ANNUAL REPORT 2023

भा कृ अनु प – केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

Front cover: The initiative in captive breeding of Goldlined seabream (*Rhabdosargus sarba*) highlights its potential for brackishwater aquaculture, demonstrating significant adaptability. Initial efforts to improve broodstock condition and induced spawning marks crucial progress towards large-scale seed production. This endeavour is pivotal in ensuring sustainable aquaculture practices, emphasizing the species' viability and the initiative's forward momentum.

Back cover: Hatchery technology for mud crabs, specifically *Scylla serrata* and *Scylla olivacea*, has advanced through improved seed production techniques, resolving key larval biology issues. These developments enhance sustainable aquaculture and ensure a stable supply of these valuable species.

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(भारतीय कृषि अनुसंधान परिषद)

75, संथोम हाई रोड, एम आर सी नगर, आर ए पुरम
चेन्नई 600028, तमिल नाडु, भारत

ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

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75, Santhome High Road, MRC Nagar, RA Puram
Chennai - 600028, Tamil Nadu, India

PUBLISHED BY

Dr Kuldeep K. Lal
Director

EDITORIAL AND DESIGNING COMMITTEE

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DIRECTOR'S WELCOME

Indian fish product export reached an all time high during 2022-23 earning revenue of $8.09 billion from which shrimp constituted a major chunk of $5.48 billion and second highest country globally. However, while it puts India's brackishwater aquaculture research, on a promising trajectory but at the same time put forward the challenge of sustainability and profitability of the shrimp aquaculture. The future course of this sector is likely to be guided by the reduction in cost of production to improve revenue and is likely to come from innovative solutions based on science. Such solutions which are cost, energy, resource efficient and at the same time, biosecure and pose minimal environmental risks. The present endeavour of ICAR- Central Institute of Brackishwater Aquaculture (ICAR-CIBA), are to develop system and species diversification, productivity enhancement, cost reduction while improving productivity and derisking aquaculture. The objective is to keep pace with technological innovations, use for improving aquaculture practices and resilient to challenges and thus, enhancing affordable and healthy seafood production which helps improving nutritional security and health of both consumers and producers.

ICAR-CIBA, concentrates its efforts on several key areas which involves species improvement, sustainable aquaculture practices, disease management, aquaculture technology, socio-economic impact analysis etc. The research focuses on developing disease-resistant, fast-growing breeds of commercially important finfish and shrimp species. This includes selective breeding programs and exploring genetic modification techniques for improved production traits. Developing eco-friendly farming practices is crucial. Research includes optimizing pond management techniques, minimizing water pollution from aquaculture activities, and exploring alternative feeds that reduce reliance on fishmeal. The diseases can devastate shrimp and fish farms; hence, research is directed towards developing diagnostic tools for early disease detection, effective vaccines, and treatment methods. Research innovation plays a vital role, therefore the institute research explores areas like developing recirculating aquaculture systems (RAS) for water reuse, using biofloc technology, and integrating automation for improved farm management for smart aquaculture. Brackishwater aquaculture is a source of income for many coastal communities. ICAR-CIBA, research examines the socio-economic impact of this industry, focusing on empowering small and marginal farmers, improving market access, and creating sustainable livelihoods. Despite the advancements, Indian brackishwater aquaculture faces challenges on climate change, the rising sea levels and salinity fluctuations which can disrupt traditional farming practices. ICAR-CIBA, therefore focusses on research areas which is needed to develop climate-resilient aquaculture models.

The key achievements, during 2023, ICAR-CIBA has successfully developed mud crab seed production hatchery technology. The mud crab species of the genus *Scylla* (*S. serrata* and *S. olivacea*) have been improved using the modified seed production technology by resolving the basic issues in larval biology. The pioneering efforts in captive breeding of the gold-lined spinefoot rabbitfish, *Siganus lineatus,* marked a significant milestone in Institute's brackishwater aquaculture landscape. The consistent efforts in Asian seabass, *Lates calcarifer* breeding and seed production contribute significantly to the aquaculture industry of the country. In the current year, 1.6 million fertilized eggs were provided to private hatcheries. Additionally, 1 lakh seeds

were distributed to farmers. Induced breeding protocols was standardized for *Acanthopagrus datnia* in RAS facility at KRC of ICAR-CIBA, Kakdwip. Shrimp crop insurance products were developed with the technical support of ICAR-CIBA by the Oriental Insurance Company Ltd. and Agricultural Insurance Company Ltd. The product was launched and received a positive response from the shrimp farmers of Tamil Nadu and Andhra Pradesh with the availing of 650 policies from both the companies. ICAR-CIBA, during the year also provided consultancy services, initiated collaborative research programmes and signed several MoU's for transfer of technology generating about 72.92 lakhs as revenue. ICAR-CIBA takes immense pride in announcing that it has achieved significant milestone by getting National Accreditation Board for Testing and Calibration Laboratories (NABL) accreditation, solidifying the position as one among the select ICAR institutes recognized for its state-of-the-art facility and ability in the field of pathogen testing.

Kakdwip Research Centre (KRC) of ICAR-CIBA participated in the Krishi Mela at Sasya Shyamala Krishi Vigyan Kendra, West Bengal and bagged the best exhibition stall award. During the year, ICAR-CIBA received 2nd prize from Town official language implementation committee (TOLIC) for the best performance in the progressive use of Official Language. Navsari Gujarat Research Centre (NGRC) of ICAR-CIBA conducted two editions of Shrimp Farmers Conclave respectively in Parangipettai, Tamil Nadu and Navsari, Gujarat, wherein more than 800 shrimp farmers attended and discussions were held on emerging issues in shrimp farming and their possible solutions. The Navsari centre also demonstrated pilot scale cage culture for Asian seabass in brackishwater creeks in Gujarat.

I express my gratitude to Dr Himanshu Pathak, Secretary (DARE) and Director General, ICAR for his overwhelming support and able guidance. My special thanks to Dr J.K. Jena, Deputy Director General (Fisheries Science), ICAR for his continuous support, guidance and direct involvement in all our research and administrative activities. I also thank our Assistant Director General (Marine Fisheries), Dr S. Ghosh for his timely help in many of the aspects. I also express my sincere gratitude to all the scientists and members of SMD in fisheries Science, particularly to mention about Dr Prem Kumar and Dr Yasmin Basade for their great support in many of our activities.

Our sincere thanks to all the farmers, stake holders, state government officials and officials from other research organizations who all have helped and collaborated along with us to achieve the success. I also thank to all the Heads of the Divisions, Scientists-in-Charge, Head of Regional Research Centres, Officer in charge and all the scientists, technical officers and administrative staff of the institute who all have put their consistent effort towards the development of this institute.

I thank and appreciate all the members of the Institute annual report 2023 committee for their efforts as editorial board members to bring this document.

Dr Kuldeep K. Lal
Director, ICAR-CIBA, Chennai

कार्यकारी सारांश

आंध्र प्रदेश में नेल्लोर जिले के उटुकुरु गांव में फार्म प्रदर्शन और हार्वेस्ट मेला

किसानों के तालाबों में उनकी उत्पादन क्षमता का आकलन करने के लिए ब्रूडस्टॉक-नस्ल वाले इंडिकस झींगा के बीज किसानों को दिए गए थे। यह प्रदर्शन आंध्र प्रदेश के नेल्लोर जिले के उटुकुरु गांव में 1.7 एकड़ के तालाब में किया गया, जिसका भंडारण घनत्व 23 नग/एम2 था। उत्पन्न झींगा का औसत वजन 21.2 ग्राम था, जीवित रहने की दर 72% थी और 98 दिनों में 2430 किलोग्राम की उपज थी। इसके अलावा, केरल के पय्यानूर में एक ऑन-फार्म प्रदर्शन और हार्वेस्ट मेले में लागत प्रभावी फ़ीड के साथ 2 एकड़ फार्म में 3330 किलोग्राम हार्वेस्ट के साथ 93 दिनों में शरीर का औसत वजन 18.50 ग्राम दर्ज किया गया।

एसएसआर मार्करों का उपयोग करके *पी. इंडिकस* के विभिन्न स्टॉक का आनुवंशिक लक्षण वर्णन

भारत के विभिन्न तटों से *पी. इंडिकस* के विभिन्न स्टॉक के सरल अनुक्रम दोहराव (एसएसआर) के लक्षण वर्णन का आकलन किया गया है। उच्च बहुरूपता दर और पूरे जीनोम में व्यापक वितरण ने एसएसआर को प्रजनन कार्यक्रमों में उपयोग किए जाने वाले सबसे प्रमुख आनुवंशिक मार्करों में से एक बना दिया है। एकत्र किए गए *पी. इंडिकस* के पूरे जीनोम में 44 स्कैफोल्ड्स हैं। बहुरूपी एसएसआर के लिए स्कैफोल्ड्स 1 से 12 की जांच की गई। प्रत्येक स्कैफोल्ड्स के लिए, चार ट्राई, टेट्रा, पेंटा और हेक्सा रिपीट एसएसआर लोसाई का परीक्षण किया गया

भारतीय सफेद झींगा, *पी. इंडिकस* के बीज उत्पादन और प्रदर्शन

भारतीय सफेद झींगा, पेनियस इंडिकस, को भारत में पालतू बनाने और आनुवंशिक सुधार कार्यक्रमों के लिए राष्ट्रीय प्राथमिकता वाली प्रजाति के रूप में पहचाना गया है। प्रजनन प्रदर्शन का मूल्यांकन करने और संस्थापक आबादी के लिए एक डेटाबेस तैयार करने के लिए, जंगली *पी. इंडिकस* ब्रूडर्स को भारत के विभिन्न स्थानों जैसे पुरी (ओडिशा), काकीनाडा (आंध्र प्रदेश), चेन्नई (तमिलनाडु), कन्याकुमारी (तमिलनाडु), और किलोन (कर्नाटक) में एकत्र किया गया था। वर्ष 2023 में तीन मिलियन बीजों का उत्पादन किया गया और पूरे भारतीय तट के विभिन्न स्थानों के किसानों को वितरित किया गया।

गोनाड विकास और *पी. इंडिकस* के स्पॉनिंग में हार्मोन का प्रभाव

यद्यपि आईस्टॉक एब्लेशन वाणिज्यिक झींगा हैचरी में उपयोग की जाने वाली सबसे आम प्रेरित परिपक्वता तकनीक है, आई डंठल एब्लेशन से तनाव, कम जीवित रहने और कैप्टिव-पालन करने वाले झींगा में मोल्टिंग में वृद्धि होती है। इस संदर्भ में, अनएब्लेटेड *पी. इंडिकस* में सेक्स स्टेरॉयड 17-बीटा-एस्ट्राडियोल इंजेक्शन की भूमिका से 23.5% सफल स्पॉनिंग का पता चला, जबकि आई डंठल एब्लेटेड समूह में 35% स्पॉनिंग दर्ज की गई।

पी. इंडिकस का कृत्रिम गर्भाधान

कृत्रिम गर्भाधान एक उपकरण है जिसका उपयोग झींगा के नियंत्रित प्रजनन के लिए किया जाता है और आनुवंशिक हेरफेर के लिए यह एक पूर्व शर्त है। सफल जोड़ीवार प्रजनन और बेहतर प्रजनन क्षमता के लिए कृत्रिम गर्भाधान तकनीकों को अनुकूलित करने के लिए,

इंटरमोल्ट *पी. इंडिकस* झींगा का उपयोग करके एक प्रयोग किया गया था। अध्ययन से पता चला कि 9वें दिन तक केवल 20% मादा ब्रूडर्स ने स्पर्मेटोफोर को सफलतापूर्वक स्वीकार किया, जबकि 40% नर ब्रूडर्स ने सामान्य शुक्राणु मोर्फोमेट्री के साथ स्पर्मेटोफोर के पुनर्जनन को दर्ज किया।

बायोफ्लॉक कल्चर प्रौद्योगिकी में भारतीय सफेद झींगा *पी. इंडिकस* का नर्सरी पालन

बायोफ्लॉक (बीएफटी) आधारित नर्सरी पालन प्रणाली को 30 दिनों के लिए 3000 पीएल/एम3 पर *पी. इंडिकस* नर्सरी में बायोफ्लॉक की दक्षता का मूल्यांकन करने के लिए डिज़ाइन किया गया था। बायोफ्लॉक नर्सरी में पाले गए भारतीय सफेद झींगा का औसत शारीरिक वजन 1.25 ग्राम था, जबकि नियंत्रण में यह 1.21 ग्राम था।

