single use plastic.

Cleaning of degradable and non-degradable items from Buddhapur village, Kakdwip, West Bengal

Special kisan diwas programme

ICAR-CIBA celebrated the National Farmers Day with the fishers, tribal farmers and fisheries students at Muttukadu Experimental Station, Muttukadu. National Farmers Day (Rastriya Kisan Diwas) is celebrated on 23rd December every year in the honour of Shri Chaudhary Charan Singh, a popular kisan leader and former Prime Minister of India. About 120 farmers, students, scientists and staff of CIBA participated in the programme. In his presidential address Dr. K.P. Jithendran, Director, CIBA, sensitized the participants about the employment opportunities in fisheries and aquaculture especially for youth and students by utilizing the brackishwater aquaculture technologies using the vast stretches of brackishwater resources. He also highlighted the importance of cleanliness, sanitation and hygiene among students and farmers.

Shri T. Kennit Raj, fish entrepreneur and proprietor of M/s V.S. Fish Waste Hydrolysate, Kasimedu and Nammbikkai Fishers Group, Pattinapakkam, Chennai, Tamil Nadu, shared his experience about the establishment of fish waste processing unit

under the technical guidance and support of CIBA for the production of CIBA-Plankton^{plus} and CIBA Horti^{Plus}, value added products by recycling of fish waste. He also appreciated the efforts of CIBA in promoting of waste to wealth as an alternative livelihood activity for the fishers in their village. At the end of the meeting, CIBA staff distributed swachh related materials to tribal families for cleaning their premises.

Participants on the occasion of Special Kisan Diwas at MES of CIBA, Muttukadu, Tamil Nadu

Digital and media display, and valedictory function

All the Swachh Bharat activities conducted at headquarters of CIBA, KRC and NGRC of CIBA are displayed in the digital display system in the institute for creating awareness about cleanliness among the visitors. During 2020-21, swachh activities were highlighted in more than 25 social media in the form of newspaper, TV channel, you tube channel, website etc. On the occasion of valedictory function of swachh campaign, stainless steel flask were distributed to 32 housekeeping staff working in CIBA including Muttukadu Experimental station, Muttukadu, Tamil Nadu as a token of appreciation for their work during implementation of special campaign as well as swachhata activities. After Swachhata Pakhwada 2018, ICAR-CIBA, Chennai, is being maintained as **"PLASTIC FREE ZONE"** till date.

Distribution of material to staff during valedictory function of special campaign at ICAR – CIBA, headquarters, Chennai

Distinguished Visitors 2021

Sl. No	Details of visitors	Date of visit
Headquarters		
1	Shri Giriraj Singh, Hon'ble Union Minister of Fisheries, Animal Husbandry & Dairying (MOFAHD), Govt. of India	21.01.2021
2	Shri Rajiv Ranjan IAS, Union Fisheries Secretary, Dr.K.Gopal, Principal Secretary, Fisheries, Govt. of Tamil Nadu, Shri J.Balaji, IAS, Join Secretary, MOFAHD, Dr.Mrs.Kripa, Member-Secretary, Coastal Aquaculture Authority, Govt. of India	21.01.2021
3	Dr. M. Vijayakumaran, former Principal Scientist of CMFRI, Mr. Ramachandra Raju and Mr. S. Sathish Kumar, IMC members of CIBA and Mrs. Oliver Rachael, Deputy Director, Department of Fisheries, Tamil Nadu	28.01.2021
4	Dr. L. Murugan, Hon'ble Union Minister of State for Fisheries, Animal Husbandry and Dairying and Information and Broadcasting, Govt. of India	18.09.2021
5	Dr. B.M.K. Reddy, Chairman, Andhra Pradesh State Biodiversity Board	20.09.2021
6	Dr. Jujjavarapu Balaji, IAS, Joint Secretary (Marine Fisheries), Department of Fisheries, Govt. of India	8.10.2021
7	Dr. Kripa, Member Secretary and senior officials from Coastal Aquaculture Authority (CAA), Govt. of India	8.10.2021
8	Dr. Bhaskaran Ravi Latha, Professor & Head, Department of Veterinary Parasitology, Madras Veterinary College, TANUVAS	30.10.2021
9	Dr. Joy Krushna Jena, Deputy Director General (Fisheries), ICAR	17.12.2021
Kakdwip Research Centre		
1	Shri Bankim Chandra Hazra, Hon'ble Minister of Sundarban Affairs, Govt. of West Bengal	10.11.2021
Navsari Gujarat Research Centre		
1	Dr. Pravin Puthra, Assistant Director General (Marine fisheries), Indian Council for Agricultural Research	29.08.2021
2	Mr. Satish Patel, IAS, Commissioner of Fisheries, Department of Fisheries, Govt. of Gujarat	15.12.2021

Shri Giriraj Singh, Hon'ble Union Minister, Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India, visited CIBA-Muttukkadu experimental station.

Shri Giriraj Singh, Hon'ble Union Minister of Fisheries, Animal Husbandry & Dairying (MOFAHD), Govt. of India visited Muttukadu experimental facilities of ICAR-CIBA on 21st January, 2021 and had discussions with scientist on the new developments in R&D at the institute. Mr. Singh visited the shrimp and finfish hatchery complex located at the Muttukadu experimental station of CIBA and appreciated the R&D initiatives by CIBA. He expressed special interest in the breeding and farming of Indian white shrimp (*Penaeus indicus*) initiated by CIBA. In the interaction meeting, he emphasized to initiate a jump start programme on the hatchery production of seed and farming of *P. indicus*, for the benefit of Indian shrimp farmers. Later the Minister honoured the CIBA's clientele M/s *Nambikkai Fish Farmers Group*, Tamil Nadu and M/s *Sai Aqua Feeds*, Andhra Pradesh, who were awarded by National Fisheries Development Board (NFDB), with the "*Best Fisheries Self Help Group-2020*" and "*Best Fisheries Enterprise Award-2020*" for their successful ventures on 'fish waste-to-wealth' and 'feed processing technology' of ICAR-CIBA respectively.

ADG (Marine Fisheries) visited NGRC-CIBA farm facilities and interacted with SHGs, farmers and fisher youth on 29th August, 2021

Dr. Pravin Puthra, ADG (Marine Fisheries), ICAR, visited NGRC-CIBA on 29th August, 2021, and appreciated the scientific team at NGRC for their efforts in the livelihood upliftment of tribals. He interacted with women SHGs at Matwad Village, Navsari, Gujarat, who were involved in nursery rearing of milkfish and pearlspot at the farm and handed over the revenue (₹ 82,900) earned by them. He also presented a cheque worth ₹ 2,16,448 to the SC youth self-help group against the sale of shrimp from the winter farming demonstration undertaken by the NGRC for SC youth. Later he visited Singod, the tribal village, to monitor the Integrated Fish Farming System (IFFS) implemented by NGRC-CIBA with cage culture of fishes in the village pond, horticulture, poultry farming and goat rearing on the periphery of the pond. ADG handed over a cheque worth ₹ 58,690 to beneficiaries against the sale of fish and poultry and distributed inputs like life jackets, lifebuoys, tree saplings, etc.

Dr. B. M. K. Reddy, Chairman Andhra Pradesh State Biodiversity Board visited ICAR-CIBA

Dr. B. M. K. Reddy, Chairman Andhra Pradesh State Biodiversity Board, visited ICAR-CIBA from 20-21st September, 2021. Dr. K.P. Jithendran, Director, CIBA, broadly narrated the mandate and activities of CIBA. The Chairman explained the activities of state biodiversity boards and interacted with HoD/Scientist In-Charges of different Divisions/Sections of CIBA on biodiversity issues in fisheries and aquaculture during the brief interaction meeting. Chairman interacted with the scientists during his visit to the laboratory facilities at headquarters and shrimp, crab and finfish hatcheries and feed mill at MES, CIBA and experimental pond facilities at Kovalam Experimental Station (KES) of CIBA.

Dr. J. Balaji, IAS, Joint Secretary, Department of Fisheries, Govt. of India, visited ICAR-CIBA

Dr. J. Balaji, IAS, Joint Secretary (Marine Fisheries), Department of Fisheries, Govt. of India, visited ICAR- CIBA, Chennai, on 8th October, 2021 and interacted with the scientists on national priorities in the brackishwater farming sector. Dr. V. Kripa, Member Secretary and senior officials from Coastal Aquaculture Authority (CAA), Govt. of India, also attended. Dr. K.P. Jithendran, Director, CIBA appraised CIBA's research achievements and significant contributions to the sector. Dr. Balaji explained the ongoing nationwide discussions on the constraints in exotic *P. vannamei* farming and issues in recent proposals to import SPF tiger shrimp (*Penaeus monodon*). Department of Fisheries is looking at the possibilities of making native Indian white shrimp, *P. indicus*, as a choice and permanent solution in the longer run. He expressed his interest in understanding CIBA's experiences, technologies and capacities concerning the development of SPF Indian white shrimp and got convinced that India can pioneer on selectively bred SPF *P. indicus*.

Shri Bankim Chandra Hazra, Hon'ble Minister of Sundarban Affairs, Govt. of West Bengal Inaugurated the Shrimp Harvest Mela and Farmers Interaction Meet at Kakdwip Research Centre of ICAR-CIBA

KRC of ICAR-CIBA demonstrated the scientific farming of *P. vannamei* in its farm at Kakdwip, South 24 Parganas district of West Bengal on 10th November, 2021. Shri Bankim Chandra Hazra, Hon'ble Minister of Sundarban Affairs, Govt. of West Bengal, witnessed the harvest and inaugurated the farmer's interaction meet as a part of the celebration of Azadi Ka Amrit Mahotsav. The harvest of vannamei shrimp generated revenue of ₹ 17 lakhs. About 250 participants comprising of aqua farmers, young entrepreneurs, women SHG's and state government officials witnessed the harvest and attended the interaction meet. The minister appreciated the activities of KRC-CIBA in the state and asked farmers to follow scientific culture technology developed by ICAR-CIBA for vannamei shrimp farming. He distributed the fish seeds (orange chromide, milkfish and pearlspot), Poly^{Plus} feed and CIBA-developed products (Plankton^{Plus} and Horti^{Plus}) to the farmers and entrepreneurs.

Dr. Joy Krushna Jena, DDG (Fisheries) visited ICAR-CIBA, Chennai

Dr. Joy Krushna Jena, Deputy Director General (Fisheries), ICAR, visited ICAR - CIBA, Chennai on 17th December, 2021 and reviewed the research activities and administrative matters of the institute through discussions with all the staff and students. Dr. K.P. Jithendran, Director, CIBA briefed the research achievements in the recent past, especially during the COVID lockdown. Dr. J.K. Jena, in his opening remarks, appreciated the research activities of CIBA and advised that appropriate strategies need to be adopted for scaling up the brackishwater finfish culture. He also visited newly emerging Kovalam experimental station and stressed that the newly acquired 64.55 acres of land need to be effectively utilised on a mission mode approach for developing KES into CIBA's visionary farming centre. He distributed the seeds of Asian seabass, mud crab and Indian white shrimp to the identified beneficiaries under SCSP and also inaugurated the sale of brackishwater ornamental fishes produced by women farmers to the aquarium entrepreneurs. During this field visit cum seed distribution event, DDG Fisheries, was accompanied by Dr. A. Gopalakrishnan, Director, CMFRI and the Director, CIBA and other senior officials of the institute.