बायोफ्लॉक सिस्टम में बायोएग्मेंटेशन प्रक्रिया का प्रभाव

बायोफ्लॉक सिस्टम में *पी. वन्नामेई* के विकास प्रदर्शन और माइक्रोबियल गतिशीलता का निरीक्षण करने के लिए एक सत्तर-दिवसीय परीक्षण से पता चला कि नियंत्रण (09.02±0.52) की तुलना में सीआईबीए-फ्लोक के साथ जैव संवर्धित किया गया *पी. वन्नामेई* में शरीर का उच्चतम औसत वजन 15.22±0.24 ग्राम था। नियंत्रण (0.83±0.06 पीपीएम) की तुलना में कम अमोनिया स्तर (0.01±0.13 पीपीएम) वाले बायोफ्लोक में जल गुणवत्ता मेट्रिक्स में उल्लेखनीय सुधार हुआ। नियंत्रण जीन और पाचन एंजाइम से संबंधित जीन की सापेक्ष अभिव्यक्ति ने नियंत्रण की तुलना में एक उन्नयन दिखाया

पी. इंडिकस का कोपफ्लोक-आधारित नर्सरी पालन

मोनोस्पेसिफिक और मिश्रित कोपिपॉड स्टॉक का उपयोग करके *पी. इंडिकस* (10,000 पीएल/एम3) की उच्च-घनत्व नर्सरी पालन ने *पी. इंडिकस* नर्सरी को अनुकूलित करने के लिए विशेष रूप से डी. रिगिडा, ई. पाइग्मिया और पी. एनांडेली सहित मिश्रित कोपिपॉड में बढ़ी हुई वृद्धि और उत्तरजीविता दर्ज की गई।

मडक्रैब बीज उत्पादन

हैचरी तकनीक लार्वा जीव विज्ञान में बुनियादी मुद्दों को हल करके संशोधित बीज उत्पादन तकनीक का उपयोग करके जीनस स्काइला (एस. सेराटा और एस. ओलिवेसिया) मिट्टी केकड़े प्रजातियों में सुधार किया गया । इस अवधि के दौरान पांच लार्वा चक्र के दौरान एस. ओलिवेसिया के लिए 25.3% जीवित दर (52000 मेगालोपा) और एस. सेरेट के 32% जीवित दर के साथ , 60,000 से 1.6 लाख मेगालोपा का उत्पादन किया गया।

समुद्री शैवाल-सहायता प्राप्त नर्सरी-पालन तकनीकें मिट्टी केकड़े में उत्तरजीविता दर को बढ़ाती हैं

मेगालोपा से इंस्टार तक नर्सरी-पालन चरण इसके नरभक्षी व्यवहार के कारण चुनौतीपूर्ण है। नर्सरी पालन के दौरान समुद्री शैवाल के एकीकरण से उत्तरजीविता में 47-55% सुधार दर्ज किया गया। यह परिणाम मिट्टी केकड़ों की नर्सरी पालन में जीवित दर सुधार के लिए मूल्यवान डेटा प्रदान करता है।

गुणवत्तापूर्ण बीज उत्पादन और पालतूकरण के लिए न्यूक्लियस प्रजनन केंद्र की योजना बनाना

पायलट स्केल एनबीसी (परमाणु प्रजनन केंद्र) को के ई एस, कोवलम में संपूर्ण आनुवंशिक सुधार कार्यक्रम (जीआईपी) इकाई के लिए डिजाइन किया गया है जिसमें संगरोध इकाइयां, नर्सरी प्रणाली, जलाशय के साथ प्री-ग्रो-आउट और ग्रो-आउट सिस्टम और उपचार प्रणालियाँ शामिल हैं।

चेंगलपट् जिले के लिए समुद्री शैवाल कैलेंडर

तमिलनाडु के चेंगलपट् में नवंबर 2022 से नवंबर 2023 के दौरान समुद्री शैवाल क्षेत्र सर्वेक्षण से एग्रोफाइटन टेनुस्टिपिटम, ग्रेसिलेरिया सैलिकोर्निया, उलवा लैक्टुका, उलवा प्रोलिफेरा और उलवा इंटेस्टाइनलिस जैसी प्रजातियों की व्यापकता और मौसमी विविधताओं का पता चला। विभिन्न मौसमों के दौरान, समुद्री शैवाल अपनी वृद्धि दर, प्रजनन चक्र और समग्र स्वास्थ्य में भिन्नता का अनुभव करते हैं।

खारे पानी के समुद्री शैवाल के साथ झींगा पालन का एकीकरण

क्षैतिज और ऊर्ध्वाधर रस्सियों के साथ जी सैलिकोर्निया फ्लोटिंग बेड़ा में *पी. वन्नामेई* (40 नग / एम2) का एकीकरण, शुरुआत में 1.5 किलोग्राम और 0.5 किलोग्राम बायोमास रखते हुए 87% जीवित रहने की दर के साथ 260 किलोग्राम झींगा उत्पादन दर्ज किया गया, जबकि नियंत्रण में 41 दिनों में 77% जीवित दर के साथ 220 किलोग्राम उपज प्राप्त हुई। एकीकृत तालाब ने 170 किलोग्राम समुद्री शैवाल बायोमास का भी उत्पादन किया, जो 3.4 टन प्रति हेक्टेयर की उत्पादकता का संकेत देता है। इसके अलावा, सी. रेसमोसा के साथ *पी. वन्नामेई* के एकीकरण के परिणामस्वरूप समुद्री शैवाल-एकीकृत और नियंत्रण तालाबों के लिए क्रमशः 4.5 और 3.4 टन/हेक्टेयर की झींगा उत्पादकता हुई। समुद्री शैवाल-एकीकृत तालाब में काटा गया समुद्री शैवाल बायोमास 6.8 किलोग्राम तक पहुंच गया , जो हरे समुद्री शैवाल की झींगा खपत को दर्शाता है। अध्ययन जलीय कृषि प्रणालियों में समुद्री शैवाल-झींगा एकीकरण के संभावित लाभों पर प्रकाश डालते हैं।

राजस्थान में नमक प्रभावित बंजर भूमि का मानचित्रण

नमक प्रभावित भूमि जो कृषि के लिए उपयुक्त नहीं है, उसका मानचित्रण वैकल्पिक उपयोग का मार्ग प्रशस्त करेगा। भू-स्थानिक प्लेटफॉर्म में उपग्रह डेटा का उपयोग करके अनुपयोगी नमक प्रभावित भूमि का मानचित्रण करते हुए, 2022 के सेंटिनल 2 बी डेटा को राजस्थान के चयनित सात जिलों अर्थात् श्रीगंगानगर, हनुमानगढ़, पाली, जालौर, बाड़मेर जोधपुर और चेरू में चित्रित किया गया, जिसमें 45 तहसीलें शामिल हैं। स्थानिक स्थान और अनुपयोगी नमक-प्रभावित भूमि का प्रसार नियामक दिशानिर्देशों के साथ झींगा जलीय कृषि विकसित करने के अवसरों का संकेत देता है।

नमक प्रभावित भूमि में मिट्टी की विशेषताओं का आकलन

राजस्थान के अंतर्देशीय लवणीय क्षेत्रों में जलीय कृषि के लिए मिट्टी की उपयुक्तता का आकलन करने के लिए क्षेत्र सर्वेक्षण किया गया था। मृदा विश्लेषण से पता चला कि मिट्टी गैर-लवणीय, विद्त चालकता <4 डीएस/एम, पीएच मान 7.53 से 9.9 के साथ क्षारीय सीमा है। अधिकांश मिट्टी में कार्बनिक कार्बन, उपलब्ध नाइट्रोजन और उपलब्ध फास्फोरस की कमी थी। चूंकि इन क्षेत्रों की मिट्टी में रेत की बनावट वाली श्रेणियां प्रमुख हैं, मौजूदा खेतों में पॉलिथीन से बने तालाब थे और नए क्षेत्रों में खारे पानी की जलीय कृषि (बीडब्ल्यूए) के लिए तालाबों को पंक्तिबद्ध करने का सुझाव दिया गया है।

गूगल अर्थ इंजन और मशीन लर्निंग तकनीकों का उपयोग करके तटीय भारत में नमक प्रभावित भूमि का स्वचालित चित्रण और उनकी प्रगति

नमक प्रभावित भूमि (एसएएल) का आकलन अभी भी दुनिया भर में, विशेषकर विकासशील देशों में एक बड़ा चुनौतीपूर्ण कार्य है। विभिन्न वर्णक्रमीय बैंडों की दूर से संवेदित डिजिटल उपग्रह छवियों की प्रगति ने मिट्टी की लवणता का आकलन करना संभव बना दिया है। बीस वर्णक्रमीय सूचकांकों का उपयोग किया गया है जिसमें चार वनस्पति सूचकांक, बारह मिट्टी की लवणता सूचकांक, चार स्थलाकृतिक विशेषताएं और उनके वर्णक्रमीय बैंड शामिल हैं। SAL का पता लगाने के लिए रैंडम फ़ॉरेस्ट मॉडल का उपयोग किया गया था। क्षेत्र में एकत्र किए गए नमूनों की विद्त चालकता मूल्यों में से, 70% मिट्टी के नमूनों का उपयोग मॉडल प्रशिक्षण के लिए किया गया था, और शेष 30% का उपयोग सत्यापन के लिए किया गया था। वर्तमान अध्ययन ने एसएएल का आकलन करने के लिए रिमोट सेंसिंग तकनीकों की ताकत का प्रदर्शन किया, जो पुनर्ग्रहण या अन्य उत्पादक उपयोग के लिए राज्य या राष्ट्रीय स्तर पर अनुत्पादक भूमि की मात्रा निर्धारित करने में मदद करेगा।

झींगा पालन में नैनो खनिजों की दक्षता का मूल्यांकन

कम खारे और अंतर्देशीय खारे पानी में खनिज की कमी होती है जो झींगा पालन की स्थिरता को प्रभावित करती है। इस समस्या को नैनोस्केल आकार में खनिजों को लागू करके प्रभावी ढंग से हल किया जा सकता है, जो झींगा द्वारा उनके अवशोषण को बढ़ाता है। तैयार नैनो खनिजों के विश्लेषण से पता चला कि CaCl2 में 35% कैल्शियम होता है और MCP में 27.7% कैल्शियम और 13.6% फॉस्फोरस होता है। नैनो कैल्शियम प्रयोग में झींगा का वजन 18.7% बढ़ गया और नैनो एमसीपी प्रयोग में झींगा का वजन 21.7% बढ़ गया

भारत में पहली बार स्पाइनफुट रैबिटफिश (*सिगानस लाइनिएटस*) का कैप्टिव प्रजनन

गोल्ड-लाइनड स्पाइनफुट रैबिटफिश, सिगानस लाइनिएटस के कैप्टिव प्रजनन में अग्रणी प्रयास, भारत के खारे पानी के जलीय कृषि परिदृश्य में महत्वपूर्ण है। ब्रूडस्टॉक मछलियाँ सावधानीपूर्वक कैप्टिव परिपक्वता से गुज़रीं, और 14 घंटों के भीतर हार्मोनल प्रेरण के माध्यम से सफलतापूर्वक पैदा हुईं। चिपकने वाले निषेचित अंडे 28-30 पीपीटी लवणता और 27-29 डिग्री सेल्सियस पानी के तापमान की इष्टतम स्थितियों के तहत 12-14 घंटों के भीतर तैयार किए गए। रोटिफ़र्स और माइक्रोएल्गे के साथ शुरू किए गए लार्वा पालन प्रोटोकॉल में अंडे सेने के बाद 58-62 घंटों के भीतर महत्वपूर्ण विकासात्मक अवस्था देखे गए। संख्या में लगभग 10,000 उन्नत लार्वा उत्पन्न हुए।