Personnel

SCIENTISTS			
SL No	**NAME**	**DESIGNATION**	**REMARKS**
1	Dr. K. K. Vijayan	Director	Retired on 31.05.2021
2	Dr. S. V. Alavandi	Principal Scientist/HOD (I/C), AAHED	Retired on 30.04.2021
3	Dr. K. P. Jithendran	Principal Scientist	Director (Acting) w.e.f. 01.06.2021
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. Akshaya 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	
27	Dr. R. Jayakumar	Principal Scientist	Joined at CIBA on 20.01.2021
28	Dr. T. Senthil Murugan	Principal Scientist	
29	Shri Ashok Kumar Jangam	Scientist (SS)	
30	Dr. R. Ananda Raja	Senior Scientist	

31	Dr. (Smt.) P. Ezhil Praveena	Senior Scientist	
32	Dr. (Smt.) Krishna Sukumaran	Senior Scientist	
33	Dr. (Smt.) P. S. Shyne Anand	Senior Scientist	
34	Dr. B. Sivamani	Senior Scientist	
35	Dr. (Smt.) R. Geetha	Senior Scientist	
36	Dr. P. Kumararaja	Senior Scientist	
37	Dr. Vinaya Kumar Katneni	Senior Scientist	
38	Dr. Sujeet Kumar	Scientist	
39	Dr. (Smt.) N. Lalitha	Scientist	
40	Dr. (Smt.) T. Bhuvaneswari	Scientist	
41	Dr. (Smt.) Vidya Rajendran	Scientist	
42	Dr. Satheesha Avunje	Scientist	
43	Shri K. P. Sandeep	Scientist	
44	Dr. Aritra Bera	Scientist	
45	Shri T. Sathish Kumar	Scientist	
46	Smt. M. U. Rekha	Scientist	Transferred on 30.01.2021
47	Dr. N. S. Sudheer	Scientist	
48	Dr. Suvana Sukumaran	Scientist	Transferred on 12.11.2021
49	Dr. (Smt.) Neethu, K.C.	Scientist	Transferred on 11.02.2021
50	Shri Dani Thomas	Scientist	
51	Shri R. Aravind	Scientist	
52	Shri Biju, I. F.	Scientist	
53	Mrs. Misha Soman	Scientist	
54	Smt. Mary Lini	Scientist	
55	Dr. J. Raymond Jani Angel	Scientist	
56	Shri T. Sivaramakrishnan	Scientist	
57	Dr. Vinay Tharabenahalli Nagaraju	Scientist	

TECHNICAL			
SL No	**NAME**	**DESIGNATION**	**REMARKS**
1	Shri R. Elankovan	Chief Tech. Officer	Retired on 30.06.2021
2	Dr. S. Sivagnanam	Chief Tech. Officer	
3	Shri D. Raja Babu	Chief Tech. Officer	
4	Shri R. Puthiavan	Assistant Chief Tech. Officer	
5	Smt. K. Jacquline	Assistant Chief Tech. Officer	

6	Shri Joseph Sahayarajan	Assistant Chief Tech. Officer	
7	Shri S. Rajamanickam	Assistant Chief Tech. Officer	
8	Shri S. Nagarajan	Assistant Chief Tech. Officer	
9	Dr. A. Nagavel	Assistant Chief Tech. Officer	
10	Shri R. Subburaj	Assistant Chief Tech. Officer	
11	Shri S. Saminathan	Tech. Officer	
12	Shri N. Jagan Mohan Raj	Tech. Officer	
13	Shri D. M. Ramesh Babu	Tech. Officer	
14	Shri G. Thiagarajan	Tech. Officer	
15	Shri K. Karaian	Senior Tech. Asst.	
16	Shri S. Prabhu	Technical Asst.	
17	Shri K.V. Delli Rao	Senior Technician	

ADMINISTRATION			
SL No	NAME	DESIGNATION	REMARKS
1	Shri Babu R.K	Finance & Accounts Officer	
2	Smt. V. Usharani	Admn. Officer	
3	Shri S. Pari	Asst. Admn. Officer	VRS on 01.03.2021
4	Shri A. Manoharan	Asst. Admn. Officer	Retired On 31.03.2021
5	Smt. E. Amudhavalli	Asst. Admn. Officer	Promoted on 21.01.2021
6	Shri A. Sekar	Asst. Admn. Officer	Promoted on 19.03.2021
7	Shri P. Srikanth	Asst. Finance & Accounts Officer	Promoted on 26.06.2021
8	Smt. S. Nalini	Private Secretary	
9	Shri K. G. Gopala Krishna Murthy	Private Secretary	Promoted on 26.06.2021
10	Smt. K. Subhashini	Personal Assistant	
11	Smt. K. Hemalatha	Personal Assistant	Promoted on 26.06.2021
12	Smt. E. Mary Desouza	Assistant	
13	Shri Raghavendra. K	Assistant	

14	Smt. R. Vetrichelvi	Upper Division Clerk	
15	Smt. M. Mathuramuthu Bala	Upper Division Clerk	
16	Smt. B. Prasanna Devi	Upper Division Clerk	
17	Shri R. Kumerasen	Upper Division Clerk	Promoted on 26.06.2021
18	Shri A. Paul Peter	Upper Division Clerk	Promoted on 26.06.2021
19	Shri V. Kishorkumar	Lower Division Clerk	Promoted on 22.03.2021
20	Shri R. Rajasekar	Lower Division Clerk	Joined on 01.11.2021

SKILLED SUPPORT STAFF			
SL No	NAME	DESIGNATION	REMARKS
1	Shri K. Nithyanandam	Skilled Support Staff	Retired on 31.07.2021
2	Shri V. M. Dhanapal	Skilled Support Staff	
3	Shri V. Kumar	Skilled Support Staff	
4	Shri C. Saravanan	Skilled Support Staff	
5	Shri S. Selvababu	Skilled Support Staff	
6	Shri C. Ragu	Skilled Support Staff	
7	Shri P.G. Samuvel	Skilled Support Staff	
8	Shri M. Sakthivel	Skilled Support Staff	
9	Shri R. Mathivanan	Skilled Support Staff	
10	Shri R. Indra Kumar	Skilled Support Staff	
11	Shri G. Dayalan	Skilled Support Staff	
12	Shri Kanaka Prasad	Skilled Support Staff	
13	Shri J. Murugan	Skilled Support Staff	
14	Shri S. Solin Igneshus	Skilled Support Staff	

Kakdwip Research Centre of CIBA

SCIENTISTS			
SL No	**NAME**	**DESIGNATION**	**REMARKS**
1	Dr. Debasis De	Principal Scientist	

2	Dr. T.K. Ghoshal	Principal Scientist	
3	Dr. Sanjoy Das	Principal Scientist	
4	Dr. G. Biswas	Senior Scientist	Transferred on 30.01.2021
5	Dr. Prem Kumar	Senior Scientist	
6	Ms. Christina Lalramchhani	Scientist	Relieved on 28.07.2021
7	Mrs. Babita Mandal	Scientist	
8	Mrs. Leesa Priyadarsani	Scientist	

TECHNICAL			
SL No	**NAME**	**DESIGNATION**	**REMARKS**
1	Smt. Chhanda Mazumder	Senior Tech. Asst.	

ADMINISTRATION			
SL No	**NAME**	**DESIGNATION**	**REMARKS**
1	Shri S.K. Bindu	Assistant	Retired on 28.02.2021
2	Shri Sanjoy Some	Lower Division Clerk	Promoted on 20.03.2021

SKILLED SUPPORT STAFF			
SL No	**NAME**	**DESIGNATION**	**REMARKS**
1	Smt. L.R. Bhuiya	Skilled Support Staff	
2	Shri U.K. Santra	Skilled Support Staff	Retired on 31.01.2021
3	Shri P.C. Das	Skilled Support Staff	

Navsari-Gujarat Research Centre of CIBA, Gujarat

SCIENTISTS			
SL No	**NAME**	**DESIGNATION**	**REMARKS**
1	Shri Pankaj Amrut Patil	Scientist	
2	Shri Tanveer Hussain	Scientist	
3	Shri Jose Antony	Scientist	

Infrastructure Development for the Year 2021

1. Expansion of laboratory building at CIBA headquarters, Chennai
2. Development of Aqua Climate Laboratory under NICRA Project at CIBA headquarters, R.A.Puram, Chennai
3. Providing modular partition in room No. 114 at CIBA headquarters, R.A.Puram, Chennai
4. Providing modular partition in room No. 409 at CIBA headquarters, R.A.Puram, Chennai
5. Minor repair work in Aquatic Animal Health Facility at CIBA headquarters, R.A.Puram, Chennai
6. Conversion of existing electricity Low Tension (LT) into High Tension (HT) power supply at Muttukadu Experimental Station of ICAR-CIBA, Muttukadu
7. Supply and installation of roof top solar plants over the feed mill and conference hall at MES of CIBA, Muttukadu
8. Re-construction of RCC tank at MES of CIBA, Muttukadu
9. Renovation of conference hall, scientist sitting room and central lab etc., at MES of CIBA, Muttukadu
10. Construction of ICAR-CIBA outlet at MES of CIBA, Muttukadu
11. Repair and renovation of RCC fish fry tanks with semi-permanent shed at MES of CIBA, Muttukadu
12. Providing barbed wire fencing in the mini Island at MES of CIBA, Muttukadu
13. PVC coated chain link fencing around pond No A9 to A12 at MES of CIBA, Muttukadu
14. Repair and renovation of the existing effluent treatment tanks in CCD at MES of CIBA, Muttukadu
15. Strengthening of the dyke and providing HDPE sheet lining in the shrimp hatchery brood stock ponds at MES of CIBA, Muttukadu

ICAR - CIBA Headquarters Block - II

16. Pond lining and elevation of polyculture and mud crab ponds at MES of CIBA, Muttukadu
17. Providing transparent roofing sheet and granite flooring in the outdoor experimental shed at MES of CIBA, Muttukadu
18. Repair and renovation of various minor works in the fish hatchery at MES of CIBA, Muttukadu
19. Providing concrete platform in front of the ornamental shed at fish hatchery side of the MES of CIBA, Muttukadu
20. Repair and renovation of ornamental fish rearing facility roof shed at FCD hatchery, MES Muttukadu
21. Barbed wire fencing in Northern side of the boundary line in R.S. No. 43 at Thiruvidanthai village at Kovalam Experimental Station (KES) of CIBA, Kelambakkam
22. Providing panel board and cable laying along with required electrical provision for ponds at KES of CIBA, Kelambakkam
23. Providing platform for setup the biofloc unit at KES of CIBA, Kelambakkam
24. Semi-permanent shed for housing the 11 KVA genset at KES of CIBA, Kelambakkam
25. Earth filling for keeping the experimental tanks at KES of CIBA, Kelambakkam
26. Installation of panel board with electrical cabling for experimental units at KES of CIBA
27. Providing M.S. Gate at the main entrance of the KES of CIBA, Kelambakkam
28. Renovation of old office building as farm house at KES of CIBA, Kelambakkam
29. Construction of eight grow-out earthen ponds with a size of 1,000-1,300 m^2 area at KES of CIBA, Kelambakkam
30. Construction of earthen reservoir pond (2,000 m^2 area) at KES of CIBA, Kelambakkam
31. Replacement of electrical panel box and cable in main building , Sector A& B farm and feed mill at KRC, ICAR-CIBA, Kakdwip
32. Renovation of boundary wall to safe guard the property at KRC of CIBA, Kakdwip
33. Renovation of main dyke in the river side of the sector A at KRC of CIBA, Kakdwip
34. Construction of structure for experimental facilities and special housing for salinity gradient system for aqua mimicry under NASF project at KRC of CIBA

Main entrance of KES of CIBA, Kelambakkam

Library and Documentation

CIBA has a full-fledged library and e-resource centre hosting valuable referral books and journals in aquaculture, physiology, nutrition, aquatic health, environment, biotechnology, genetics, bioinformatics, socio-economics and extension catering to the needs of scientists, research scholars, scientific personnel of other research organisations, academicians, university students and other stakeholders.

Library Resources

CIBA library has a rich collection of around 3,050 referral books, 1,610 journal back volumes, 6,800 journal issues, 4,800 abstracts, newsletters and reports, 140 Ph.D. thesis and 2,600 other publications. The library is augmented every year with the purchase of new books and subscriptions to national and international journals. The library has established online connectivity for the Consortium for Electronic Resources in Agriculture (CeRA), consisting of more than 100 international and national journals related to fisheries and aquaculture. It can be accessed online by scientists at headquarters and research centres at Kakdwip and Navsari. CIBA has subscribed to the antiplagiarism software iThenticate and Grammarly to aid the publishing of high-quality research papers in reputed journals.

Automation

CIBA library is fully automated on the KOHA library management system with various features, including holdings and circulation facilities. Online Public Access Catalogue (OPAC) module has been activated, which provides a simple and clear interface for searching books, journals and other documents in the library.

Library and e-Resource Centre

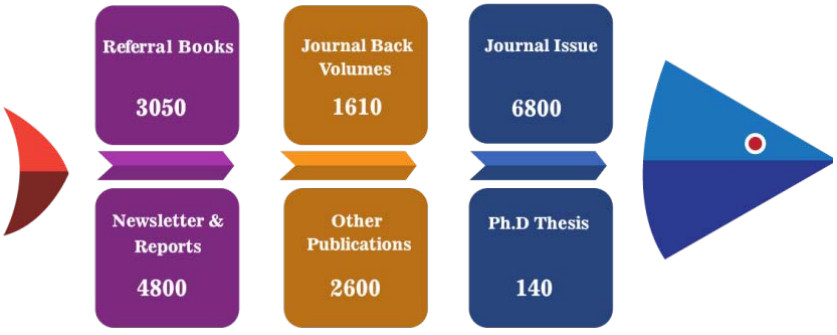
CIBA library has been upgraded as Library and e-Resource Centre with six workstations having the facility to access e-books, online journals, Institute publications and scientists' publications for easy retrieval and use by scientists and scholars. It also helps research scholars to use antiplagiarism and grammarly software.

Data Repository

This year, the CIBA digital library system has been established to manage library holdings and maintain records. The system provides details about the list of books available in the library, journals under CeRA, scientists and Institute publications. It is programmed to monitor the lending of books and automatically sends email reminders for the return of books. In addition to this, scientists can indent their books in the same portal. Under the digitization initiative, all Institute and scientists publications have been digitized and uploaded in the ICAR-KRISHI portal.

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. The library sent the research papers requested by scientists of various ICAR institutes under CeRA document delivery request (DDR).



Library Holdings

Utilization of funds

The funds allotted to the library were effectively utilized to procure referral books, journals, antiplagiarism and grammarly software for the scientists and staff of Headquarters, KRC and NGRC.

Publications 2021

CIBA Publications

Annual Report 2020
CIBANews Issue 10, 11
Jaltarang Vol.7 (Hindi Magazine)

Special Publication

1. Frequently Asked Questions on Asian seabass *(Lates calcarifer)* Seed Production and Farming (Special Publication 87)

CIBA Extension Series

1. Seed production technology of brackishwater catfish, *Mystus gulio* : A livelihood option for farmers of Sundarban, West Bengal (CIBA-Extension Series No. 83)
2. Integrated aqua-agri-poultry-goat farming system in brackishwater aquaculture pond as a livelihood model for coastal communities of Gujarat (CIBA-Extension Series No. 84)
3. Nursery rearing of Asian seabass, *Lates calcarifer* in hapa as livelihood activity for coastal communities of Gujarat (CIBA-Extension Series No. 85)
4. Low volume cage culture of Asian seabass and pearlspot in backwater creeks: An alternate livelihood model for coastal communities of Gujarat (CIBA-Extension Series No. 86)
5. Low input-based brackishwater shellfish and finfish polyculture models for coastal communities: A Gujarat perspective (CIBA-Extension Series No. 87)
6. Farming of Indian white shrimp, *Penaeus indicus* and winter farming of whiteleg shrimp, *Penaeus vannamei* in South Gujarat (CIBA-Extension Series No. 88)

Patents

1. Bera A, Kailasam M, Mandal B, Ambasankar K, Makesh M, Sukumaran K, Kumararaja P, Padiyar A, Vijayan KK. Hormone pellet implant formulation and methodology for inducing maturation and spawning in milkfish (*Chanos Chanos*). Application number: 202041003962, dated: 07/02/2020.

Peer Reviewed Journals

1. Anand, P.S.S., Aravind, R., Biju, I.F., Balasubramanian, C. P., Antony, J., Saranya, C., Christina, L., Rajamanickam, S., Panigrahi, A., Ambasankar, K., Vijayan, K.K., 2021. Nursery rearing of Indian white shrimp, *Penaeus indicus*: Optimization of dietary protein levels and stocking densities under different management regimes. Aquaculture, 542, 736807. (http://krishi.icar.gov.in/jspui/handle/123456789/71687)
2. Aravind, R., Anand, P.S.S., Vinay, T.N., Biju, I.F., Sandeep, K.P., Raymond, J.A.J., Rajamanickam, S., Balasubramanian, C.P., Vijayan, K.K., 2021. Population growth and mass production of brackishwater cladoceran *Eurycercus beringi* sp. nov. under different diet and salinity regime, and its role in *P. indicus* larval rearing. Reg. Stud. Mar. Sci., 44-101777. (http://krishi.icar.gov.in/jspui/handle/123456789/69831)
3. Avunje, S., Patil, P.K., Ezaz, W., Praveena, E., Ray, A., Viswanathan, B., Alavandi, S.V., Puthiyedathu, S.K., Vijayan, K.K., 2021. Effect of oxytetracycline on the biosafety, gut microbial diversity, immune gene expression and withdrawal period in Pacific whiteleg shrimp, *Penaeus vannamei*. Aquaculture, 543, 736957. (http://krishi.icar.gov.in/jspui/handle/123456789/50214)
4. Bera, A., Kailasam, M., Mandal, B., Padiyar, A., Ambasankar, K., Sukumaran, K., Makesh, M., Kumararaja, P., Subburaj, R., Thiagarajan, G., Vijayan, K.K., 2021. Maturity induction and extended spawning kinetics of milkfish (*Chanos chanos*) administered with combined GnRHa and 17α-methyl testosterone pellet at varied frequencies. Aquaculture, 543, 736993. (http://krishi.icar.gov.in/jspui/handle/123456789/70014)
5. Biju, I.F., Antony, J., Aravind, R., Anand, P.S.S., Balasubramanian, C.P., Rajamanickam, S., Veerachamy, P., Ambasankar, K., Gopal, C., Vijayan,

K.K., 2021. Reproductive performance, salinity tolerance, growth and production performance of a cryptic species *Penaeus (Marsupenaeus) japonicus*. Aquac. Res., 52, 5506– 5516. (http://krishi.icar.gov.in/jspui/handle/123456789/70007)

6. Chakrapani, S., Panigrahi, A., Sundaresan, J., Sivakumar, M.R., Palanisamy, R., Kumar, V., 2021. Three different C: N ratios for Pacific white shrimp, *Penaeus vannamei* under practical conditions: Evaluation of growth performance, immune and metabolic pathways. Aquac. Res., 52, 1255-1266. (http://krishi.icar.gov.in/jspui/handle/123456789/71692)
7. Das, R.R., Sarkar, S., Saranya, C., Esakkiraj, P., Aravind, R., Saraswathy, R., Rekha, P.N., Muralidhar, M., Panigrahi, A., 2022. Co-culture of Indian white shrimp, *Penaeus indicus* and seaweed, *Gracilaria tenuistipitata* in amended biofloc and recirculating aquaculture system (RAS). Aquaculture, 548, 737432. (http://krishi.icar.gov.in/jspui/handle/123456789/71690)
8. Das, S., Lalitha, K.V., 2022. *Listeria monocytogenes* biofilms on glass surface: survival and efficacy of two sanitizing agents for inactivation. Fish. Tech., 59: 49-55. (http://krishi.icar.gov.in/jspui/handle/123456789/69899)
9. Devika, N.T., Kumar, J.A., Katneni, V.K., Patil, P.K., Suganya, N., Shekhar, M.S., 2021. In silico prediction of novel probiotic species limiting pathogenic vibrio growth using constraint-based genome scale metabolic modeling. Front. Cell. Infect. Microbiol. 11:752477. (https://krishi.icar.gov.in/jspui/handle/123456789/69837)
10. Hussain, T., Philipose, K.K., Loka Jayasree., Kailasam, M., Biswas, G., Prem Kumar., Bera, Aritra., and R., Subburaj. 2021. Cannibalism, Survival and growth of Asian seabass, *Lates calcarifier* (Bloch,1790) fry in different stocking densities. Journal of Experimental Zoology, India. 24: 147-153. http://krishi.icar.gov.in/jspui/handle/123456789/69919
11. Jannathulla, R., Sravanthi, O., Khan, H.I., Moomeen, S., Gomathi, A., Dayal, J.S., 2021. Chemoattractants: their essentiality and efficacy in shrimp aquaculture. Indian J. Fish., 68: 151-159 (http://krishi.icar.gov.in/jspui/handle/123456789/69722)
12. Jannathulla, R., Sravanthi, O., Moomeen, S., Gopikrishna, G., Dayal, J.S., 2021. Microbial products in terms of isolates, whole-cell biomass, and live organisms as aquafeed ingredients: production, nutritional values, and market potential-a review. Aquac. Int., 21:1-28, (http://krishi.icar.gov.in/jspui/handle/123456789/48075)
13. Jayanthi, M., Balasubramaniam, A.A.K., Suryaprakash, S., Veerapandian, N., Ravisankar, T., Vijayan, K.K., 2021. Assessment of standard aeration efficiency of different aerators and its relation to the overall economics in shrimp culture. Aquac. Eng., 92, 102142. (http://krishi.icar.gov.in/jspui/handle/123456789/70006)
14. Jayanthi, M., Duraisamy, M., Thirumurthy, S., Samynathan, M., Muralidhar, M., 2021. Dynamics of land-use changes and their future trends using spatial analysis and the CA-Markov model-A case-study with a special emphasis on aquaculture development in India. Land Degrad. Dev., 32, 2563-2579. (http://krishi.icar.gov.in/jspui/handle/123456789/69974)
15. Jayanthi, M., Samynathan, M., Thirumurthy, S., Kumararaja, P., Muralidhar, M., Vijayan, K. K., 2021. Mapping coastal lagoon characteristics for the aquaculture suitability using multi-criteria decision support (MCDS) spatial analysis: A case study from south-east coast of India. J. Earth Syst. Sci., 130, 1-14. (http://krishi.icar.gov.in/jspui/handle/123456789/69973)
16. Jayanthi, M., Thirumurthy, S., Samynathan, M., Kumararaja, P., Muralidhar, M., Vijayan, K. K., 2021. Multi-criteria based geospatial assessment to utilize brackishwater resources to enhance fish production. Aquaculture, 537, 736528. (http://krishi.icar.gov.in/jspui/handle/123456789/70005)
17. Jeyagoby, B., Balasubramanian, C. P., Vijayan, K. K., Biju, I. F., Anand, P.S.S., Aravind, R., Kumar, T.S., 2021. In vitro fertilization and hybridization potential of the Indian white shrimp (*Penaeus indicus*). Anim. Reprod. Sci., 235, 106885. (http://krishi.icar.gov.in/jspui/handle/123456789/71694)
18. Jithendran, K.P., Krishnan, A. N., Jegadeesan, V., Raja, R.A., Praveena, P.E., Anushya, S., Amarnath, C.B., Bhuvaneswari, T., 2021. Co-infection of infectious myonecrosis virus and *Enterocytozoon hepatopenaei* in *Penaeus vannamei* farms in the east coast of India. Aquac. Res., 52, 4701-4710. (http://krishi.icar.gov.in/jspui/handle/123456789/69903)
19. Jithendran, K.P., Krishnan, A.N., Aneesh, P.T., Praveena, P.E., Bhuvaneswari, T., 2021. Susceptibility of orange chromide, *Etroplus maculatus* (Bloch, 1795) to experimental infection of Betanodavirus. Aquac. Int., 29, 697-710. (http://krishi.icar.gov.in/jspui/handle/123456789/69912)
20. Kannappan, S., Sivagnanam, S., Jithendran, K.P., Praveena, P.E., Balasubramanian, C.P., Vijayan, K.K., 2021. Development of indoor grow-out practices for polychaete, *Marphysa gravelyi* with a note on biochemical composition.