मैंग्रोव रेड स्नैपर और ग्रे मुलेट का प्रेरित प्रजनन, लार्वा पालन और बीज उत्पादन

टैंक-आधारित प्रणालियों के भीतर मैंग्रोव रेड स्नैपर ब्रूडस्टॉक की सावधानीपूर्वक निगरानी और प्रबंधन के परिणामस्वरूप सफल गोनाडल परिपक्वता हुई, जिसमें उल्लेखनीय 70% नर और 30% मादा आबादी थी। 15वें दिन तक 10,000 लार्वा की जीवित आबादी हासिल करने के लिए लार्वा पालन तकनीक लागू की गई और 45वें दिन तक यह एक इंच आकार तक पहुंच गई। सीबा ने हैचरी के आगे की नर्सरी पालन के लिए एक स्वयं सहायता समूह को बीज की आपूर्ति की, मछली 90 दिनों के बाद 6-8 इंच के आकार तक पहुंच गई। ग्रे मुलेट के लिए कैप्टिव प्रजनन कार्यक्रम ने आरसीसी टैंकों और मिट्टी के तालाबों दोनों में ब्रूडस्टॉक बनाए रखा। प्रजनन परीक्षणों के तीन सेट आयोजित किए गए, जिसके परिणामस्वरूप एक उदाहरण में सफल प्रजनन हुआ।

सफल प्रजनन प्रयास के बाद लार्वा को अंडे से निकलने के 15 दिन बाद तक सफलतापूर्वक पाला गया।

अंडे की उत्प्लावकता और ग्रे मुलेट, मुगिल सेफलस के लार्वा अस्तित्व पर लवणता का प्रभाव

अंडे की उत्प्लावकता और ग्रे मुलेट लार्वा की जीवितीता दर लवणता की महत्वपूर्ण भूमिका को है, जो प्रजनन कार्यक्रम के लिए व्यावहारिक अंतर्दृष्टि प्रदान करता है। 25-35 पीपीटी लवणता पर बनाए रखे गए अंडों ने इष्टतम उत्प्लावकता और अंडे सेने की दर प्रदर्शित की, जिससे भ्रूण की व्यवहार्यता और लार्वा फिटनेस सुनिश्चित हुई। विशेष रूप से, उपयुक्त लवणता स्थितियों के तहत पाले गए लार्वा ने बेहतर विकास और जीवित रहने की दर प्रदर्शित की, जिससे लार्वा-पालन प्रोटोकॉल में पर्यावरणीय कारकों के महत्व पर जोर दिया गया।

गोल्डलाइन्ड सीब्रीम (*रबडोसारगस सरबा*) का कैप्टिव प्रजनन

गोल्डलाइन्ड सीब्रीम, रबडोसार्गस सरबा के कैप्टिव प्रजनन की पहल, खारे पानी के जलीय कृषि के लिए इसकी क्षमता और अनुकूलनशीलता को रेखांकित करती है। ब्रूडस्टॉक की स्थिति को बढ़ाने और अंडे देने को प्रेरित करने के शुरुआती उपाय बड़े पैमाने पर बीज उत्पादन की दिशा में प्रगति को दर्शाते हैं। जबकि एक प्रजनन परीक्षण से स्पॉनिंग प्राप्त हुई, कैप्टिव स्थितियों को अनुकूलित करने के लिए आगे के विकास चल रहे हैं। 120-850 ग्राम आकार की लगभग 70 मछलियों को शामिल करके ब्रूडस्टॉक को मजबूत किया गया।

मांग को पूरा करने के लिए एशियाई समुद्री सीबास का बीज उत्पादन

एशियाई समुद्री सीबास, लेटेस कैल्केरिफ़र प्रजनन और बीज उत्पादन में लगातार प्रयास देश के जलीय कृषि उद्योग में महत्वपूर्ण योगदान देते हैं। चालू वर्ष में, प्रजनन परीक्षणों के परिणामस्वरूप 81% की औसत निषेचन दर और 82.6% की हैचिंग दर के साथ 3.24 मिलियन अंडे पैदा हुए। इनमें से 1.6 मिलियन निषेचित अंडे निजी हैचरी को उपलब्ध कराए गए थे। इसके अतिरिक्त, किसानों को 1 लाख बीज वितरित किए गए और कुल 4.1 लाख रुपये का राजस्व प्राप्त हुआ।

मिल्कफिश का कैप्टिव बीज उत्पादन

चेन्नई और काकीनाडा से औसतन 6.6 किलोग्राम वजन वाली 35 मिल्कफिश चानोस चानोस ब्रूडस्टॉक के साथ, द्वितीयक ब्रूडस्टॉक लाइनें स्थापित की गईं। विशेष रूप से, चेन्नई तट से बारह नए स्टॉक प्रजनन पूल को और समृद्ध करते हैं। सफल स्पॉनिंग से 2 लाख निषेचित अंडे और 1.5 लाख लार्वा प्राप्त हुए, जो प्रजनन कार्यक्रम की प्रभावकारिता को प्रदर्शित करते हैं। केरल, तमिलनाडु और पश्चिम बंगाल में किसानों को 17,526 मिल्कफिश फ्राई का वितरण इस प्रयास के व्यावहारिक प्रभाव को रेखांकित करता है, जिससे राजस्व की प्राप्ति होती है ।

सिल्वर मूनी में वृद्धि और परिपक्वता पर विटामिन ई का प्रभाव

मछली के प्रजनन विज्ञान में विटामिन ई की महत्वपूर्ण भूमिका को समझते हुए, सिल्वर मूनी, मोनोडैक्टाइलस अर्जेन्टियस के विकास और परिपक्वता पर इसके प्रभावों पर एक व्यापक 120-दिवसीय अध्ययन किया गया था। अध्ययन विभिन्न आहार विटामिन ई स्तरों (0, 100, 200, और 300 मिलीग्राम/किग्रा आहार) के साथ था, और 200 मिलीग्राम/किग्रा आहार के साथ खिलाई गई मछली ने इष्टतम वजन वृद्धि और परिपक्वता प्रदर्शित की, जिसमें मादाओं ने परिपक्वता दर में वृद्धि देखी। विशेष रूप से, विटामिन ई अनुपूरण ने पहले गोनाड विकास की शुरुआत की, जिससे समय पर प्रजनन में सुविधा हुई। ये निष्कर्ष सिल्वर मूनी में प्रजनन प्रदर्शन और वृद्धि को बढ़ाने में, विशेष रूप से 200 मिलीग्राम/किलोग्राम आहार में विटामिन ई अनुपूरण के महत्व को रेखांकित करते हैं।

पर्लस्पॉट में वृद्धि पर चयनात्मक प्रजनन के लिए आधार जनसंख्या का विकास

पर्लस्पॉट में चयनात्मक प्रजनन के लिए आधार आबादी विकसित करने पर शोध का उद्देश्य इस प्रजाति में धीमी वृद्धि की चुनौती का समाधान करना है। अध्ययन में पर्लस्पॉट के पांच पूर्ण-भाई परिवारों (F0 पीढ़ी) का उपयोग करके परिवार के भीतर चयन का उपयोग किया गया, जिसमें 360 दिनों में शरीर के वजन पर फेनोटाइपिक डेटा दर्ज किया गया। एक अंतर-पारिवारिक क्रॉसिंग प्रयोग के परिणामस्वरूप 11 क्रॉस हुए, जिससे आनुवंशिक विविधता को बढ़ावा मिला। एफ1 परिवारों को व्यक्तिगत रूप से सुसंस्कृत किया गया और उन्हें पर्लस्पॉट मछली का भोजन खिलाया गया, जिसके परिणामस्वरूप 240 दिनों में शरीर के वजन में 8 से 9% का अनुमानित आनुवंशिक लाभ हुआ। इस शोध का व्यावसायिक प्रभाव स्पष्ट है, चालू वर्ष के दौरान किसानों को 3551 पर्लस्पॉट बेचे गए, जिससे 32,367/- रुपये का राजस्व प्राप्त हुआ।

अवरुद्ध हुए स्टॉक का उपयोग करके मिल्कफिश मोनोकल्चर

अवरुद्ध हुए स्टॉक को पैदा करने के लिए मिल्कफिश फिंगरलिंग्स को

एक तालाब में सघन रूप से जमा किया गया और कम से कम चारे के साथ एक साल तक पाला गया। इस आबादी के 17 ग्राम औसत शरीर के वजन वाले छोटे कद के बच्चों को फिर एक पंक्तिबद्ध तालाब में कम घनत्व पर रखा गया और सीआईबीए मिल्कफिश ग्रोवआउटप्लस खिलाया गया। 210 दिनों में, इन अविकसित वार्षिक बच्चों ने उल्लेखनीय वृद्धि प्रदर्शित की, जो औसत वजन 589.4 ग्राम और कुल लंबाई 42.08 सेमी तक पहुंच गई, जिसमें फ़ीड रूपांतरण अनुपात 1.2 और उत्पादकता 5.5 टन प्रति हेक्टेयर थी। विशेष रूप से, अविकसित वर्ष के शिशुओं में गैर-अविकसित अंगुलियों की तुलना में दैनिक वजन में उल्लेखनीय वृद्धि और विशिष्ट वृद्धि दर देखी गई।

गुजरात में समुद्री सीबास के लिए हापा आधारित नर्सरी पालन का प्रदर्शन

मयंक एक्वाकल्चर प्राइवेट लिमिटेड, नवसारी, गुजरात की बहुप्रजाति हैचरी इकाई में तालाब आधारित हापा में सीबास (10000 नग, 1.8-4.6 सेमी) की नर्सरी पालन का प्रदर्शन किया गया। प्रदर्शन के परिणामस्वरूप कुल मिलाकर 62% जीवितीता दर पायी गयी। उत्पादित अंगुलिकाएँ स्थानीय मछली पालकों को प्रति फिंगरलिंग 30-50 रु की दर से बेची गईं।

गुजरात की खारे पानी खाड़ियों में एशियाई सीबास केज पालन का प्रदर्शन

खारे पानी की खाड़ियों और तालाबों में सीबास और पर्लस्पॉट केज कल्चर का प्रदर्शन स्थानीय समुदायों के साथ गुजरात के मेंढर, शिल और जाफराबाद गांवों में किया गया। खाड़ियों में, जाफराबाद और शिल में, 4 x 4 x 2 मीटर (32 मीटर^3) आकार के कुल आठ जीआई पाइप निर्मित पिंजरे स्थापित किए गए थे। प्रदर्शन के परिणामस्वरूप 1400 किलोग्राम 250-500 ग्राम समुद्री सीबास उत्पादित हुई। तीन स्थलों पर एसएचजी ने सीबास की बिक्री से कुल 13.72 लाख रु. की आय अर्जित की।

तालाब-आधारित पिंजरों में पर्लस्पॉट के लिए पालन पद्धतियों का अनुकूलन

पर्लस्पॉट फ्राई (4000 नग, 2.5-3.5 सेमी) नर्सरी में 120 दिनों तक हापा (5 नग x 2 सेट) में पाले गए, उन्हें तीन समूहों अर्थात छोटे, मध्यम और बड़े आकार में बांटा गया और बाद में 60 दिनों तक उगाया गया। तीन आकार समूहों में आने वाले मछलियों का प्रतिशत दोनों सेटों में लगभग समान था, जो दर्शाता है कि जनसंख्या संरचना में मध्यम आकार के समूहों (53%) का प्रभुत्व है, उसके बाद बड़े (27%) और छोटे समूहों (19%) का वर्चस्व है। आकार की क्रमबद्ध मछलियों को पालने से एक सेट (10.65-11.65) में सभी तीन आकार समूहों के लिए समान वजन में वृद्धि हुई, जबकि दूसरे सेट में मध्यम और बड़े समूह में समान वजन में वृद्धि (11.12-12.21) हुई और छोटी मछलियों के वजन (पी<0.05) (7.13 ग्राम) में काफी कमी आई। ।

अंतर्देशीय लवणीय भूजल में पाले गए *पेनियस वनामेई* के विकास और अस्तित्व पर अलग-अलग Mg^{2+}/Ca^{2+} अनुपात का प्रभाव