Aquac. Res., 52, 4278-4287. (http://krishi.icar.gov.in/jspui/handle/123456789/72396)

21. Kannappan, S., Sivakumar, K., Jithendran, K.P., Sivamani, B., Praveena, E.P., 2021. Effect of Asiatic mangrove plant (*Rhizophora mucronata*) extract on the growth and virulence of *Vibrio harveyi* causing bioluminescence disease in *Penaeus monodon* larviculture. Span. J. Agric. Res., 19, 1-12. (http://krishi.icar.gov.in/jspui/handle/123456789/72382)
22. Khatua, R., Mohanta, K.N., Chandan, N.K., Pattanayak, R., Mishra, C.S., Kumar, P., 2021. Dietary protein and lipid concentrations affect the growth, nutritional indices, and whole-body composition of long-whisker catfish, *Mystus gulio*, fry. Aquac. Int. 29, 2085-2099. (http://krishi.icar.gov.in/jspui/handle/123456789/69934)
23. Krishnan, A.N., Kannappan, S., Aneesh, P.T., Praveena, P.E., Jithendran, K.P., 2021. Polychaete worm - A passive carrier for *Enterocytozoon hepatopenaei in* shrimp. Aquaculture, 545, 737187. (http://krishi.icar.gov.in/jspui/handle/123456789/69901)
24. Kulkarni, A., Krishnan, S., Anand, D., Uthaman, S.K., Otta, S.K., Karunasagar, I., Rajendran, K.V., 2021. Immune responses and immunoprotection in crustaceans with special reference to shrimp. Rev. Aquac., 13, 431-459. (http://krishi.icar.gov.in/jspui/handle/123456789/72481)
25. Katneni, V.K., Shekhar, M.S., Kumar, J.A., Balasubramanian, C.P., Ashok, S., Karthic, K., Nimisha, K., Sudheesh, K.P., Gopikrishna, G., Vijayan, K.K., 2021. Phylogenetic relations and mitogenome-wide similarity metrics reveal monophyly of *Penaeus* sensu lato. Ecol. Evol., 11: 2040-2049. (http://krishi.icar.gov.in/jspui/handle/123456789/69829)
26. Kumar, N., Bhushan, S., Gupta, S.K., Kumar, P., Chandan, N.K., Singh, D.K., Kumar, P., 2021. Metal determination and biochemical status of marine fishes facilitate the biomonitoring of marine pollution. Mar. Pollut. Bull., 170, 112682. (http://krishi.icar.gov.in/jspui/handle/123456789/69933)
27. Kumar, S., Kumar, C.B., Rajendran, V., Abishaw, N., Anand, P.S.S., Kannapan, S., Nagaleekar, V.K., Vijayan, K.K., Alavandi, S.V., 2021. Delineating virulence of *Vibrio campbellii*: a predominant luminescent bacterial pathogen in Indian shrimp hatcheries. Sci. Rep., 11, 1-16. (http://krishi.icar.gov.in/jspui/handle/123456789/69876)
28. Kumar, T.S., Makesh, M., Alavandi, S.V., Vijayan, K.K., 2022. Clinical manifestations of White feces syndrome (WFS), and its association with *Enterocytozoon hepatopenaei* in *Penaeus vannamei* grow-out farms: A pathobiological investigation. Aquaculture, 547, 737463. (http://krishi.icar.gov.in/jspui/handle/123456789/69877)
29. Kumar, T.S., Radhika, K., Rajan, J.J.S., Makesh, M., Alavandi, S.V., Vijayan, K.K., 2021. Closed-tube field-deployable loop-mediated isothermal amplification (LAMP) assay based on spore wall protein (SWP) for the visual detection of *Enterocytozoon hepatopenaei* (EHP). J. Invertebr. Pathol., 183, 107624. (http://krishi.icar.gov.in/jspui/handle/123456789/69874)
30. Kumaran, M., Anand, P.R., Kumar, J.A., · Muralidhar, M., Vasagam, K.P.K., Vijayan, K.K., 2021. Assessment of perceived farming risks, communication of risk management practices, and evaluation of their efficiency in Pacific white shrimp (*Penaeus vannamei*) farming-a survey-based cross-sectional study. Aquacult. Int., 29, 2713-2730. (http://krishi.icar.gov.in/jspui/handle/123456789/71887).
31. Kumaran, M., Vasagam, K.P.K., Kailasam, M., Subburaj, R., Anand, P.R., Ravisankar, T., Sendhilkumar, R., Santhanakumar, J., Vijayan, K.K., 2021. Three-tier cage aquaculture of Asian Seabass (*Lates calcarifer*) fish in the coastal brackishwaters-A techno-economic appraisal. Aquaculture, 543, 737025. (http://krishi.icar.gov.in/jspui/handle/123456789/71888)
32. Kumaran, M., Vasagam, K.P.K., Subburaj, R., Anand, P.R., Ramachandran, K., Geetha, R., Vimala, D.D., Raja, R.A., Jayanthi, M., Sairam, C.V., 2021. Techno-economic evaluation of Asian seabass (*Lates calcarifer*) nursery rearing in small net cages (hapas) under different coastal salinities. Aquacult. Int., 30, 157–172. (http://krishi.icar.gov.in/jspui/handle/123456789/70370).
33. Madhubabu, E.P., Jannathulla, R., Khan, H.I., Ambasankar, K., Dayal, J.S., 2021. A blend of plant proteins as a potential fishmeal substitute in the diet of Asian seabass *Lates calcarifer* (Bloch, 1790): Effect on growth, digestive enzymes and fatty acid composition. Indian J. Fish., 68, 65-75.(http://krishi.icar.gov.in/jspui/handle/123456789/69721)
34. Mandal, B., Kailasam, M., Bera, A., Sukumaran, K., Hussain, T., Biswas, G., Vijayan, K.K., 2021. Standardization of oocyte size during artificial fertilization and optimization of stocking density during indoor larval and outdoor nursery rearing of captive spotted scat (*Scatophagus argus*) for a viable juvenile production system. Aquaculture, 534, 736262. (http://krishi.icar.gov.in/jspui/handle/123456789/52627)

35. Mani, S., Ramasamy, S.M., Chakrapani, S., Krishna, A., Anand, P.S.S., Lalramchhani, C., Antony, J., Panigrahi, A., 2021. The effect of natural and artificial periphytic substrates with biofloc system on shrimp *Penaeus vannamei* (Boone 1931) culture: growth and immune response. Aquac. Int., 29, 651-668. (http://krishi.icar.gov.in/jspui/handle/123456789/71691)

36. Muralidhar, M., Kumaran, M., Jayanthi, M., Dayal, J.S., Kumar, J.A., Saraswathy, R., Nagavel, A., 2021. Impacts of climate change and adaptations in shrimp aquaculture: A study in coastal Andhra Pradesh, India. Aquat. Ecosyst. Health Manag., 24, 28-38. (http://krishi.icar.gov.in/jspui/handle/123456789/69885)

37. Nallala, V.S., Makesh, M., Radhika, K., Kumar, T.S., Raja, P., Subburaj, R., Kailasam, M., Vijayan, K.K., 2021. Characterization of red-spotted grouper nervous necrosis virus isolated from ovarian fluids of asymptomatic wild Asian seabass, *Lates calcarifer*. Aquaculture, 542, 736846. (http://krishi.icar.gov.in/jspui/handle/123456789/48073)

38. Nitin, M.S., Girisha, S.K., Kushala, K.B., Chandan, D.V., Puneeth, T.G., Naveen, B.T., Vinay, T.N., Suresh, T., Sahoo, L., Ramesh, K.S., 2021. Novel lytic bacteriophages (AhFM4 & AhFM5) as bio-control measures against multidrug resistant biofilm producing *Aeromonas hydrophila* AhZ1K. Aquaculture, 544, 737106 (http://krishi.icar.gov.in/jspui/handle/123456789/70011)

39. Panigrahi, A., Das, R.R., Sundaram, M., Sivakumar, M.R., Jannathulla, R., Lalramchhani, C., Antony, J., Anand, P.S.S., Jayanthi, M., Dayal, J. S., 2021. Cellular and molecular immune response and production performance of Indian white shrimp *Penaeus indicus* (H. Milne-Edwards, 1837), reared in a biofloc-based system with different protein levels of feed. Fish Shellfish Immunol., 119, 31-41. (http://krishi.icar.gov.in/jspui/handle/123456789/71693)

40. Panigrahi, A., Esakkiraj, P., Das, R.R., Saranya, C., Vinay, T.N., Otta, S.K., Shekhar, M.S., 2021. Bioaugmentation of biofloc system with enzymatic bacterial strains for high health and production performance of *Penaeus indicus*. Sci. Rep., 11, 1-13. (http://krishi.icar.gov.in/jspui/handle/123456789/69913)

41. Patil, P.K., Antony, L., Avunje, S., Viswanathan, V., Lalitha, N., Kumar, J.A., Kumar, D., Solanki, H.G., Reddy, M.A., Alavandi, S.V., Vijayan, K.K., 2021. Bioaugmentation with nitrifying and denitrifying microbial consortia for mitigation of nitrogenous metabolites in shrimp ponds. Aquaculture 541, 736819. (http://krishi.icar.gov.in/jspui/handle/123456789/69875)

42. Patil, P.K., Baskaran, V., Vinay, T.N., Avunje, S., Leo-Antony, M., Shekhar, M.S., Alavandi, S.V., Vijayan, K.K., 2021. Abundance, community structure and diversity of nitrifying bacterial enrichments from low and high saline brackishwater environments. Lett. Appl. Microbiol.,73, 96-106. (http://krishi.icar.gov.in/jspui/handle/123456789/69879)

43. Patil, P.K., Geetha, R., Bhuvaneswari, T., Saraswathy, R., Raja, R.A., Avunje, S., Solanki, H.G., Alavandi, S.V., Vijayan, K.K., 2021. Use of chemicals and veterinary medicinal products VMPs in Pacific whiteleg shrimp, *P. vannamei* farming in India. Aquaculture, 546, 737285. (http://krishi.icar.gov.in/jspui/handle/123456789/69881)

44. Patil, P.K., Vinay, T.N., Aravind, R., Avunje, S., Vijayan, K.K., 2021. Effect of *Bacillus* spp. on the composition of gut microbiota in early life stages of Indian white shrimp, *Penaeus indicus*. J. Appl. Aquac., DOI: 10.1080/10454438.2021.2011527. (http://krishi.icar.gov.in/jspui/handle/123456789/69882)

45. Patil, P.K., Vinay, T.N., Ghate, S.D., Baskaran, V., Avunje, S., 2021. 16S rRNA gene diversity and gut microbial composition of the Indian white shrimp (*Penaeus indicus*). Antonie van Leeuwenhoek, 114:2019-2031. (http://krishi.icar.gov.in/jspui/handle/123456789/70012)

46. Priyadarsani, L., Abraham, T.J., Adikesavalu, H., Dash, G., Nagesh, T.S., 2021. Effects of dietary supplementation of vitamin-E and commercial probiotics on the innate immunity of *Labeo rohita* against *Aeromonas hydrophila* infection. Fish Shellfish Immunol. Rep., 2, 100013. (http://krishi.icar.gov.in/jspui/handle/123456789/69900)

47. Raja, R.A., Patil, P.K., Avunje, S., Kumaran, M., Jithendran, K.P., Vijayan, K.K., 2021. Efficacy of emamectin benzoate in controlling natural infestations of ectoparasites in economically important fish species of India. Aquaculture, https://doi.org/10.1016/j.aquaculture.2022.737940. (http://krishi.icar.gov.in/jspui/handle/123456789/69872)

48. Rajaram, V., Jannathulla, R., Ambasankar, K., Dayal, J.S., 2021. Supplementation of coated and uncoated crystalline amino acid mix in formulating a low fishmeal diet for *Penaeus monodon* (Fabricius, 1798): Effect on growth, digestibility, body composition, haemolymph indices and nitrogen metabolism. Aquac. Nutr., https://doi.org/10.1111/anu.13351 (http://krishi.icar.gov.in/jspui/handle/123456789/69723)

49. Raymond, J.A.J., Shekhar, M.S., Katneni, V.K., Kumar, J.A., Prabhudas, S.K., Kaikkolante, N.,

Krishnan, K., Sukumaran, K., Kailasam, M., Vijayan, K.K., 2021. Comparative genome size estimation of different life stages of grey mullet, *Mugil cephalus* Linnaeus, 1758 by flow cytometry. Aqua. Res., 53, 1151-1158. (https://krishi.icar.gov.in/jspui/retrieve/145553/Raymond%20et%20al.pdf)

50. Rekha, M.U., Tomy, S., Sukumaran, K., Vidya, R., Kailasam, M., Balasubramanian, C.P., Vijayan, K.K., 2021. Comparison of the reproductive biology of two stocks of Indian subcontinental *Mugil cephalus* (Linnaeus, 1758) with special reference to reproductive isolation and philopatry. Indian J. Mar. Sci. 50, 130-140. (http://krishi.icar.gov.in/jspui/handle/123456789/69886)
51. Sandeep, K.P., Avunje, S., Dayal, J.S., Balasubramanian, C.P., Sawant, P.B., Chadha, N.K., Ambasankar, K., Vijayan, K.K., 2021. Efficiency of different microalgae as monospecific and bispecific diets in larval rearing of *Penaeus indicus* with special reference to growth, nutrient composition and antimicrobial activity of microalgae. Aquac. Res., 52, 5146-5154, 1–9. https://doi.org/10.1111/are.15382 (http://krishi.icar.gov.in/jspui/handle/123456789/70246)
52. Sandeep, K.P., De, D., Kumar, S., Raja, R.A., Mahalakshmi, P., Suvana, S., Sivaramakrishnan, T., Ambasankar, K., Vijayan, K.K., 2022. Effect of fish waste hydrolysate on growth performance and health status of milk fish (*Chanos chanos*) and its potential to reduce feed. Aquaculture, 550, 737834. (http://krishi.icar.gov.in/jspui/handle/123456789/70250)
53. Saraswathy, R., Kumararaja, P., Patil, P.K., Rajesh, R., Kumar, R.A., Alavandi, S.V., Vijayan, K.K., 2021. Effect of abiotic factors on the degradation of oxytetracycline in water. Aquac. Res., 52, 4008-4011. (http://krishi.icar.gov.in/jspui/handle/123456789/51841)
54. Saravanan, K., Sivaramakrishnan, T., Praveenraj, J., Sankar, R.K., Haridas, H., Kumar, S., Varghese, B., 2021. Effects of single and multi-strain probiotics on the growth, hemato-immunological, enzymatic activity, gut morphology and disease resistance in Rohu, *Labeo rohita*. Aquaculture, 736-749. (http://krishi.icar.gov.in/jspui/handle/123456789/46512)
55. Sarkar, S., Rekha, P.N., Ambasankar, K., Vijayan, K.K., 2021. Bioremediation efficiency of indigenous seaweeds of Chennai coast in brackishwater system. Aquac. Int., 29, 233–251. (http://krishi.icar.gov.in/jspui/handle/123456789/72384)
56. Sarkar, S., Rekha, P.N., Panigrahi, A., Das, R., Rajamanickam, S., Balasubramanian, C.P., 2021. Integrated brackishwater farming of red seaweed *Agarophyton tenuistipitatum* and Pacific white leg shrimp *Litopenaeus vannamei* (Boone) in biofloc system: a production and bioremediation way out. Aquac. Int., 29, 2145-2159. (http://krishi.icar.gov.in/jspui/handle/123456789/72385)
57. Satyanarayana, N.V., Makesh, M., Sain, A., Jayaprakash, N.S., Kailasam, M., Vijayan, K. K., 2021. Non-lethal screening of Asian seabass (*Lates calcarifer*) by monoclonal antibody based indirect enzyme linked immunosorbent assay for viral nervous necrosis. Fish Shellfish Immunol. Rep., 2, 2021, 100011. (http://krishi.icar.gov.in/jspui/handle/123456789/68842)
58. Shekhar, M.S., Katneni, V.K., Kumar, J.A., Karthic, K., Nimisha, K., Vijayan, K.K., 2021. The genomics of the farmed shrimp: current status and application. Rev. Fish. Sci. Aquac., 29, 654-665. (http://krishi.icar.gov.in/jspui/handle/123456789/69658)
59. Sivakumar, K., Kannappan, S., Vijayakumar, B., Jithendran, K.P., Balasubramaniam, S., Panigrahi, A., 2021. Molecular docking study of bio-inhibitors extracted from marine macro-alga Ulva fasciata against hemolysin protein of luminescence disease-causing *Vibrio harveyi*. Arch. Microbiol., 203, 4243-4258. (http://krishi.icar.gov.in/jspui/handle/123456789/72381)
60. Sivaramakrishnan, T., Ambasankar, K., Kumar, T.S., Sandeep, K.P., Thomas, D., Raja, R.A., Vasagam, K.K., Dayal, J.S., Kailasam, M., 2022. Influence of dietary protein levels on growth, feed utilization, body indices and serum profile of silver moony *Monodactylus argenteus*. Aquaculture, 549, 737823. https://doi.org/10.1016/j.aquaculture.2021.737823 (http://krishi.icar.gov.in/jspui/handle/123456789/70254)
61. Sivaramakrishnan, T., Ambasankar, K., Vasagam, K.P.K., Dayal, J.S., Sandeep, K.P., Bera, A., Kailasam, M., Vijayan, K.K., 2021. Effect of dietary soy lecithin inclusion levels on growth, feed utilization, fatty acid profile, deformity and survival of milkfish (*Chanos chanos*) larvae. Aquac. Res., 52, 5366-5374. https://doi. org/10.1111/are.15406 (http://krishi.icar.gov.in/jspui/handle/123456789/70251)
62. Soman, M., Chadha, N.K., Madhu, K., Madhu, R., Sawant, P.B., Biju, I.F., 2021. Optimization of temperature improves embryonic development and hatching efficiency of false clown fish, *Amphiprion ocellaris* Cuvier, 1830 under captive condition. Aquaculture 536, 736417. (http://krishi.icar.gov.in/jspui/handle/123456789/69884)
63. Sukumaran, K., Thomas, D., Rekha, M.U., Raymond, J.A.J., Bera, A., Mandal, B., Subburaj, R., Thiagarajan, G., Makesh, M., Ambasankar,

K., Krishnakumar, K., Kailasam, M., Vijayan, K.K., 2021. Reproductive maturation and induced breeding of two geographical groups of grey mullet, *Mugil cephalus* Linnaeus, 1758. Aquaculture, 536, 736423. (http://krishi.icar.gov.in/jspui/handle/123456789/71686)

64. Swathi, A., Shekhar, M.S., Karthic, K., Katneni, V.K., Muralidhar, M., Hauton, C., Vijayan, K.K., 2021. Variation in biotic and abiotic factors associated with white spot syndrome virus (WSSV) outbreak in shrimp culture ponds. Indian J. Fish., 68, 127-136. (http://krishi.icar.gov.in/jspui/handle/123456789/69657)
65. Swathi, A., Shekhar, M.S., Katneni, V.K., Vijayan, K.K., 2021. Flow cytometry analysis of apoptotic progression and expression analysis of four apoptosis-related genes in *Penaeus vannamei* in response to white spot syndrome virus infection. VirusDisease, 32, 244-250. (http://krishi.icar.gov.in/jspui/handle/123456789/69656)
66. Thomas, D., Rekha, M.U., Raymond, J.A.J, Sreekanth, G.B., Sukumaran, K., Sandeep, K.P., Bera, A., Thiagarajan, G. and Kailasam, M., 2022. The effect of acclimation temperature and optimal temperature gradient for egg and larvae of silver moony (*Monodactylus argenteus*) during the early ontogenesis. Environ. Sci. Pollut. Res., 1-12, DOI: 10.1007/s11356-021-18329-x. (http://krishi.icar.gov.in/jspui/handle/123456789/70013)
67. Thomas, D., Rekha, M.U., Raymond, J.A.J, Sreekanth, G.B., Thiagarajan, G., Subburaj, R., Kailasam, M., Vijayan, K.K., 2021. Effects of salinity amendments on the embryonic and larval development of a tropical brackishwater ornamental silver moony fish, *Monodactylus argenteus* (Linnaeus, 1758). Aquaculture, 544, 737073. (http://krishi.icar.gov.in/jspui/handle/123456789/70043)
68. Vinay, T.N., Patil, P.K., Aravind, R., Shyne, P.S.S., Baskaran, V., Balasubramanian, C.P., 2021. Microbial community composition associated with early developmental stages of the Indian white shrimp, *Penaeus indicus*. Mol. Genet. Genom., https://doi.org/10.1007/s00438-022-01865. (http://krishi.icar.gov.in/jspui/handle/123456789/70010)

Popular Articles

1. Antony, J., Mahalakshmi, P., Hussain, T., Patil, P.A., Biju, I.F., Anand, P.S.S., 2021. Farming of *P. vannamei* during winter season: A success story from South Gujarat (Hindi). JalTarang, 7:50-52.
2. Biju, I.F., Antony, J., Sudheer, N.S., Aravind, R., Soman, M., 2021. Jinga beej ki gunvatha ki aakalan: Mool vishayom ki aur lautem (Hindi). JalTarang, 7:74-78.
3. De, D., Sandeep K.P., Mahalakshmi, P., Ambasankar, K., 2021. CIBA-Plankton Plus – a promising way to optimize formulated feed usage in aquaculture. *Aquaculture Spectrum,* 4: 23-25.
4. De, D., Sandeep, K.P., Mahalakshmi, P., Kumar, S., Raja, R.A., Raymond J.A.J., Ambasankar, K., 2021. CIBA-Plankton^{Plus} evam CIBA-Horti Plus matsya avasisht se vikasit moolya vardhit udpad. JalTarang, 7:40-41.
5. Hussian, T., Patil, P.A., Antony, J., Mahalakshmi, P., Kailasam, M., Sukumaran, K., Kumar, P., Jithendran, K.P., 2021. Net kej me andajanan evam recirculatory aquaculture system mein larva savardhan: Pearlspot *Etroplus surantesis* ke liye navonmeshee beej utpadan takanik. JalTarang, 7:53-56.
6. Kumar, S., Avunje, S., Rajendran, V., Alavandi, S.V., 2021. Phage thereapy for the control of luminescent vibriosis in shrimp hatcheries (In Hindi: Jhinga hatchriyon me luminescent vibriosis niyantran ke liye phage therapy). JalTarang, 7:43.
7. Patil, P.A., Hussain, T., Antony, J., Mahalakshmi, P., Kailasam, M., 2021. Gujarat ke janjatiya samudayo ke liye aajivika model ke roop me khara jaljiv palan- talab me aekikrut matsya palan pranali. JalTarang, 7:92-98.
8. Patil, P.A., Hussain, T., Kailasam, M., Sairam, C.V., Subburaj, R., 2021. Sindhudurg Maharashtra ke mangrove tatiya samudayo ke aajivika suraksha ke roop me mangrove aadharit seabass or pearlspot ki lagat prabhavi pinjara palan- ek safalta ki kahani. JalTarang, 7:102-107.
9. Poornima, M., Kannappan, S., Kailasam, M., Jithendran, K.P., 2021. Opercular deformities in Asian Sea bass fish (*Lates calcarifer*) under nursery rearing in hapas. Aqua Tech magazine (October):77-79
10. Poornima, M., Subramanian, S.K., 2021. Tilapia: An ideal fish for Indian fish farming. Aqua Tech magazine (August):78-80
11. Raja, R.A., Patil, P.K., Avunje, S., Jithendran, K.P., 2021. Controlling parasitic infestations in commercially important fishes through oral administration of emamectin benzoate. JalTarang, 7:81-84.
12. Rekha, P.N., 2021. Women in coastal fisheries and aquaculture sector. Women and fisheries: Achieving an equal future in a post COVID-19 world, NABARD, 9 789354 575136.
13. Sukumaran, K., Rekha, M.U., Thomas, D., Raymond, J.A., Bera, A., Babita, M., Makesh, M.,

Ambasankar, K., Kailasam, M., 2021. Success in captive production of grey mullet *mugil cephalus* (Hindi). JalTarang, 7:46-47.

14. Sukumaran, K., Vasagam, K.P.K., Thomas, D., Raymond, J.A.J., Bera, A., Hussain, T., Kailasam, M., Vijayan, K.K., 2021. Pearlspot farming: Recent advances and way forward. Aquaculture Spectrum, 4:9-15.

BOOKS/BOOK CHAPTER

1. Ghoshal, T.K., De, D., Das, S., Kumar, P., Christina, L., 2021. Brackishwater aquaculture management in coastal ecosystem. In: Mandal, U.K., Lama, T.D., Burman, D., Mandal, S., and Raut, S. (Eds). 2021. Souvenir, International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, Indian Society of Coastal Agricultural Research, 16 - 19 March, 2021, 68-85.
2. Kumar, P., Behera, P., Christina, L., Kailasam M., 2021. Sex hormones and their role in gonad development and reproductive cycle of fishes. In: Sundaray, J.K., Rather, M.A., Kumar, S., Agarwal, D. (Eds). Recent updates in molecular endocrinology and reproductive physiology of fish, An Imperative step in Aquaculture. Springer: Singapore, 12-22.
3. 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.
4. Panigrahi, A., Esakkiraj, P., Saranya, C., Vinay, T.N., 2021. Biofloc Technology: An eco-based emerging avenue in aquaculture health management. In: Gupta, S.K., Giri, S.S. (Eds). Biotechnological Advances in Aquaculture Health Management. Springer, Singapore.
5. Panigrahi, A., Naveenkumar, R., Das, R.R., 2021. Immunoprophylactic measures in aquaculture. In: Pandey P.K., Parhi J. (Eds). Advances in Fisheries Biotechnology. Springer, Singapore.