पी. वन्नामेई पीएल (~0.08 ग्राम) को अलग-अलग Mg^{2+}/Ca^{2+} अनुपात जैसे 0.5:1, 0.75:1, 1:1, 1.25:1, 1.5:1, 1.75:1, 2.0:1 (लवणता 10 पीपीटी, कुल कठोरता 2900 पीपीएम उपचार के दौरान स्थिर थी) के अंतर्देशीय खारे भूजल परीक्षण में पाला गया। । अध्ययन के परिणामों से संकेत मिलता है कि 1.25:1 से कम का Mg^{2+}/Ca^{2+} अनुपात *पी. वन्नामेई* के विकास प्रदर्शन को महत्वपूर्ण रूप से प्रभावित करता है और Mg^{2+}/Ca^{2+} अनुपात, 1.25:1 और इससे अधिक के खारे भूजल का उपयोग वाणिज्यिक अंतर्देशीय खारा झींगा पालन के लिए किया जा सकता है।

टीडीएस<500 पीपीएम के मीठे पानी में मिश्रित आयन वातावरण में *पेनेअस वनामेई* की वृद्धि और अस्तित्व

पी. वन्नामेई जूवेनिल्स (~0.29 ग्राम) के उत्पादन में मीठे पानी (टीडीएस<500 पीपीएम) का मूल्यांकन में पोटैशियम (K^+), मैग्नीशियम (Mg^{2+}), और कैल्शियम (Ca^{2+}) आयनों के विभिन्न संयोजनों के साथ 30-दिवसीय प्रयोग किया गया था। 30 दिनों के अंत में, मीठे पानी उपचारों के बीच अंतिम औसत शरीर वजन में कोई खास अंतर नहीं आया। जीवित रहने की दर ने जलीय Mg^{2+} स्तरों के साथ एक रैखिक संबंध का पालन किया, जबकि जलीय K^+ स्तरों के लिए एक घंटी के आकार का पैटर्न देखा गया।

गुजरात में ग्रे मुलेट मुगल सेफेलस के लिए कैप्टिव ब्रूडस्टॉक विकास और प्रजनन परीक्षण

एनजीआरसी फार्म में रखे गए ग्रे मुलेट ब्रूडस्टॉक को प्रजनन परीक्षणों के लिए नियोजित किया गया था। दिसंबर, 2023 के पहले सप्ताह के दौरान बायोप्सी नमूने के दौरान 442-562.2 µm के oocyte व्यास के साथ कुल 19 नर (590-1005 ग्राम) और 44 परिपक्व मादा (870-2010 ग्राम) प्राप्त किए गए। प्रजनन सेटों को वाणिज्यिक जीएनआरएचए फॉर्मूलेशन का उपयोग करके प्रेरित किया गया और तालाबों में मलमल के कपड़े के हापा में रखा गया। एक प्रजनन सेट में आंशिक स्पॉनिंग देखी गई, हालांकि अंडों को निषेचित नहीं किया गया था।

उच्च घनत्व और कम घनत्व वाले झींगा पालन पर प्लैंकटनप्लस और पॉलीप्लस का प्रभाव

दो अलग-अलग स्टॉकिंग घनत्व 60/m^2 और 40/m^2 पर प्लैंकटन बूस्टर (प्लैंकटनप्लस) और पॉलीप्लस फ़ीड के संयुक्त प्रभाव का आकलन करने के लिए केआरसी में झींगा पालन प्रदर्शन आयोजित किया गया था। 112 दिनों के अंत में क्रमशः 60/m^2 और 40/m^2 घनत्व में शरीर का वजन 16.3 ग्राम और 17.54 ग्राम और उत्पादकता 3.73 टन/हेक्टेयर और 3.37 टन/हेक्टेयर हासिल की गई।

क्रैबलेट उत्पादन के लिए मिट्टी के तालाबों में स्काइला ओलिवेसिया का नर्सरी पालन

मिट्टी के तालाब आधारित क्रैबलेट उत्पादन की व्यवहार्यता का अध्ययन करने के लिए केआरसी में स्काइला ओलिवेसिया के लिए एक नर्सरी पालन प्रयोग आयोजित किया गया था। 0.5-1 ग्राम वाले स्काइला ओलिवेसिया शिशु केकड़ों को अलग-अलग स्टॉकिंग घनत्व अर्थात 5,10 और 15/एम2 पर स्टॉक किया गया था। 80 दिनों के पालन के अंत में, केकड़ों ने औसतन 20-30% जीवित रहने के साथ शरीर का वजन और कवच की चौड़ाई क्रमशः 7-17 ग्राम और 34-45 मिमी प्राप्त की।

मिट्टी केकड़े स्काइला ओलिवेसिया की वृद्धि और गलन पर केकड़े बॉक्स के आयामों का प्रभाव

मिट्टी केकड़े, स्काइला ओलिवेसिया की वृद्धि और गलन दो अलग-अलग प्रकार के एचडीपीई केकड़े बक्सों (बड़े और छोटे) में दर्ज की गई थी। 75-85 ग्राम आकार की स्काइला ओलिवेसिया, इंटरमोल्ट चरण में 70-80 मिमी की कैरपेस चौड़ाई के साथ केकड़े के बक्सों में रखी गई थी। पालन-पोषण के 60 दिनों के बाद, बड़े बक्से में काफी अधिक मोल्टिंग और जीवित दर देखी गई। केकड़े बक्से के आयाम का बक्से में पाले गए केकड़ों के मोल्टिंग और वृद्धि पर महत्वपूर्ण प्रभाव पड़ता है।

हिल्सा के ग्रो-आउट पालन प्रोटोकॉल का परिशोधन

हिल्सा फ्राई (9-10 ग्राम) के नर्सरी पालन प्रोटोकॉल को उन्नत नर्सरी प्रबंधन प्रोटोकॉल और प्लैंकटनप्लस एप्लिकेशन के साथ परिष्कृत किया गया था। तैयार ग्रोआउट फ़ीड हिल्साप्लस (सीपी-36.6%) का उपयोग फ़ीड के रूप में किया गया था। छह महीने के ग्रोआउट कल्चर के बाद, मछली का वजन/शरीर की लंबाई 46.60±2.02 ग्राम/16.78±0.24 सेमी हो गई।

स्फिंगोबैक्टीरियम एसपी. एसडीकेआरसी-13, मछली और झींगा पालन टैंक प्रणाली में अमोनिया और नाइट्राइट की कमी के लिए एक संभावित आइसोलेट

स्फिंगोबैक्टीरियम एसपी की प्रभावकारिता कुल अमोनिया नाइट्रोजन (टीएएन) और नाइट्राइट में कमी लाने के लिए फ्रेंच बीन (फेजोलस वल्गेरिस) की जड़ से अलग किए गए एसडीकेआरसी-13 का विश्लेषण किया गया। *पी. इंडिकस* और *एम. गुलियो* पालन टैंकों में 7 दिनों के अंतराल पर 8 × 10^7 सीएफयू की दर से इनोकुलम मिलाया गया। स्फिंगोबैक्टीरियम एसपीपी के उपयोग से TAN और NO2 के स्तर में उल्लेखनीय कमी आई।

खारे पानी के तालाबों में उच्च प्रोटीन, कम प्रोटीन और एज़ोला आधारित आहार के साथ संवर्धित पेनियस वन्नामेई की आंत में कवक की विविधता

उच्च प्रोटीन, कम प्रोटीन और एजोला-आधारित आहार पर रहने वाले पेनेअस वन्नामेई की आंत में फंगल विविधता का अध्ययन किया गया। 43 कवक आइसोलेट्स की पहचान की गई, जिनमें पैरासारोक्लैडियम ब्रेव और पेनिसिलियम ऑक्सालिकम उच्च प्रोटीन फ़ीड समूह में पाई जाने वाली सबसे प्रचुर प्रजातियाँ थीं।

बैसिलस प्यूमिलस की प्रोबायोटिक क्षमता

झींगा पालन के लिए एक उपयुक्त प्रोबायोटिक जीवाणु विकसित करने के लिए, रोगजनकों के खिलाफ विरोधी गतिविधि के लिए जीवाणु आइसोलेट्स की जांच की गई। *बैसिलस प्यूमिलस* आइसोलेट में विब्रियो कैंपबेली, *वी.मिमिकस* और एडवर्डसिएला टार्डा के खिलाफ प्रतिकूल प्रभाव पाया गया और इसमें इम्यूनोमॉड्यूलेटरी गुण भी हैं, जैसा कि प्रोफेनोल ऑक्सीडेज जीन (पीओपीओ), बीटा-ग्लूकन बाइंडिंग प्रोटीन (बीजीबीपी) जीन और हेमोसाइनिन (एचसी) के अपग्रेडेशन से संकेत मिलता है।

कैप्टिव में बंगाल येलोफिन सीब्रीम (एकेंथोपाग्रस डैटनिया) के जीवन चक्र को बंद करना

आईसीएआर- सीबा, काकद्वीप के केआरसी में आरएएस सुविधा में एकैन्थोपाग्रस डेटनिया के लिए प्रेरित प्रजनन प्रोटोकॉल को मानकीकृत किया गया। ब्रूडस्टॉक को ट्रैश मछली के साथ-साथ तैयार फ़ीड (सीपी -40%, ईई 14%) के साथ पाला गया। 100 ग्राम से अधिक वजन वाले वयस्क नर और मादा 10-14 पीपीटी की पानी की लवणता में गोनाडल परिपक्वता प्राप्त कर सकते थे और अंडे देने के लिए लवणता 26-27 पीपीटी तक बढ़ाई गई थी। 450 sqm से अधिक अंडाणु व्यास वाली मादा को 3-5 बार अंडे देने के लिए 2000 IU/ Kg शरीर के वजन/ मादा की मानकीकृत खुराक के साथ प्रेरित किया गया था। 200-300 ग्राम

वजन वाली मादा में प्रजनन क्षमता 1-2 लाख देखी गई। नए निकले लार्वा की लंबाई 1.92-1.98 मिमी मापी गई और 50 घंटों के बाद मुंह खुलता हुआ देखा गया।

कैप्टिव ग्रीन पफरफिश (*डा इ को टो मा इ क्टे रे प्लुवियाटिलिस*) में परिपक्वता और पहली बार ओव्यूलेशन

ग्रीन पफ़रफ़िश के 43 वयस्कों को आरएएस में पाला गया और कैप्टिव में परिपक्वता प्राप्त की। परिपक्व अंडाणु अंडे देने से पहले 500 - 600 µm तक होते थे। एलएचआरएचए (मादा : 100 माइक्रोग्राम/किग्रा शरीर का वजन; नर : 50 माइक्रोग्राम/किग्रा शरीर का वजन) की एक खुराक के साथ हार्मोनल इंडक्शन प्रदान किया गया और 1:3 (मादा : नर) का लिंग अनुपात बनाए रखा गया। 24 घंटे की विलंब अवधि के बाद स्पॉनिंग हुई और निषेचित अंडे पारभासी, डीमर्सल, थोड़े चिपकने वाले थे, और उनमें 730 - 820 µm के आकार के साथ कई तेल की बूंदें थीं।

कैप्टिव में टेड मुलेट (*लिज़ा टेड*) में परिपक्वता का आकलन

कैप्टिव में टेड मुलेट की परिपक्वता का आकलन करने के लिए, उप-वयस्कों/वयस्कों (1, 2, और 3 वर्ष की आयु) को एकत्र किया गया और मिट्टी के तालाबों में जमा किया गया। जुलाई महीने के दौरान 559.01 ± 10.19 µm के अधिकतम आकार के साथ 2+ वर्ष की आयु में परिपक्व अंडाणु देखे गए। मिलटिंग नर (1 वर्ष आयु वर्ग) जून-जुलाई महीनों के दौरान देखे गए।

हिल्सा (*तेनुअलोसा इलिशा*) का कृत्रिम प्रजनन

गोदाखली में हुगली नदी से एकत्र किए गए परिपक्व हिल्सा ब्रूडर्स का उपयोग करके नाव पर सूखी स्ट्रिपिंग के माध्यम से कृत्रिम प्रजनन किया गया था। निषेचित अंडों को ऑक्सीजन युक्त पॉलिथीन बैग में ले जाया गया और 24±1.0°C तापमान पर ऊष्मायन किया गया। निषेचन और अंडे सेने की दर क्रमशः 95.62±0.44% और 70.30±1.64% थी।