ORAL PRESENTATIONS

1. Biswas, G., De, D., Kumar, P., Das, S., Ghoshal, T.K., 2021. An innovative nursery rearing method of brackishwater catfish, *Mystus gulio* at varied densities in simplified floc system. Sarangi, S.K., Mahanta, K.K., Raut, S., Bhutia, R.N., and Prakash, N. R. (Eds.). 2021. Book of Abstracts, International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 - 19 March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal, India.
2. De, D., Ghoshal, T.K., Das, S., Kumar, P., Das, U., 2021. Brackishwater aquaculture: Opportunities and challenges for meeting livelihood demand in Indian Sundarbans. Sarangi, S. K., Mahanta, K.K., Raut, S., Bhutia, R. N. and Prakash, N. R. (Eds.). 2021. Book of Abstracts, International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 - 19 March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal, India.
3. Kumar, P., Behera, P., Biswas, G.B., Ghoshal, T.K., Kailasam, M., 2021. Estradiol dependent stimulation of brain dopaminergic systems in the female gold spot mullet, *Liza parsia*. Sarangi, Mahanta, S.K., K.K., Raut, S., Bhutia, R. N. and Prakash, N. R. (Eds.). 2021. Book of Abstracts, International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 - 19 March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal, India.
4. Makesh, M., 2021. Immune response of Asian seabass (*Lates calcarifer*) vaccinated with recombinant viral nervous necrosis vaccine. 7th European Veterinary Immunology Workshop, Serbia, 29-31, August, 2021. Book of abstracts, Pp 46.
5. Lalitha, N., Avunje, S., Nagavel, A., Muralidhar, M., 2021. Mycotic bioremediation of toxic ammonia in waters varying in salinity. In: International conference on Earth and Environment in Anthropocene (ICEEA-2021) Organised by Department of Geology Central University of Karnataka Jointly with Centre for Environmental Sciences and Department of Geology, University of Madras, during 29 – 31 October, 2021, Chennai.
6. Lalitha, N., Suvana, S., Nagavel, A., Muralidhar, M., 2021. Methane oxidising bacteria prevalence in water bodies and shrimp culture ponds and their effect on water quality. In: The International Conference on Novel paradigms in Biotechnology-Bioengineering interface from concepts to reality – (NPBBI 2021) organised by Satyabhama Institute of Science and Technology and Indian Association of Applied microbiologist and California University of Science in and Medicine during 10th to 12th November, 2021, Chennai.
7. Naskar, S., Biswas, G., Kumar, P., De, D., Sawant, P.B., 2021. Optimization of biomass density of

estuarine oyster, *Crassostrea cuttackensis* in integrated multi-trophic aquaculture (IMTA) system for better water quality and production performance. Sarangi, S. K., Mahanta, K.K., Raut, S., Bhutia, R.N., and Prakash, N. R. (Eds.). 2021. Book of Abstracts, International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 - 19 March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal, India.

8. Mahalakshmi, P., 2021. Role of ICT application in contact free communication in COVID times: Aquaculture sector. Umamaheswari.T., Balasundari, S. and Sugumar. G. (Eds.), In Proc. Fisheries in COVID Times and After: Gender, Ground Truths and Growth. TNJFU, Nagapattinam, 82-93.
9. Raja, R.N., Rekha, P.N., Sarkar, S., Sunny, A., Balasubramanian, C.P., 2021. Mapping of aquaculture potential zones using geospatial multi criteria method for sustainable aquaculture development- Thiruvallur district. International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 - 19 March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal, India
10. Raja, R.N., Rekha, P.N., Chandrasekar, V., Sunny, A., Sandeep, K.P., Balasubramanian, C.P., 2021. Mapping of potential cage farming area availability for brackishwater eco-tourism development, Muttukadu Lagoon, Chengalpattu district. Two-day International Conference on Earth and Environment in Anthropocene during 29-30 October, 2021.
11. Rekha, P.N., Sunny, A., Raja, R.N., Ambasankar, K., Balasubramanian, C.P., 2021. Design, fabrication and evaluation of a prototype portable solar dryer for shrimp feeds and feed ingredients. XV Agricultural Science Congress & ASC Expo during 13-16 November, 2021.
12. Rekha, P.N., Vijayan, K.K., 2021. Water management for sustainable brackishwater aquaculture in coastal ecosystem-Innovative approaches. International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 - 19 March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal, India.
13. Rekha, P.N., Raja, R.N., Sunny, A., Kannappan, S., Balasubramanian, C.P., 2021. Impact assessment of floods on coastal aquaculture for effective planning and management – A micro level analysis. Two-day International Conference on Earth and Environment in Anthropocene during 29-30 October, 2021.
14. Rekha, P.N., Raja, R.N., Sunny, A., Panigrahi, A., Balasubramanian, C.P., 2021. Design, development and evaluation of prototype IoT based water quality monitoring system for shrimp farming. XV Agricultural Science Congress & ASC Expo during 13-16 November, 2021.
15. Saraswathy, R., Patil, P.K., Kumararaja, P., Raja, R.A., Avunje, S., Jithendran, K.P., 2021. Degradation of emamectin benzoate in aquaculture pond sediment under tropical conditions. In: 3rd Online International conference on Aquaculture and Fisheries organised by Coalesce Research Group, USA, during 15-16, November, 2021.
16. Sarkar, S., Rekha, P.N., Biswas, G., Raja, R.N., Sunny, A., Panigrahi, A., Balasubramanian, C.P., Vijayan, K.K., 2021. Integrated multi-trophic aquaculture (IMTA): A potential farming system to enhance production of the red seaweed *Gracilaria tenuistipitata* (Chang and Xia) in brackishwater. International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, 16 - 19 March, 2021. Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town – 743 329, West Bengal, India.
17. Sivamani, B., Makesh M., Misha, S., Subburaj, R. and Kailasam, M. 2021. Molecular cloning and sequencing of Immunoglobulin M heavy chain gene in Asian seabass. International Conference on Novel paradigms in Biotechnology - Bioengineering interface - from concepts to reality (NPBBI-2021), Sathyabama Institute of Science and Technology in association with California University of Science and Medicine, USA and Indian Association of Applied Microbiologists (IAAM) during 10-12th November, 2021.

Participation in Conferences, Meetings, Workshops and Symposia

Dr. K.K. Vijayan, Director (upto 31.05.2021)

1. Monthly Meeting of Directors with Fisheries SMD organized by SMD (Fisheries), ICAR, New Delhi held on 25th January, 2021
2. Monthly Meeting of Directors with Fisheries SMD organized by SMD (Fisheries), ICAR, New Delhi held on 10th February, 2021
3. Meeting on Indo-UK Aquaculture Partnerships for Research and Innovation, organized by UK Science and Innovation Network, British High Commission, New Delhi held during 8-11th March, 2021
4. Monthly Meeting of Directors with Fisheries SMD organized by SMD (Fisheries), ICAR, New Delhi held on 10th March, 2021
5. Meeting on UK - India Aquaculture partnership event, organized by DDG (Fy.), ICAR New Delhi held on 11th March, 2021
6. Review Meeting of the Directors/ Regional Centre In-charges to discuss on the Action taken report of the Regional Committee Meeting of the Zone VI (Rajasthan, Gujarat, UT of Dadra & Nagar Haveli & Daman & Diu) on at ICAR, New Delhi held on 12th March, 2021
7. International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security, organized by Indian Society of Coastal Agricultural Research, in collaboration with CSSRI, Karnal at ISCAR, Canning Town, West Bengal held during 16-17th March, 2021

Dr. K.P. Jithendran, Director

8. Meeting of the Directors of ICAR Institutes chaired by the Director General, ICAR at ICAR, New Delhi held on 4th June, 2021
9. Meeting with regard to SFC of 3 Schemes of Fisheries SMD at ICAR, New Delhi held on 5th June, 2021
10. 66th Meeting of Coastal Aquaculture Authority (CAA) at Chennai held on 16th June, 2021
11. 27th meeting of the National Committee on Introduction of Exotic Aquatic Species into Indian Waters organized by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi held on 16th June, 2021
12. 65th Executive Committee and 28th Annual General Body Meetings of Rajiv Gandhi Centre for Aquaculture organized by RGCA at Sirkazhi held on 22nd June, 2021
13. Meetings of Directors & Senior Officers of Fisheries SMD organized at SMD (Fy.), ICAR, New Delhi held on 1st July, 2021
14. Directors Conference organized at ICAR, New Delhi held on 2nd July, 2021
15. Meeting on the demonstration of new AQMS software of AQF, RGCA at RGCA, Sirkazhi held on 6th July, 2021
16. Meeting on UK-India Pilot Project – One Health Aquaculture, organized by UK Science and Innovation Network, British High Commission, New Delhi held on 6th July, 2021
17. 53rd Meeting of the Institute Management Committee of CIBA at CIBA, Chennai held on 14th July, 2021
18. 93rd Foundation Day of ICAR organized at ICAR, New Delhi held on 16th July, 2021
19. Meeting of the Fisheries SMD and Director of ICAR Fisheries Institutes with Director and Senior Officers of Department of Fisheries, Govt. of Bihar organized at SMD (Fy.), ICAR, New Delhi held on 20th July, 2021
20. Meeting with regard to the presentation of SFC of 3 Schemes by SMD (Fisheries) to Additional Secretary and Financial Advisor, DARE, with the participation of Fisheries Institutes organized at SMD (Fy.), ICAR, New Delhi held on 29th July, 2021

21. Meeting of the Partner Institutes of NASF Project on "Captive breeding of hilsa: *Tenualosa ilisha* Phase II", organized by CIFRI, Barrackpore held on 3rd August, 2021
22. Inauguration and Handing Over of the room constructed with a new type of cement called Limestone Calcined Clay Cement (LC3) which is ecofriendly, by the Department of Civil Engineering, IIT, Madras in the Island area at Muttukadu Experimental Station (MES), Muttukadu on 7th August, 2021
23. Indian Aquaculture Insurance Webinar on "Blue Revolution in India" organized by Willis Towers Watson India Insurance Brokers Private Ltd., Mumbai (As a Panellist in the Webinar) held on 10th August, 2021
24. Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.), ICAR held on 13th August, 2021
25. 6th Meeting of the Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) organized by Ministry of Fisheries, Animal Husbandry and Dairying, Department of Fisheries, Govt. of India on 24th August, 2021
26. XXVI Meeting of the ICAR Regional Committee No.VII comprising the States of Maharashtra, Madhya Pradesh, Chhtattisgarh and Goa organized by ICAR, New Delhi held on 25th August, 2021
27. National Level Campaign on "Food and Nutrition for Farmers" as a part of Azadi ka Amrut Mahotsav organized by ICAR, New Delhi held on 26th August, 2021
28. Scientist-Farmer-Industry Interaction meet under Bharat Ki Azadi Ka Amrut Mahotsav 2021-22, under the thematic area is "Species and system diversification in brackishwater aquaculture" organized by CIBA, Chennai on 1st September, 2021
29. Special Meeting of the Coastal Aquaculture Authority is scheduled to discuss on the urgent amendments required to be made in the CAA Rules in view of the difficulties in registration and renewal of coastal aquaculture farms organized by CAA, Chennai on 3rd September, 2021
30. 4th Rashtriya Poshan Maah 2021 - Webinar on "Consumption of Fish and Other Aquatic Foods for Improving Food and Nutrition Security" organized by NFDB, Hyderabad held on 6th September, 2021
31. Indo-UK Project Proposals - Shrimp Health Pilot Discussion, under GPF Uplift funding organized by UK Science and Innovation Network, British High Commission, New Delhi held on 7th September, 2021
32. XXVII Meeting of ICAR Regional Committee No. VIII, organized by CMFRI, Kochi at Committee Hall, ICAR, Krishi Bhavan, New Delhi held on 14th September, 2021
33. Meeting with the Directors of Fisheries Research Institutes for discussion on Campaign on Nutri-garden and Tree Plantation organized by SMD (Fisheries), ICAR, New Delhi held on 17th September, 2021.
34. Nutri-Cereals Multi-Stakeholders Mega Convention (NCMC 3.0), and Poshan Vatika and Tree Plantation Campaign Run-up for International Year of Millets 2023 organized by HICC, Kondapur, Hyderabad held on 17th September, 2021
35. Preparatory Meeting of SFC presentations of Fisheries Division, organized by DDG (Fy.), ICAR at SMD (Fisheries), ICAR, New Delhi held on 27th September, 2021
36. Consultation with stakeholders and domain experts on "Return of Tiger – Exploring Sustainability organized by Coastal Aquaculture Authority, Chennai on 28th September, 2021
37. Institute Joint Staff Council Meeting of CIBA organized at CIBA, Chennai on 28th September, 2021
38. 66th Executive Committee Meeting of Rajiv Gandhi Centre for Aquaculture (RGCA) organized at RGCA, Sirkazhi held on 29th September, 2021
39. SFC/EFC Meeting of ICAR/DARE organized by ICAR, New Delhi held on 29th September, 2021
40. Key Stakeholders Consultation Meeting - Revival of *P.monodon* culture in India and need for BMC for commercialization of MPEDA-RGCA DTSP produced SPF germplasm organized by MPEDA, Kochi held on 6th October, 2021
41. Review and Sensitization Workshop of ZTMUs/ ITMUs/PMEs under NAIF Scheme, organised by IPTM Division, ICAR Hosted by CIFT, Kochi held on 8th October, 2021
42. Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.), ICAR on 21st October, 2021
43. 67th Meeting of Coastal Aquaculture Authority convened by CAA, Chennai on 22nd October, 2021
44. Review meeting on Special Campaign on Swachhta and pending matters under the Chairmanship of Hon'ble Minister of State, Ministry of Agriculture and Farmers Welfare, Govt. of India, hosted by ICT Unit, ICAR held on 27th October, 2021
45. Interaction meeting of ICAR Scientists with Secretory DARE & Director General,