हिल्सा का ब्रूडस्टॉक फ़ीड विकास

कैप्टिव हिल्सा अंडाशय और पूरी तरह से परिपक्व (चलने वाले चरण) जंगली हिल्सा अंडाशय की जैव रासायनिक संरचना को ध्यान में रखते हुए पोषण से संतुलित तैयार ब्रूडस्टॉक फ़ीड (सीपी-42.52% और ईई-14.47%) विकसित किया गया था। ब्रूडस्टॉक आहारखिलाने के बाद, यह पाया गया कि 90-95% मादा और 95-100% नर ब्रूड स्टॉक तालाब में परिपक्वता के विभिन्न चरण में थे।

खारा पानी तालाब प्रणाली में हिल्सा ब्रूडस्टॉक का विकास

उप वयस्क हिलसा (158.84± 12.50 ग्राम/ 22.85± 0.72 सेमी) को हिल्साप्लस फ़ीड (सीपी-36.6% और ईई-13.1%) के साथ एकत्र और रखरखाव किया गया। प्रजनन मौसम से पहले कार्यात्मक आहार (सीपी-42.52±0.03%, ईई-14.47±0.03%) लागू किया गया था। अक्टूबर माह में 80% मछलियों में गोनाडल परिपक्वता देखी गई। 406-551 ग्राम की मछली के आकार की सीमा में 9.74 का जीएसआई और 2,09,085-2,67,211 की उर्वरता प्राप्त की गई।

हिल्सा के लिए नर्सरी फ़ीड विकास

हिल्सा के लार्वा को खिलाने के लिए दो प्रकार के लार्वा फ़ीड, फ़ीड- I (CP- 51%) पशु मूल की सामग्री के साथ तैयार किए गए और फ़ीड- II (CP- 49.35%), पशु और पौधे दोनों मूल की सामग्री के साथ तैयार किए गए थे। और इसका व्यावसायिक रूप से उपलब्ध ज़ोप्लांकटन पाउडर से तुलना की गयी । 90 दिनों के बाद, ज़ोप्लांकटन पाउडर अनुपूरण की तुलना में, फ़ीड-I और फ़ीड-II के साथ पूरक तालाब में वृद्धि क्रमशः 18.07% और 99.71% अधिक थी।

मछली अपशिष्ट से मूल्यवर्धित उत्पाद का उन्नयन

अलग-अलग तापमान (70 और 80 डिग्री सेल्सियस) पर गर्म करके प्लैंकटनप्लस की नमी की मात्रा को कम करने के लिए एक प्रयोग किया गया था। प्लैंकटनप्लस को पूरी तरह से सुखाने के लिए आवश्यक समय क्रमशः 70 और 80 डिग्री सेल्सियस पर 168 घंटे और 120 घंटे पाया गया।

सब्जी उत्पादन में मछली अपशिष्ट मूल्य वर्धित उत्पाद (हॉर्टी प्लस) का मूल्यांकन

आलू की उपज और गुणवत्ता में हॉर्टी प्लस के प्रभाव का मूल्यांकन करने के लिए एक प्रयोग किया गया था। 15 वर्ग मीटर क्षेत्रफल वाले नौ भूखंडों का हॉर्टीप्लस संयोजन के साथ और उसके बिना उपचार किया गया। रोपण के 60 दिनों के बाद, यह पाया गया कि जब हॉर्टी प्लस को मिट्टी में लगाया गया तो आलू की उपज बेहतर थी, हालांकि अंतर सांख्यिकीय रूप से महत्वपूर्ण नहीं थे (पी>0.05)। खनिज विश्लेषण से पता चला कि जब हॉर्टी प्लस को पूरक किया गया तो आलू Ca, Mn, Fe, Cu और Zn तत्व से समृद्ध हो गया।

सब्जी उत्पादन में हॉर्टी प्लस के संभावित लाभ की खोज

विभिन्न शीतकालीन सब्जियों की उपज और गुणवत्ता में हॉर्टी प्लस के प्रभाव का मूल्यांकन करने के लिए, अकार्बनिक उर्वरकों के संयोजन में हॉर्टी प्लस के साथ और उसके बिना सात प्रकार की

शीतकालीन सब्जियों की खेती की गई। 60 दिनों की खेती के बाद, यह पाया गया कि जब हॉर्टी प्लस को मिट्टी में डाला गया तो सब्जियों की उपज बेहतर थी।

झींगा फ़ीड में ब्लैक सोल्जर फ्लाई लार्वा भोजन

ब्लैक सोल्जर फ्लाई (बीएसएफ) लार्वा भोजन के प्रभाव को विभिन्न स्तरों पर शामिल करके पी. वन्नामेई और *पी. मोनोडोन* जूवेनिल्स में परीक्षण किया गया था। प्रयोग इन-डोर वेट प्रयोगशाला में आयोजित किया गया था। परिणामों ने संकेत दिया कि बीएसएफ लार्वा भोजन को *पी. वन्नामेई* और *पी. मोनोडोन* में क्रमशः 7.5% और 6% तक शामिल किया जा सकता है।

एक जलीय घटक के रूप में बीएसएफ फ्रैस

बीएसएफ फ्रैस लार्वा भोजन उद्योग का उप-उत्पाद है और इसमें लार्वा मलमूत्र, एक्सोस्केलेटन शेड और अवशिष्ट फ़ीड सामग्री शामिल हैं। इसकी पोषक संरचना के लिए फ्रैस के दो अलग-अलग स्रोतों का विश्लेषण किया गया और परिणामों से पता चला कि कच्चे प्रोटीन और ईथर एक्सट्रेक्ट क्रमशः 18.82 से 23.44% और 0.56 से 3.65% तक थी। इस फ्रैस को झींगा (*पी. वन्नामेई*) और दूध मछली (*चानोस चानोस*) में 5% तक शामिल किया जा सकता है। विभिन्न सांद्रता पर परीक्षण करके माइक्रोएल्गल वृद्धि के लिए फ्रैस का परीक्षण किया गया है। 6-दिवसीय विकास प्रयोग के परिणामों से पता चला कि 0.7 ग्राम/लीटर ने एन. ऑक्युलाटा की बेहतर वृद्धि दी और 0.6 ग्राम/लीटर ने सी. ग्रैसिलिस की बेहतर वृद्धि दी।

प्रोबायोटिक के साथ उच्च स्वास्थ्य फ़ीड

उच्च स्वास्थ्य कार्यात्मक फ़ीड को *लैक्टिप्लांटिबैसिलस प्लांटारम* प्रोबायोटिक (एलएलपी) @10^{11} सीएफयू/किग्रा फ़ीड के साथ तैयार किया गया था और *पी. वन्नामेई* में विकास, प्रतिरक्षा स्थिति, आंत माइक्रोबायोम के लिए परीक्षण किया गया था। परिणामों ने प्रोबायोटिक खिलाए गए झींगा में सकारात्मक वृद्धि, उच्च पाचन एंजाइम प्रोफ़ाइल का संकेत दिया। *रोडोबैक्टीरिया* और *फ्लेवोबैक्टीरियासी* लाभकारी कोर माइक्रोबायोम जीवाणु हस्ताक्षर थे जो मुख्य रूप से एलएलपी पूरक आहार में देखे गए थे। चुनौती प्रयोग के पांच दिनों के अंत में, एलएलपी ने काफी कम संचयी मृत्यु दर (30%) दर्ज की।

कार्यात्मक ब्रूडस्टॉक फ़ीड पर कैप्टिव में पाली गई रैबिटफिश (*सिगानस एसपी*) ने प्रेरित परिपक्वता और स्पॉनिंग के लिए सफलतापूर्वक प्रतिक्रिया दी

रैबिटफिश खारे पानी की पालन क्षमता पेश करती हैं, लेकिन हैचरी से उत्पादित बीज प्राप्त करना एक चुनौती बनी हुई है। वयस्क *सिगानस जावस* (एन=120) और *सिगानस लाइनिएटस* (एन=23) को एक वर्ष तक विशेष आहार दिया गया। अक्टूबर में, दोनों प्रजातियों ने अंडाशय और वृषण में परिपक्वता प्रदर्शित की। सीआईबीए एफसीडी हैचरी में हार्मोनल प्रेरण का प्रयास किया गया, जिससे अक्टूबर 2023 के अंत में सिगानस लाइनिएटस की सफल स्पॉनिंग और हैचिंग हुई।

जीवित फ़ीड के रूप में इसके पोषण मूल्य में सुधार के लिए कोपेपोड का संवर्धन

फ़िनफ़िश लार्वा पालन में लार्वा अस्तित्व में सुधार के लिए कोपेपोड पालन के लिए एक विशेष सुविधा स्थापित की गई थी। विभिन्न तकनीकों का उपयोग करके खारे पानी और समुद्री पारिस्थितिक तंत्र से पांच कोपेपोड प्रजातियों को अलग किया गया। परिणामों ने टेट्रासेलमिस और एफडब्ल्यूएच (40 पीपीएम) के साथ उपचार में उच्चतम वृद्धि (कोपेपोड प्रति एमएल) का संकेत दिया।

समुद्री पॉलीकीट पालन

समुद्री पॉलीकीट कीड़े, पेरिनेरिस एसपीपी को मंडपम में मरैकयार पट्टिनम के समुद्री तट क्षेत्र से एकत्र किया गया था। पेरिनेरिस एसपीपी को डीएनए निष्कर्षण, और लगभग 700 बीपी साइटोक्रोम सी ऑक्सीडेज सबयूनिट। (सीओआई) जीन को प्राइमर पॉलीएलसीओ की मदद से बनाया गया और अनुक्रमित कर पेरिनेरिस नुंटिया के रूप में पहचाना गया। परिपक्वता प्राप्त करने पर मादा का सिर क्षेत्र हरा और नर का सफेद हो जाता है। परिपक्व कीड़ों को निरंतर वातन के साथ अंडे देने के लिए फ़िल्टर किए गए समुद्री जल वाले एफआरपी टैंक में 1: 2 अनुपात (नर और मादा) में रखा गया था। मुक्त-तैराकी मेटाट्रोकोफोर लार्वा बाहर निकले, लेकिन उनका अस्तित्व बहुत कम था, और नेक्टोसेटा के रूप में उनका आगे विकास नहीं हुआ।

झींगा फ़ीड में *बैसिलस सबटलिस* या *सैक्रोमाइसेस सेरेविसिया* के साथ ठोस अवस्था किण्वित सोयाबीन भोजन

इसके समावेशन स्तर को बढ़ाने के लिए, सोयाबीन भोजन को पायलट स्केल किण्वक में *बैसिलस सबटलिस* या *सैक्रोमाइसेस सेरेविसिया* के साथ किण्वित किया गया था। कच्चे और किण्वित सोयाबीन भोजन के विभिन्न स्तरों को शामिल करके प्रायोगिक आहार तैयार किया गया था। विकास परीक्षण के परिणामों से संकेत मिलता है कि किण्वित सोयाबीन भोजन को *पी. वन्नामेई* के ग्रो-आउट फ़ीड में 35% तक शामिल किया जा सकता है और किण्वन ने बेसिलस और यीस्ट के साथ क्रमशः 9.5 और 8.7% की वृद्धि में सुधार किया है।

झींगा में न्यूट्रीजीनोमिक्स दृष्टिकोण के माध्यम से आहार प्रोटीन के अनुकूलन के लिए सटीक पोषण

झींगा फ़ीड में पांच कच्चे प्रोटीन स्तर को लेकर *पी. वन्नामेई* के जूवेनिल्स में परीक्षण किया गया। निम्न क्रूड प्रोटीन समूहों में लगभग 114 डीईजी सामान्य हैं और उच्च क्रूड प्रोटीन समूहों में 31 डीईजी सामान्य हैं। कुल मिलाकर, नियंत्रण समूह की तुलना में क्रूड प्रोटीन के स्तर में बदलाव के कारण 23 डीईजी में अंतर आया है। कम प्रोटीन समूहों के लिए समृद्ध केईजीजी मार्गों में उल्लेखनीय टिप्पणियों में से एक साइट्रेट चक्र और पाइरूवेट चक्र का डाउन-रेगुलेशन था। इससे पता चलता है कि जब मछलियों को कम प्रोटीन वाला आहार दिया जाता है तो ऊर्जा पैदा करने के माइटोकॉन्ड्रियल कार्यों में कमी आती है। कम प्रोटीन वाले झींगा में अन्य चयापचय संबंधी डाउन-रेगुलेटेड मार्ग फ़ीड में कच्चे प्रोटीन की अपर्याप्त मात्रा के कारण सेलुलर प्रक्रियाओं का संकेत देते हैं।

आलू और सब्जी फसलों में सब्जी उत्पादन में मछली के अपशिष्ट का मूल्य वर्धित उत्पाद (हॉर्टी प्लस) के रूप में मूल्यांकन किया गया

यह पाया गया कि जब हॉर्टी प्लस को मिट्टी में लगाया गया तो आलू की उपज बेहतर थी, हालांकि अंतर सांख्यिकीय रूप से महत्वपूर्ण नहीं थे (पी> 0.05)। इसी तरह, विभिन्न शीतकालीन सब्जियों की उपज और गुणवत्ता में हॉर्टी प्लस का मूल्यांकन किया गया। यह पाया गया कि जब हॉर्टी प्लस को मिट्टी में डाला गया तो हर सब्जी की उपज बेहतर थी, हालांकि, पोषक तत्वों की मात्रा में कोई खास अंतर नहीं आया।

रेड स्नैपर के लिए जीनोम असेंबली और पूर्ण-लंबाई ट्रांसक्रिप्ट संसाधन

रेड स्नैपर के जीनोम, जिसकी लंबाई 1.04 जीबी है, 97.2% पूर्ण होने का अनुमान लगाया गया है और इसमें 31,969 प्रोटीन-कोडिंग जीन शामिल होने का अनुमान लगाया गया है। प्रतिलेख संसाधन में 19,144 अद्वितीय जीनों से संबंधित 57,100 आइसोफॉर्म-स्तरीय प्रतिलेख शामिल थे।

खारे पानी की जलीय कृषि उम्मीदवार प्रजातियों की जीनोम अनुक्रमण

आनुवंशिक संसाधन खारे पानी की उम्मीदवार प्रजातियों के पूरे जीनोम के संयोजन और एनोटेशन द्वारा उत्पन्न किए जा रहे हैं, जैसे कि सोने की परत वाली सीब्रीम (*रबडोसार्गस सरबा*), ब्लैकटिप ट्रेवली (*कैरनक्स हेबेरी*), लंबी मूंछ वाली कैटफ़िश (*मिस्टस गुलियो*)। सीओआई बारकोडिंग प्राइमरों का उपयोग करके प्रजातियों की पुष्टि की गई जिसके परिणामस्वरूप 690 बीपी प्रवर्धन उत्पाद प्राप्त हुआ। जीनोम आकार का आकलन बीडी एक्यूरी™ सी6 प्लस फ्लो साइटोमीटर (*बीडी बायोसाइंसेज, यूएसए*) का उपयोग करके किया गया था, जिसमें प्रोपीडियम आयोडाइड का उपयोग किया गया था, जिसमें जीनोम का आकार 0.96 पीजी (*रबडोसारगस सरबा*), 0.5 पीजी (कारानक्स हेबेरी), 0.69 पीजी (*मिस्टस गुलियो*) का पता चला।

पर्लस्पॉट के लिए आइसोफॉर्म-स्तरीय पूर्ण-लंबाई प्रतिलेख संसाधन

छह वयस्क ऊतकों (मस्तिष्क, गिल, गुर्दे, यकृत, मांसपेशियों और प्लीहा) और दो विकासात्मक चरण (1- और 15 दिन पुराने लार्वा) के लिए आइसोफॉर्म-स्तरीय पूर्ण-लंबाई प्रतिलेखों के साथ-साथ उनकी आइसोफॉर्म श्रेणियों और वैकल्पिक स्प्लिसिंग घटनाओं की सूचना दी गई है।

विभिन्न तनाव स्थितियों के संपर्क में आने वाले *पेनेअस वन्नामेई* में कोर ट्रांसक्रिप्टोमिक प्रतिक्रियाएं

झींगा जलीय कृषि में अजैविक और जैविक तनाव स्थितियों से संबंधित 21 व्यक्तिगत बायोप्रोजेक्ट्स के मेटा-विश्लेषण से इन तनाव स्थितियों के अंतर्निहित मूल आणविक तंत्र पर महत्वपूर्ण अंतर्दृष्टि का पता चला। अजैविक तनाव के लिए, ऊर्जा उत्पादन और प्रतिरक्षा प्रतिक्रियाओं से जुड़े मार्गों पर प्रकाश डाला गया, जबकि जैविक तनाव के लिए विषहरण और प्रतिरक्षा प्रतिक्रिया मार्गों पर जोर दिया गया। इस अध्ययन के माध्यम से पहचाने गए तनाव नियामक रूपांकन *पी. वन्नामेई* पालन में तनाव सुधार तंत्र विकसित करने के लिए एक वैध संसाधन हो सकते हैं।

जलकृषि प्रणालियों का तकनीकी-आर्थिक मूल्यांकन

खेत में नर्सरी के तकनीकी-आर्थिक विश्लेषण से पता चला कि नर्सरी में उगाए गए बीज से फसल की अवधि और वृद्धि के मामले में लाभ होता है, जिससे किसान को दो से अधिक फसलें लेने और बाजार की मांग के अनुसार अपनी फसल की योजना बनाने में सुविधा होती है। इसी तरह, अभिग्रहण वाली नर्सरी ने झींगा पालन के लिए गुणवत्तापूर्ण बीज सुनिश्चित करने, कुशल चारा प्रबंधन, जनशक्ति और ऊर्जा लागत को कम करने में मदद की, जिससे झींगा पालन की तकनीकी दक्षता बढ़ गई।

एकीकृत मल्टी-ट्रॉफिक एक्वाकल्चर (आईएमटीए) मॉडल में समुद्री सीबास, समुद्री शैवाल और मसल पालन शामिल है, जिसे मछुआरे परिवारों के आजीविका विकास के लिए प्रदर्शित किया

गया है, जिसमें दिखाया गया है कि सीबास और समुद्री शैवाल पालन संभावित पर्यावरणीय लाभों के साथ समुद्री सीबास की खेती की सराहना करती है। आईएमटीए मॉडल को आय सृजनात्मक और आर्थिक रूप से व्यवहार्य पाया गया।

एशियन सीबास फार्मिंग के प्रौद्योगिकी प्रभाव मूल्यांकन से पता चला है कि प्रमुख आर्थिक पैरामीटर जैसे सीबास मछली उत्पादन प्रणालियों: नर्सरी, तालाब और कैप्टिव में पालन के लिए निवेश पर रिटर्न, लाभ-लागत अनुपात, रिटर्न की आंतरिक दर और तकनीकी दक्षता का अनुमान लगाया गया था और संकेत दिया गया था कि सभी तीन प्रणालियां आर्थिक रूप से व्यवहार्य और तकनीकी रूप से कुशल हैं। इनपुट को 80% से अधिक आउटपुट में परिवर्तित करना।

बाजार और व्यापार विश्लेषणों से पता चला है कि भारत के झींगा निर्यात में 2021-22 की तुलना में 2023-24 में डॉलर मूल्य में 5.9 प्रतिशत और मात्रा में 2.3 प्रतिशत की गिरावट आई है। संयुक्त राज्य अमेरिका को निर्यात में पिछले वर्ष की तुलना में 19.5% की गिरावट आई, जिसका मुख्य कारण इक्वाडोर से प्रतिस्पर्धा था ।

मछुआरों का मानना है कि सीबा की मछली अपशिष्ट-से-संपत्ति तकनीक में मछली बाजारों को साफ करने, मछली के अपशिष्ट की उच्च मात्रा से उत्पन्न पर्यावरणीय समस्याओं को कम करने की क्षमता है और यह सर्कुलर इकोनॉमी मोड पर उनके लिए एक वैकल्पिक आजीविका गतिविधि हो सकती है।

जलकृषि विकास और नीतिगत हस्तक्षेप

ओरिएंटल इंश्योरेंस कंपनी लिमिटेड और एग्रीकल्चरल इंश्योरेंस कंपनी लिमिटेड द्वारा आईसीएआर-सीआईबीए के तकनीकी सहयोग से विकसित झींगा फसल बीमा उत्पादों को लॉन्च किया गया और 650 पॉलिसियों का लाभ उठाकर तमिलनाडु और आंध्र प्रदेश के झींगा किसानों से सकारात्मक प्रतिक्रिया मिली।

झींगा जलकृषि हितधारकों को मछली किसान उत्पादक संगठन योजना के बारे में पर्याप्त जानकारी नहीं है । मत्स्य पालन क्षेत्र में कार्यरत एफएफपीओ पर केस अध्ययन से पता चला कि उनमें मछली खाद्य मूल्य श्रृंखला में किसानों की सौदेबाजी की शक्ति और दक्षता बढ़ाने की क्षमता है। इसलिए, राज्यों में एफपीओ योजना की खूबियों के बारे में झींगा किसानों को जागरूक करने के लिए एक जन अभियान, झींगा किसानों के साथ काम करने वाले संस्थानों की सीधी भागीदारी, एफएफपीओ सदस्य आकार में छूट, शेयर पूंजी आवश्यकताओं और क्रेडिट गारंटी सीमा से झींगा पालन क्षेत्र में एफएफपीओ को बढ़ावा मिलेगा।

जलकृषि तालाब की मिट्टी की उर्वरता पर उम्र बढ़ने का प्रभाव

जलीय कृषि तालाबों की उम्र बढ़ने का मिट्टी की उर्वरता पर प्रभाव पर अध्ययन से पता चला है कि जलीय कृषि तालाबों की उर्वरता स्थिति उम्र बढ़ने के साथ खराब होती गई। ताजे तालाब 1.75 से अधिक पोषक तत्व सूचकांक के साथ अत्यधिक उपजाऊ होते हैं।

जोखिम और भेद्यता मूल्यांकन संकेतक

जलवायु परिवर्तन के प्रति खारे पानी के जलीय कृषि के जोखिम और भेद्यता मूल्यांकन के लिए संकेतकों का मूल्यांकन आईपीसीसी पद्धति के एआर5 के अनुसार किया गया था, जिसमें तीन महत्वपूर्ण कारकों जैसे खतरा, जोखिम और भेद्यता पर विचार किया गया था।

सर्दियों के महीनों के दौरान पर्लस्पॉट के प्रजनन प्रदर्शन पर तापमान का प्रभाव

नवंबर से जनवरी की अवधि के दौरान पर्लस्पॉट के प्रजनन प्रदर्शन पर ऊंचे तापमान (32^0C) के निरंतर संपर्क के प्रभाव पर किए गए प्रयोग में मिट्टी के बर्तनों के अंदर अंडे देना देखा गया। यह खोज पर्लस्पॉट के ऑफ-सीज़न प्रजनन के लिए एक प्रोटोकॉल विकसित करने का मार्ग प्रशस्त करती है।

मिल्कफिश के अंडे सेने, लार्वा के अस्तित्व और विकृति पर विभिन्न लवणता का प्रभाव

मिल्कफिश हैचिंग, लार्वा अस्तित्व और विकृति पर विभिन्न लवणता के प्रभाव पर एक प्रयोग से पता चला कि पसंदीदा लवणता 30-35 पीपीटी थी और औसत हैचिंग दर 75% थी।

वर्षा पैटर्न परिवर्तनशीलता का प्रभाव

पानी की गुणवत्ता, प्रतिरक्षा मापदंडों में बदलाव और झींगा पालने वाले वातावरण में व्हाइट स्पॉट सिंड्रोम वायरस की घटनाओं पर वर्षा पैटर्न परिवर्तनशीलता के प्रभाव ने झींगा के तनाव को कम करने के लिए भारी बारिश के तुरंत बाद बीएमपी के कार्यान्वयन की आवश्यकता का संकेत दिया।

गर्मी की लहर की अवधि के दौरान वाणिज्यिक झींगा फार्मों में *पेनेअस वन्नामेई* और *पेनेअस मोनोडोन* की वृद्धि की विशेषताएं

गर्मी की लहर की अवधि के दौरान, *पी.वन्नामेई* और पी.मोनोडोन की औसत दैनिक वृद्धि दर सामान्य तापमान अवधि की तुलना में काफी कम थी। लंबे समय तक चलने वाली गर्मी की लहरें झींगा को बीमारियों के प्रति संवेदनशील बनाती हैं।