ICAR organized by ICAR, New Delhi on 28th October, 2021

46. Virtual meeting on "Finalization of Draft Final Report of Road Map and Action Plan submitted by the Consultant, NITTE University, Mangalore to achieve seafood exports worth ₹ 20,000 crore per annum from Odisha conducted by Directorate of Fisheries, Govt. of Odisha, Cuttack held on 8th November, 2021
47. Webinar on "Antimicrobial Resistance in Aquaculture – Who is responsible?" organized by ICAR-CIBA held on 9th November, 2021
48. Webinar on "Antimicrobial Resistance in Fish" organized as part of celebration of Azadi Ka Amrit Mahotsav organized by ICAR-CIFT, Kochi held on 23rd November, 2021
49. 233rd Board Meeting and 47th Annual General Meeting of TNFDC Ltd. conducted at Secretariat, Chennai held on 29th November, 2021
50. Meeting to discuss the program of Honourable Prime Minister conducted at SMD (Fisheries), ICAR held on 13th December, 2021
51. Conference on "Natural Farming (Zero Budget Natural Farming) organized as a part of "Agro and Cooperation Pre-Vibrant Gujarat Summit 2021", organized at Anand, Gujarat on 16th December, 2021
52. First meeting of the Expert Committee constituted to draft the Coastal Aquaculture Authority (CAA) Amendment Bill, 2021 scheduled under the Chairmanship of Joint Secretary (Marine Fisheries), Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India, through Video Conferencing held on 21st December, 2021

Scientists

1. International Webinar on 'Sustainable Marine Fisheries and Aquaculture: Policies, Packages and Perspectives in Blue Economy Paradigm" (SMART P3 BLUEECO-2021) organized by Department of Aquatic Biology and Fisheries, University of Kerala during 12-13th March, 2021 - Dr. B. Sivamani
2. "Mapping of aquaculture potential zones using geospatial multi criteria method for sustainable aquaculture development-Thiruvallur district". International Symposium on Coastal Agriculture during March 16-19, 2021 organized by Indian Society of Coastal Agricultural Research- Dr. P. Nila Rekha
3. Webinar on "Culture-based fisheries for rural development" organized by NACA, Bangkok, Thailand on 31st May, 2021 - Dr. B. Shanthi
4. World Zoonoses day 2021-Webinar on "Preventing future zoonotic pandemics: Interventions at the wildlife, livestock & human interface" organized by ICAR-NRCE in collaboration with National Centre for Diseases and Indian Virological Society on 6th July, 2021- Dr. B. Sivamani
5. "Biofloc technology and its sustainability in north east region of India" conducted by NFDB during 15-16th July, 2021- Dr. Shyne Anand
6. International symposium on "Harnessing the potentials of genome editing tools to augment the productivity and health of farm animals" organized by ICAR-NDRI in online mode during 19-20th July, 2021 - Dr. Sherly Tomy, Dr. Vinaya Kumar Katneni, Dr. B. Sivamani, Ms. Misha Soman
7. 2nd International Conference on Recent strategies in biotechnology and biosciences (ICRSBBS-2021) held during 27-28th July, 2021 organised by Aarupadai Veedu Institute of Technology, Vinayaka Mission's Research Foundation, Chennai - Dr. M. Poornima
8. Webinar on Aquaculture Insurance on 10th August, 2021, organized by Willis Tower Watson & ICAR-CIBA, Chennai - Dr. M. Muralidhar, Dr. M. Shashi Shekhar
9. Meeting on "Inland saline aquaculture in Rajasthan and the way forward" with Commissioner (AH), and Department of Fisheries, Govt. of Rajasthan at Govt. Secretariat, Jaipur, Rajasthan on 18th August, 2021- Mr. Jose Antony
10. Meeting with Head of Aquaculture & Marine Biotechnology, Dr. Nitin K. Jain and Programme Officer, Dr. Vamsi Krishna on 5th October, 2021- Dr. M. Shashi Shekhar
11. "Impact assessment of floods on coastal aquaculture for effective planning and management – A micro level analysis". Two-day International Conference on Earth and Environment in Anthropocene during 29-30th October, 2021 organized by Department of Geology Central University of Karnataka, India - Dr. P. Nila Rekha and Dr. N. Lalitha
12. The International Conference on Novel paradigms in Biotechnology-Bioengineering interface from concepts to reality – (NPBBI 2021) organized by Satyabhama Institute of Science and Technology and Indian Association of Applied microbiologist and California University of Science in and Medicine during 10-12th November, 2021, Chennai - Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. N. Lalitha, Dr. Vinaya Kumar Katneni, Dr. B. Sivamani

13. Design, development and evaluation of prototype IoT based water quality monitoring system for shrimp farming". XV Agricultural Science Congress & ASC Expo during 13-16th November, 2021 - Dr. P. Nila Rekha
14. Online Training Program on "Emotional Intelligence at Workplace" for Scientists/ Technologists organized by Centre for Organization Development, Hyderabad during 29th November to 3rd December, 2021 - Dr. B. Shanthi
15. Virtual meeting of the 'Livelihood Working Group' organized by Nature Environment Wildlife Society (NEWS) on the 23rd of November, 2021 - Dr. Debasis De
16. Meeting of Scientific Advisory committee of Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, South 24 Parganas on 24th September, 2021 - Dr. Debasis De
17. International Symposium on "Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security" organized by Indian Society of Coastal Agricultural Research, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town held during 16 – 19th March, 2021 - Dr. T.K. Ghoshal
18. XV Agricultural Science Congress & ASC Expo organized by National Academy of Agricultural Sciences and Banaras Hindu University at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi held during 13-16th November, 2021 - Dr. P. Nila Rekha, Mr. K.P. Sandeep, Mr. T. Sivaramakrishnan
19. National Webinar (13-17 July, 2021) on Advancement in Finfish seed production for SMART Aquapreneurship. Organized by Tripura Fisheries College, Central Agricultural University, Imphal, Lembucherra, Agartala - 799 210, Tripura, India - Dr. Prem Kumar
20. Farmers meet on "Soil and water characteristics of brackishwater farms in coastal Karnataka and BMPs for sustainable Aquaculture" at Kundapura, Karnataka on 4th December, 2021- Mr. Tanveer Hussain, Mr. Biju I.F.
21. National program on "Pre-Vibrant Gujarat Summit" organized by Agriculture, Farmers Welfare and Co-operation Department, Govt. of Gujarat during 14-16th December, 2021 at Anand Agricultural University, Gujarat - Mr. Pankaj Patil

Invited Lectures

1. Delivered a lecture on "Farm made feed preparation and its management in brackishwater fish and shrimp culture" in the online awareness cum training programme under ICAR-DoF convergence at ICAR-CIFE, Kolkata Centre on 12th February, 2021 - Dr. T.K. Ghoshal
2. Delivered a talk on "Overview of brackishwater aquaculture with reference to feed management" to the participants of Bengal Fisherman Orientation & Exposure Meet-2021 organized by Indian Chamber of Commerce, Kolkata and Dept. of Fisheries, Govt. of West Bengal on 27th February, 2021- Dr. T.K. Ghoshal
3. Invited Speaker for online training on Fish disease and health management in inland waters, CIFRI on 6th March, 2021-Dr. S.K. Otta
4. Delivered invited talk on Brackishwater Aquaculture: Opportunities and Challenges for Meeting Livelihood Demand in Indian Sundarbans in International virtual symposium on "Transforming coastal zones for sustainable food & income security", organized by Indian Society of Coastal Agriculture, on 16th March, 2021 - Dr. Debasis De
5. Invited speaker for the webinar "International Symposium on Coastal Agriculture" conducted by ISCAR, ICAR-CSSRI, West Bengal during 16-19th March, 2021. - Dr. P. Nila Rekha
6. Delivered a lecture on "Brackishwater aquaculture scenario in India with special reference to shrimp farming" in the National Seminar on 'Frontiers in Marine Resources, Biotechnology and conservation' organized by Post graduate and Research department of Zoology, Nirmala College for women, Coimbatore held on 17th March, 2021 - Mr. R. Aravind
7. Delivered a lecture on Water management in coastal areas. Advances and innovative challenges in water technology and its application organized by Sathyabama University on 22-27th March, 2021- Dr. P. Nila Rekha
8. Delivered a invited talk On "Sustainable Aquaculture Development Using Geo Spatial Techniques" on 15th July, 2021 organized by PG and Research Department of Advanced Zoology and Biotechnology, Guru Nanak college, Chennai. - Dr. M Jayanthi
9. Delivered a invited talk on "Application of Remote sensing and GIS in Aquaculture" on 9.9.2021 at Department of Architecture, Anna University, Chennai, India. - Dr. M Jayanthi
10. Delivered a invited talk on "Need for planned aquaculture: Issues and way forward" in the National Workshop on Geospatial Technologies Applications, on 29th October, 2021 at Department of Geography, Presidency College, Chennai, India. - Dr. M Jayanthi