तटीय भारत के सतही मौसम मापदंडों में रुझान और खारे

पानी की जलीय कृषि के लिए निहितार्थ

एक उत्पन्न हीट मैप ने आरसीपी 4.5 के तहत 2020, 2050 और 2080 के लिए भविष्य के परिदृश्यों द्वारा पूरक, तटीय ग्रिड माध्य मूल्यों के स्थानिक वितरण को चित्रित किया। ये अनुमान तालाब की तैयारी, प्रजातियों के भंडारण और कटाई जैसी फसल कैलेंडर गतिविधियों की योजना बनाने में उपयोगी होते हैं।

जीवन चक्र मूल्यांकन दृष्टिकोण के माध्यम से झींगा प्रसंस्करण के पर्यावरणीय पदचिह्न का मूल्यांकन करना

झींगा प्रसंस्करण के पर्यावरणीय पदचिह्न का मूल्यांकन जीवन चक्र मूल्यांकन दृष्टिकोण के माध्यम से किया गया था। प्रति टन झींगा का अनुमानित उत्सर्जन 433 किलोग्राम CO2eq (ग्लोबल वार्मिंग क्षमता) था। बिजली के माध्यम से ऊर्जा का उपयोग ग्लोबल वार्मिंग क्षमता में प्राथमिक योगदानकर्ता के रूप में उभरा।

झींगा प्रसंस्करण संयंत्र से ग्लोबल वार्मिंग क्षमता (जीडब्ल्यूपी) को कम करने के लिए वैकल्पिक ऊर्जा परिदृश्य

झींगा प्रसंस्करण संयंत्रों में फोटोवोल्टिक पैनलों की स्थापना से जीडब्ल्यूपी कम हो जाती है। GWP 50% PV के साथ 339 किलोग्राम CO2eq और 100% PV के साथ 222 किलोग्राम CO2eq था, जबकि प्रति टन झींगा की पूर्ण ग्रिड बिजली की विशिष्ट परिस्थितियों में 433 किलोग्राम CO2eq था।

मीथेन ऑक्सीकरण बैक्टीरिया की गतिविधि

घुलनशील मीथेन मोनोऑक्सीजिनेज गतिविधि के लिए 0 से 38 पीपीटी के बीच लवणता वाले विभिन्न वातावरणों से अलग किए गए मीथेन ऑक्सीकरण बैक्टीरिया की जांच की गई।

सेंसर दक्षता का परीक्षण और सेंसर मॉड्यूल के साथ जल बोया की तैनाती

एक एक्वा बोय प्रोटोटाइप विकसित किया गया था, जिस पर कैलिब्रेटेड सेंसर लगाए गए थे और सेंसर की उछाल और सटीकता का परीक्षण करने के लिए हैचरी और कल्चर सिस्टम में तैनात किया गया था। एक्वा बॉय से कैप्चर किए गए डेटा की तुलना मैन्युअल माप से की गई। किसानों को सचेत करने और विशिष्ट सलाह प्रदान करने के लिए गहन शिक्षण सहायता प्रणाली पद्धति, जल स्वास्थ्य वर्गीकरण के लिए वास्तुकला और एक एंड्रॉइड-आधारित एप्लिकेशन विकसित किया गया है।

व्हाइट स्पॉट सिंड्रोम वायरस का जीनोटाइपिंग और विषाणु विश्लेषण

व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्यूएसएसवी) अनुक्रमों की बढ़ती संख्या के साथ, डब्ल्यूएसएसवी परिवर्तनशील जीनोम आकार के साथ उच्च आनुवंशिक परिवर्तनशीलता दिखाता है। मिसिंग रीजन फाइंडर (एमआरएफ) पर आधारित प्राइमरों का उपयोग पेनियस इंडिकस के डब्ल्यूएसएसवी संक्रमित नमूनों की जीनोटाइपिंग के लिए किया गया था। डब्ल्यूएसएसवी के जीनोटाइपिंग से आणविक महामारी विज्ञान का अध्ययन करने और सटीक निदान और नियंत्रण करने में मदद मिलेगी।

रोग प्रत्यावर्तन के लिए झींगा में डब्ल्यूएसएसवी की कॉपी संख्या का अनुमान लगाना

डब्ल्यूएसएसवी विषाणु पैटर्न का अध्ययन करने के लिए *पेनेअस वन्नामेई* झींगा में एक प्रयोग किया गया था। गिल और प्लियोपोड में वायरल प्रतिलिपि संख्या का अनुमान लगाया गया था, 10^6 समूह के गिल ने 24 घंटे के बाद से सकारात्मक संकेत , यह दर्शाता है कि प्रारंभिक डब्लूएसएसवी निदान के लिए गिल ऊतक अधिक उपयुक्त है। 10^1, 10^2 और 10^3 के टीकाकरण वाले प्रायोगिक समूहों में मृत्यु दर नहीं थी, हालाँकि, 106 समूह में 6 घंटे के बाद से मृत्यु दर थी।

डब्ल्यूएसएसवी -संक्रमित *पी. इंडिकस* झींगा की प्रतिरक्षा प्रतिक्रिया का फ्लो साइटोमेट्री विश्लेषण

27 डिग्री सेल्सियस, 30 डिग्री सेल्सियस और 33 डिग्री सेल्सियस के विभिन्न तापमानों के संपर्क में आने वाले डब्ल्यूएसएसवी-चुनौती वाले *पी. इंडिकस* झींगा की प्रतिरक्षाविज्ञान प्रतिक्रिया का विश्लेषण करने के लिए फ्लो साइटोमेट्री का उपयोग किया गया था। झींगा के नमूने अलग-अलग समय बिंदुओं पर एकत्र किए गए, जैसे 12 घंटे बाद चुनौती (एचपीसी), 24 एचपीसी, और 48 एचपीसी और साइटोप्लाज्मिक मुक्त सीए 2+ एकाग्रता, श्वसन विस्फोट गतिविधि, सेल चक्र विश्लेषण, एपोप्टोसिस और फागोसाइटोसिस के लिए प्रवाह साइटोमेट्री विश्लेषण के लिए उपयोग किया जाता है। वर्तमान अध्ययन विभिन्न तापमान स्थितियों के संपर्क में आने वाले झींगा में डब्ल्यूएसएसवी संक्रमण के दौरान प्रतिरक्षाविज्ञान प्रतिक्रिया में भिन्नता का संकेत देता है।

पेनेअस मोनोडोन फार्मों में *एंटरोसाइटोज़ून हेपेटोपेनेई* (ईएचपी) की व्यापकता और इसकी संक्रामकता

आंध्र प्रदेश, तमिलनाडु, पश्चिम बंगाल, गुजरात और केरल में *पी. मोनोडोन* में ईएचपी की व्यापकता को समझने के लिए 62 तालाबों में एक सर्वेक्षण किया गया था।

विश्लेषण से 30.6% (19/62 फ़ार्म) की व्यापकता का पता चला, जिसमें 94.7% सकारात्मक फ़ार्म का परीक्षण केवल नेस्टेड पीसीआर स्तर पर किया गया। पश्चिम बंगाल के फार्मों में ईएचपी का प्रचलन सबसे अधिक था (53.85%; 7/13 फार्म)। मौखिक संक्रमण द्वारा *पी. मोनोडोन* और *पी. वन्नामेई* में चुनौती प्रयोगों से पता चला कि *पी. मोनोडोन, पी. वन्नामेई* की तुलना में ईएचपी के प्रति तुलनात्मक रूप से कम संवेदनशील है।

एंटरोसाइटोज़ून हेपेटोपेनेई (ईएचपी) के प्रति केकड़े प्रजातियों की संवेदनशीलता

हे पे टो पैं क्रि ए टि क माइक्रोस्पोरिडिओसिस (एचपीएम) और माइक्रोस्पोरिडियन परजीवी ईएचपी और विब्रियो एसपीपी के कारण होने वाली वाइब्रियोसिस, क्रमशः धीमी वृद्धि, आकार भिन्नता, सफेद मल सिंड्रोम (डब्ल्यूएफएस) और मृत्यु दर के साथ झींगा जलीय कृषि में महत्वपूर्ण बीमारियां मानी जाती हैं। इसलिए, मेजबान और रोगजनकों की कई अंतःक्रियाओं को समझने के लिए केकड़े प्रजातियों में बहु-खुराक मौखिक चुनौती और संवेदनशीलता अध्ययन प्रयोग आयोजित किया गया था। हेपेटोपेंक्रियाज (एचपी) के क्यूपीसीआर विश्लेषण से पता चला कि ईएचपी लोड का स्तर बहुत कम था और 42वीं डीपीसी तक लगातार कमी आई और 42वीं डीपीसी के बाद शून्य तक पहुंच गया। यह केकड़े प्रजातियों में एचपी ऊतकों में ईएचपी बीजाणुओं की कोई स्थापना और/या कोई प्रसार नहीं होने का संकेत है।

एंटरोसाइटोज़ून हेपेटोपेनेई (ईएचपी) के खिलाफ संवेदनशीलता और प्रतिरोध में झींगा प्रजातियों की विविधता पर अध्ययन

बहु-खुराक मौखिक चुनौती और संवेदनशीलता अध्ययन प्रयोग तीन आर्थिक रूप से महत्वपूर्ण झींगा प्रजातियों जैसे कि *पी. इंडिकस, पी. मोनोडॉन* और *पी. वन्नामेई* के जूवेनिल्स में आयोजित किया गया था। झींगा की विभिन्न प्रजातियों से एकत्र किए गए एचपी के मात्रात्मक पीसीआर विश्लेषण से पता चला कि ईएचपी लोड में महत्वपूर्ण अंतर था। प्रयोग के 42वें दिन *पी. वन्नामेई* के एचपी में ईएचपी प्रतियां सबसे अधिक (एचपी ऊतक की 64.35x106 प्रतियां जी-1) थीं, इसके बाद 35वें दिन पी. मोनोडोन में एचपी की $1.61x10^6$ प्रतियां जी-1 और एचपी में सबसे कम ईएचपी लोड था। प्रयोग के पूरे 42 दिनों के दौरान *पी. इंडिकस* एचपी ऊतक की $0.02x10^6$ प्रतियां जी-1 थी।

सफेद मल सिंड्रोम (डब्ल्यूएफएस) से प्रभावित झींगा से *विब्रियो पैराहेमोलिटिकस* की रोगजनकता

सफेद मल सिंड्रोम (डब्ल्यूएफएस) दुनिया भर में झींगा पालन में एक बड़ी समस्या बनकर उभरा है। डब्ल्यूएफएस के साथ ईएचपी के जुड़ाव की पिछली रिपोर्टों की तुलना में, हाल की रिपोर्टें ईएचपी के साथ वाइब्रियोस और अन्य जीवाणु प्रजातियों को जोड़ती हैं। इसलिए, बैक्टीरिया की भूमिका को समझने के लिए, डब्ल्यूएफएस तालाबों से उत्पन्न बैक्टीरिया आइसोलेट्स और डब्ल्यूएफएस की रिपोर्ट से पहले आइसोलेट्स के साथ आठ चुनौती परीक्षणों की एक श्रृंखला आयोजित की गई थी। विश्लेषण से पता चलता है कि डब्लूएफएस प्रभावित तालाबों से उत्पन्न बैक्टीरिया विशेष रूप से *वी. पैराहेमोलिटिकस* के कारण झींगा के जूवेनिल्स में निमज्जन विधि द्वारा चुनौती से 15 से 25% तक मृत्यु दर होती है।

ईएचपी और विब्रियो एसपीपी के खिलाफ रोगनिरोधी और चिकित्सा

ईएचपी अन्य अवसरवादी बैक्टीरिया के साथ मिलकर गंभीर विकास मंदता, डब्ल्यूएफएस और मृत्यु दर का कारण बनता है जिससे झींगा पालन करने वाले देशों में गंभीर आर्थिक नुकसान होता है। विब्रियो एसपीपी के खिलाफ तीन हर्बल अर्क प्रभावी पाए गए। उनकी पानी में घुलनशीलता, अवशोषण, जैवउपलब्धता और लंबे आधे जीवन को बढ़ाने के लिए उन्हें ऊतक पहचान लिगेंड के साथ नैनोकणों में हरे रंग में संश्लेषित किया गया था। एक अन्य अध्ययन में, टी के लिए विभिन्न संभावित प्राकृतिक उपचारों का भी मूल्यांकन किया गया ।