11. Delivered lecture on Diseases in farmed mud crabs in the virtual training programme held on 15th April, 2021 organized by SIFT, Kakinada- Dr. M. Poornima
12. Delivered an invited lecture on "*Enterocytozoon hepatopenaei* (EHP) and management" on 11th June, 2021 to 750 Village Fisheries Assistants of Government of Andhra Pradesh to enable them to render necessary extension services to Aquaculture sector - Dr. R. Ananda Raja
13. Delivered a lecture in the National Webinar on Quality Shrimp Seed and Assessment through PCR Techniques & Inland Cage Culture organised by Marsco Aqua Clinics - Aqua One Centre on 12th June, 2021 - Dr. Akshaya Panigrahi
14. Delivered an invited lecture on Present prospects of brackishwater finfish culture in India organized by National Virtual Conference on Mariculture in India, Recent Advances (NCMIRA-2021) Dept. of Biotech., AMET University held on 16th June, 2021 - Dr. M. Kailasam
15. Delivered a lecture on Application of Artificial Intelligence in Brackishwater Aquaculture in smart aquaculture- IoT (Internet of Things) approach towards efficient farming organised by TNJFU, Ponneri, Thiruvallur district on 23rd June, 2021 - Dr. P. Nila Rekha
16. Delivered an online lecture on "Brackishwater fish cage culture" in one day online webinar on " Pradhan Mantri Matsya Sampada Yojana (PMMSY) Schemes for Marine Fisheries Development" jointly organized by National fisheries development board (NFDB), Hyderabad and College of Fisheries, Ratnagiri on 30th June, 2021 - Mr. Pankaj Patil
17. Delivered an Invited talk on 'Disease management of brackishwater aquaculture with special reference to shrimp diseases' online mode at Indo-Bangladesh International Webinar on 'Aquaculture and Fisheries' organized by The Neotia University as a part of National Farmers' day celebration on 10th July, 2021 - Dr. Sanjoy Das
18. Delivered an Invited talk Brainstorming session organized by the Agricultural Engineering Department 17th July, 2021 - Dr. P. Nila Rekha
19. Delivered an invited lecture on Reproduction & culture of brackishwater finfishes organized by Dept. of Marine Science, Bharathidasan University on 9-14th August, 2021 - Dr. M. Kailasam
20. Delivered an Invited lecture on "Improving Coastal Livelihoods through Sustainable Aquaculture Technologies" for Stakeholders on 25th August, 2021 organised by National Institute of Disaster Management, Delhi (Ministry of Home Affairs), and Sathyabama University of Science and Technology - Dr. D. Deboral Vimala
21. Delivered a talk on "Diseases in shrimp aquaculture and BMPs" with shrimp farmers at Thumlapalli, Bapatla in connection with implementation NASF project activities and conduction of farmer field school on smart farming as part of the project on 21st September, 2021- Dr. R. Ananda Raja
22. Delivered a lecture in National Conference "Ponshrimp 2021" conducted by Dr. MGR FC&RI, Ponneri on the topic "Aquaculture systems and Biosecurity Strategies in Shrimp Farming" on 3rd September, 2021 - Dr. Shyne Anand
23. Delivered a lecture on 'Use of veterinary medical products in food animal production' on 23rd September, 2021 organized by Export Inspection Council, Ministry of Commerce and Trade, Govt. of India - Dr. P.K. Patil
24. Delivered a virtual lecture on "Recent technologies by ICAR-CIBA" and "Candidate species for brackishwater aquaculture" to Staff of Department of Fisheries, Gujarat during 45 days "Technical Departmental Training Programme" organised by Centre of Excellence in Aquaculture, Kamdhenu University, Ukai, Gujarat on 29th September, 2021 -Mr. Pankaj Patil
25. Delivered a lecture on "Biofloc Technology: Principles & Prospects in Shrimp Aquaculture" in Webinar on "Biofloc Technology" organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University ICAR - Krishi Vigyan Kendra, Sikkal, Nagapattinam on 30th September, 2021 - Dr. Akshaya Panigrahi
26. Lecture on "Crab farming and disease management" in the virtual training programme held on 29th October, 2021 organized by SIFT, Kakinada - Dr. M. Poornima
27. Handled a session on 'Fish health & disease Management in Brackish water fishes' under capacity building programme organized by Kerala state fisheries on 22nd October, 2021 - Dr. P. Ezhil Praveena
28. Delivered an invited lecture on Importance of private hatcheries for quality seed production in BW Aqua Industry organized by ICAR-IIHR/ Task Force Committee/ Agro-Climatic zone X on 2nd November, 2021 - Dr. M. Kailasam
29. Delivered a lecture on "Promotion of inland saline aquaculture" in the "Azadi ka Amrit Mahotsav" webinar organised by Department

of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt of India, on 5th November, 2021- Mr. Jose Antony.

30. Delivered a lecture on "Warranted Research breakthroughs in Shrimp farming" in the National Webinar on Transformation of Shrimp farming in India: Sustainability & Feasibility" organized by Department of Aquaculture, Dr. MGR Fisheries College and Research Institute, Thalainayeru, Nagapattinam, Tamil Nadu, on 27th November, 2021 - Dr. Akshaya Panigrahi
31. Presented a lecture on "Recent advances in shrimp farming sector" in the farmers meet on "Soil and water characteristics of brackishwater farms in coastal Karnataka and BMPs for sustainable aquaculture under NICRA project at Kundapura, Karnataka on 4th December, 2021 - Mr. Biju Francis
32. Delivered an invited lecture on "Recirculation Aquaculture Systems" in the UGC- HRD Refresher course organized for the University teachers by the Department of Zoology, University of Madras through online mode on 8th December, 2021 - Dr. R. Jayakumar
33. Delivered a talk on "Scientific aquaculture practices to augment the income from small farming" on 29th December, 2021 at West Bengal University of Animal & Fishery Sciences, Kolkata - Dr. T.K. Ghoshal
34. Delivered an invited lecture entitled "Sustainable aqua feed formulations" in the Virtual Lecture Workshop on Sustainable Aquaculture Technologies (SAT-2021) organized by Department of Marine Science, School of Marine Sciences Bharathidasan University Tiruchirappalli-620 024, Tamil Nadu on 09-14th August, 2021 - Dr. K. Ambasankar
35. Delivered an invited lecture entitled "Fish Nutrition and Feed Technology: R& D to Commercialization" in the Workshop on "Cutting Edge Technologies in Fisheries and Aquaculture for food and Nutritional Security" organized by ICAR-NBFGR at Kochi on 20th December, 2021 - Dr. K. Ambasankar
36. Delivered two invited lectures entitled "Nutrient requirement of Fish and Shellfish" and "Feed processing Technologies" in the on campus training program conducted by LINAC- NCDC Fisheries Incubation centre at Gurugram, Harayana on 29th November, 2021 - Dr. K. Ambasankar

TV Talk

1. "Velaan Kalam" Live programme in Door Darshan Kendra Pothigai Channel, Chennai on the topic "Seabass Nursery Rearing" telecasted on 20th December, 2021 - Dr. D. Deboral Vimala

Radio Talk

1. Delivered a radio talk on "Brackishwater finfish and shrimp farming" and broadcasted in All India Radio Kolkata channel on 21st January, 2021 and in online All India Radio Akashvani Maitree Kolkata channel on 24th January, 2021- Dr. T.K. Ghoshal
2. Delivered a radio talk on "Vannamei farming in brackishwater area" and broadcasted in All India Radio Kolkata channel on 14th February, 2021 - Dr. T.K. Ghoshal
3. Delivered a radio talk on "Damages to coastal shrimp farming of West Bengal due to Yaas cyclone and its restoration guidelines " and broadcasted in Krishi Kothar Asar Programme of All India Radio Kolkata channel on 17th June, 2021 - Dr. T.K. Ghoshal

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 1st 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 and Kovalam about 35 km south of the city. It has two Regional Research Centres, one at Kakdwip, West Bengal on the east coast and the other at Navasari, Gujarat, on the west coast.

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

BEST ANNUAL REPORT AWARD 2020
(Large Institute)

ICAR-Central Institute of Brakishwater Aquaculture, Chennai

CITATION

The Best Annual Report Award-2020 in the category of Large Institute has been conferred on ICAR-Central Institute of Brakishwater Aquaculture, Chennai. The Annual Report of ICAR-CIBA-2019 presents salient accomplishments of the institute during the year 2019 (April to December 2019). The research work of the institute has been highlighted precisely with beautiful illustrations, colourful graphs and photographs that give a clear picture of the successful progress of the work carried out during the reporting period. The tabulated and pictorial representations make it easy for the reader to understand and analyze the research work. Action photographs of demonstrations at farmers' fields, trainings and other events have been given in the report. Enlistment of Ph.D Students, Workshops, meetings and Seminars attended and organized, Awards and Recognitions received, Linkages and Collaborations have been appropriately done. Also details of consultancies, technology development and transfer and patent granted have been mentioned. Separate mention of the official language implementation programme, research and administrative meetings, services and assignment have been done apart from presentation of programmes like ARYA, Swachh Bharat Mission, Jal Shakti Abhiyan, Mera Gaon Mera Gaurav. A detailed list of distinguished visitors, staff members, infrastructure development during the year can be seen in the report. An account of library holdings has been given with total number of books, Journals, Abstracts, Bulletins and Miscellaneous. The Annual Report also includes list of publications and participation in conferences and meetings. The Annual Report 2019 of ICAR-CIBA, Chennai is a single window that gives the reader an overall insight into the research and development work undergoing in the Institute.

Indian Council of Agricultural Research

ICAR ANNUAL REPORT AWARD
2020

(Large Institute)

is presented to

ICAR–Central Institute of Brakishwater Aquaculture, Chennai

16 July, 2021
New Delhi

(T. Mohapatra)
Secretary (DARE)
Director General (ICAR)

(Narendra Singh Tomar)
Union Minister of Agriculture & Farmers Welfare
Govt. of India

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 3210 255072, Fax : +91 3210 257030
E-mail : krckakdwip@gmail.com

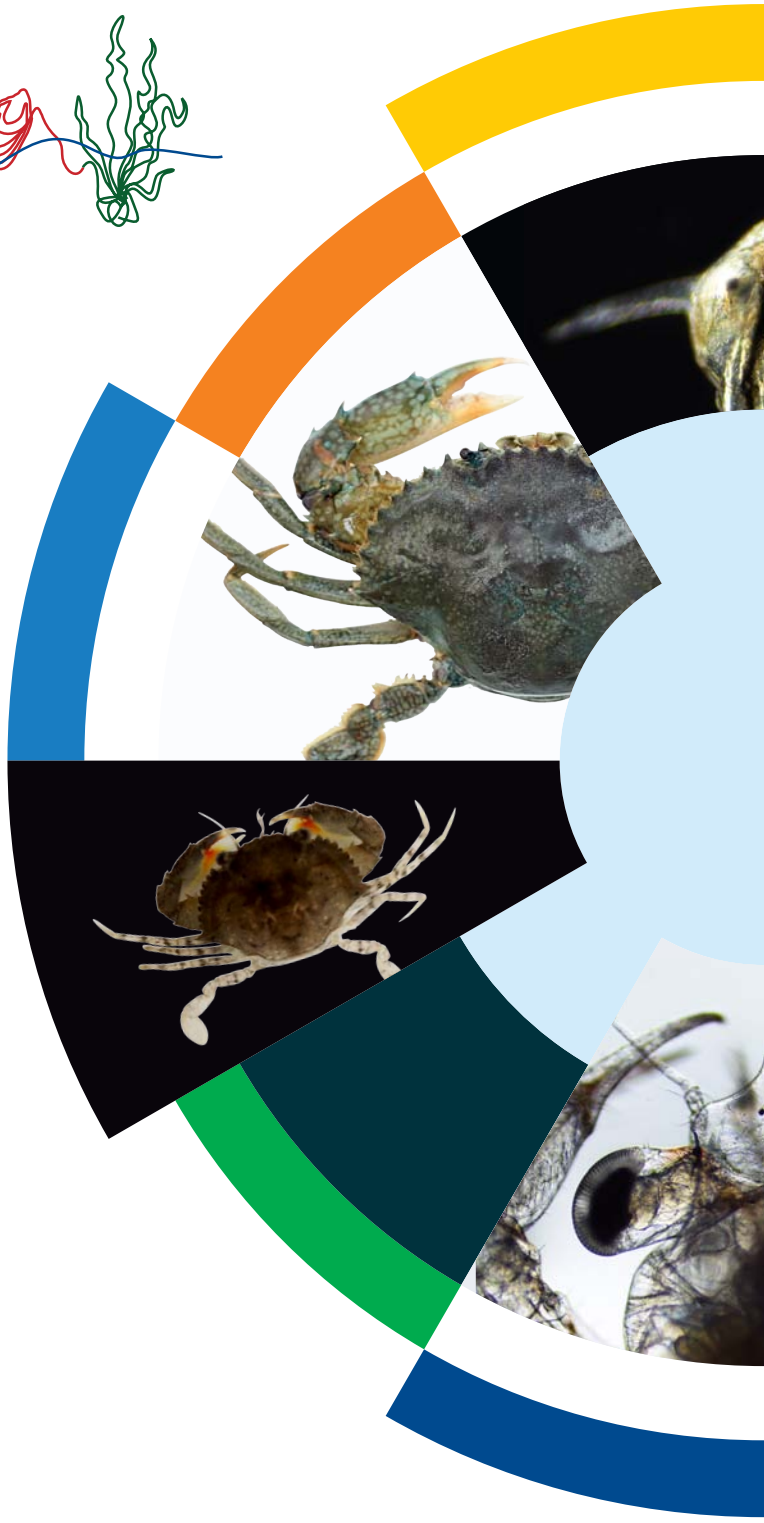
Navsari Gujarat Research Centre of CIBA
1st Floor, Animal Husbandry Polytechnic Building
Navsari Agricultural University Campus
Eru Char Rasta, Dandi Road,
Navsari - 396 450, Gujarat.
Telephone: +91 2637-283509
E-mail: oic_ngrc.ciba@icar.gov.in

भाकृअनुप
ICAR

CIBA

www.ciba.res.in

"Brackishwater aquaculture for food, employment and prosperity"



ISSN 0976-5336

ICAR-Central Institute of Brackishwater Aquaculture
(Indian Council of Agricultural Research)
No. 75, Santhome High Road, MRC Nagar, Raja Annamalai 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

/ icarciba