ईएचपी और विब्रियो एसपीपी के साथ सह-संक्रमण के खिलाफ झींगा में हेपेटोप्रोटेक्टेंट के रूप में सिलीमारिन यौगिकों की प्रभावकारिता का आकलन

ईएचपी हेपटोपेन्क्रीअस को नुकसान पहुंचाता है, जिसके परिणामस्वरूप पोषक तत्वों का चयापचय बिगड़ जाता है, जिससे आकार में भिन्नता, विकास मंदता, द्वितीयक जीवाणु संक्रमण और मृत्यु दर जैसे नैदानिक संकेत सामने आते हैं। सेलुलर पुनर्जनन क्षमता वाले सिलीमारिन यौगिकों जैसे हेपेटोप्रोटेक्टेंट जानवरों और मछलियों में हेपेटोटॉक्सिसिटी को रोकने या उलटने में मददगार साबित हुए हैं। इसलिए अध्ययन का उद्देश्य झींगा में ईएचपी संक्रमण की रोकथाम और/या उपचार में फ़ीड अनुपूरक के रूप में सिलीमारिन की प्रभावकारिता का आकलन करना था।

प्रोफेनोलॉक्सिडेज़ सक्रिय करने वाला पेप्टिडेज़ ईएचपी के स्पोर वाल प्रोटीन (एसडब्ल्यूपी) के साथ प्रभाव डालता है

माइक्रोस्पोरिडियन के स्पोर वाल प्रोटीन (एसडब्ल्यूपी) संक्रमण के दौरान मेजबान कोशिकाओं के साथ सीधे संपर्क करते हैं और मेजबान कोशिका आसंजन, आयन चैनल, ऊर्जा हस्तांतरण, सिग्नल ट्रांसडक्शन और एंजाइमी

प्रतिक्रियाओं में महत्वपूर्ण भूमिका निभाते हैं। सिलिको प्रोटीन-पेप्टिडेज़ इंटरेक्शन अध्ययन में पी. वन्नामेई के लक्षित अंग में संक्रमण और प्रसार को कम करने के लिए ईएचपी एसडब्ल्यूपी के खिलाफ जैव-एंजाइम (पेप्टिडेज़) की पहचान की गई।

ई. हेपेटोपेनेई (ईएचपी) चिकित्सीय सीआईबीए ईएचपी क्यूरा । का क्षेत्र मूल्यांकन

सीबा ने ईएचपी के उपचार और नियंत्रण के लिए ' सीबा ईएचपी क्यूरा । ' विकसित किया है। ' सीबा ईएचपी क्यूरा । ' प्राकृतिक उत्पाद और पोषक तत्वों की खुराक का एक संयोजन है जिसने ईएचपी लोड को काफी कम कर दिया है और प्रयोगशाला और क्षेत्रों दोनों में झींगा की प्रतिरक्षा और विकास में सुधार किया है। सीआईबीए ईएचपी क्यूरा । का क्षेत्र मूल्यांकन तमिलनाडु के नागापट्टिनम, तिरुवल्लूर जिलों, आंध्र प्रदेश के बापटला और भीमावरम जिलों और गुजरात के नवसारी जिले के झींगा फार्मों में शुरू किया गया है। क्षेत्र मूल्यांकन के लिए लगभग 1500 लीटर सीबा ईएचपी क्यूरा । का उपयोग किया गया है और 7,47,450 रुपये का राजस्व उत्पन्न हुआ है।

प्रमुख झींगा रोगजनकों डब्ल्यूएसएसवी और ईएचपी का पता लगाने के लिए निदान बिंदु का विकास

ईएचपी पार्श्व प्रवाह प्रतिरक्षा परख के विकास के लिए, ईएचपी संक्रमित झींगा हेपटोपेन्क्रीअस से ईएचपी बीजाणुओं को शुद्ध किया गया था। ईएचपी एसडब्ल्यूपी जीन का पूरा अनुक्रम प्रवर्धित किया गया है, और इन्फ्यूजन क्लोनिंग विधि द्वारा पीजीईएक्स-6पी-1 में क्लोन किया गया है। शुद्ध पुनः संयोजक एसडब्ल्यूपी को केंद्रित किया गया और पॉलीक्लोनल एंटीबॉडी उत्पादन के लिए उपयोग किया गया।

रोग निदान के लिए जीन संपादन प्रौद्योगिकियों (सी आर आई ए स पी आर / सीएएस) का अनुप्रयोग

WSSV TATA बॉक्स लक्ष्यीकरण जीन को सफलतापूर्वक क्लोन किया गया था और कॉपी नंबर को सामान्यीकृत किया गया था, जो CRISPR/Cas12 परख के लिए एक टेम्पलेट के रूप में काम कर रहा था। क्लोनों को अनुक्रमण के माध्यम से सत्यापित किया गया था, और मात्रात्मक रिवर्स ट्रांसक्रिप्शन पोलीमरेज़ चेन रिएक्शन (क्यूआरटी-पीसीआर) का उपयोग करके डब्ल्यूएसएसवी का एक मानक वक्र स्थापित किया गया था। इसके बाद, इन विट्रो ट्रांसक्रिप्शन आयोजित किया गया, और CRISPR/Cas12a का उपयोग करके रुचि के प्रवर्धित क्षेत्र का पता लगाया गया। CRISPR/Cas12a की ट्रांस-क्लीवेज गतिविधि को FAM-BHQ1-लेबल रिपोर्टर परख का उपयोग करके मानकीकृत किया गया था।

डब्ल्यूएसएसवी और ईएचपी के लिए मल्टीप्लेक्स LAMP परख का विकास

सीबा ने EHP और WSSV का एक साथ पता लगाने के लिए एक मल्टीप्लेक्स लैंप विकसित किया। LAMP प्राइमरों को WSSV का पता लगाने के लिए VP28 क्षेत्र और EHP का पता लगाने के लिए SWP क्षेत्र का उपयोग करके डिज़ाइन किया गया था। यह मल्टीप्लेक्स लैंप एक बंद ट्यूब लैंप है और इससे क्रॉस संदूषण नहीं होता है। यह एक साधारण सूखे स्नान में किया गया है और इसके लिए किसी महंगे उपकरण की आवश्यकता नहीं है। यह 45 मिनट में 10 प्रतियों तक डब्ल्यूएसएसवी और ईएचपी दोनों का पता लगा सकता है।

झींगा के लिए प्रोबायोटिक्स और इम्यूनोस्टिमुलेंट का विकास

माइक्रोबियल उपभेदों को प्राकृतिक पर्यावरण और पालन प्रणालियों से अलग किया गया और संभावित बायोरेमेडिएशन गुणों की जांच की गई। 34 आइसोलेट्स में से पंद्रह ने एमाइलेज़ (स्टार्च), प्रोटीज़ (जिलेटिन और मलाई रहित दूध) और लाइपेज़ (ट्रिब्यूटिरिन और ट्वीन 80) गतिविधियों का प्रदर्शन किया। अमोनिया और नाइट्राइट के उपयोग में दक्षता का मूल्यांकन 10 पीपीएम अमोनिया और नाइट्राइट युक्त मीडिया का उपयोग करके किया गया था।

महत्वपूर्ण विब्रियो प्रजातियों के लिए प्रजाति-विशिष्ट मात्रात्मक वास्तविक समय पीसीआर का विकास

हार्वेई क्लैड विब्रियोस की 13 निकट संबंधी प्रजातियों के एक समूह का गठन करता है, जिनके नाम हैं वी. हार्वेई, वी. कैंपबेली, वी. पैराहामोलिटिकस, वी. एल्गिनोलिटिकस, वी. ओवेन्सि, वी. रोटिफ़ेरियनस, वी. नैट्रीजेन्स, वी. जैसिडिडा, वी. डायबोलिकस, वी. एक्कामेरियस, वी. सैगामिएन्सिस, वी. अज़ूरियस और वी. मायटिली। इनमें से कई प्रजातियाँ झींगा और फ़िनफ़िश में बहुत महत्वपूर्ण रोगज़नक़ हैं। इसलिए, उनके रोगजनन को समझने और नैदानिक मार्कर विकसित करने के लिए इन 13 प्रजातियों के 2244 आइसोलेट्स वाले संपूर्ण जीनोम अनुक्रमों का विश्लेषण किया गया।

सिगानस जावस के कैप्टिव स्टॉक में *पॉलीओपिस्टहोकोटिलियन मोनोजीनियन, पॉलीलैब्रिस* से जुड़ी मृत्यु दर पर पहली रिपोर्ट

मोनोजीनियन उच्च मेजबान विशिष्टता वाले जलीय जंतुओं में परजीवी फ़्लूक्स हैं। वाइल्ड एकत्रित जावा खरगोश मछली में बार-बार होने वाली मौतों की जांच की गई। रूपात्मक पहचान ने भारत के विशाखापत्तनम तट से सिगनस जावस से रिपोर्ट किए

गए *एफ. माइक्रोकोटाइलिडे*, पॉलीलैब्रिस बेंगालेंसिस के पॉलीओपिस्टहोकोटाइलडॉन के साथ उनकी करीबी रूपात्मक समानता दिखाई है और मोनोजेनियन के 28S आरआरएनए जीन के आणविक लक्षण वर्णन से इसकी 97% पहचान ओमान की खाड़ी के पी. मामेवी से पता चली है।

तमिलनाडु के तिरुवल्लुर जिले में *पी. वन्नामेई* झींगा फार्मों में रोग निगरानी

2023 के दौरान, तमिलनाडु के तिरुवल्लूर जिले में 30 पी. वन्नामेई फार्मों से 71 झींगा नमूने एकत्र किए गए। इन फार्मों की डब्लू. ओ.ए.एच. (ओआईई) सूचीबद्ध झींगा रोगजनकों के लिए जांच की गई। छत्तीस प्रतिशत फार्म ईएचपी से, आठ प्रतिशत फार्म आईएमएनवी से और पांच प्रतिशत फार्म डब्ल्यूएसएसवी से संक्रमित थे। जून माह के दौरान समग्र रोग का प्रसार अधिक पाया गया।

इम्यूनोमॉड्यूलेटर *पी. वन्नामेई* को उच्च वृद्धि और रोग प्रतिरोधक क्षमता प्रदान करने में प्रभावी थे

परियोजना का उद्देश्य बेहतर विकास और रोग प्रतिरोधक क्षमता प्रदान करने के लिए इम्युनोमोड्यूलेटर (प्रीबायोटिक्स, प्रोबायोटिक्स और इम्यूनोस्टिमुलेंट) की प्रभावी खुराक निर्धारित करना था। प्रतिरक्षा और विकास जीन के लिए जीन अभिव्यक्ति अध्ययन से पता चला कि नियंत्रण की तुलना में सभी प्रयोगात्मक समूहों में अभिव्यक्ति का स्तर उच्च है। मेटाजेनोम परिणामों ने प्रयोगात्मक पशु की आंत में नियंत्रण की तुलना में अधिक जीवाणु परिवार की प्रचुरता को स्पष्ट किया।

पालन तालाबों में झींगा डब्ल्यूएसएसवी के नियंत्रण के लिए सूक्ष्म शैवाल आधारित उन्नत वितरण पद्धति का विकास

परियोजना का उद्देश्य डब्ल्यूएसएसवी के उपचार के लिए शैवाल आधारित क्षेत्र वितरण पद्धति विकसित करना था। डब्ल्यूएसएसवी के VP28 जीन को माइक्रोएल्गे अनुक्रम और प्रतिबंध स्थल सम्मिलन के आधार पर कोडन अनुकूलन के अधीन किया गया था। अनुकूलित अनुक्रम को आगे के उपयोग के लिए कस्टम रूप से संश्लेषित किया गया था। पीसीआर प्रवर्धन के बाद, इसे प्रतिबंध एंजाइम से पचाया गया और शैवाल वेक्टर से जोड़ा गया।

EXECUTIVE SUMMARY

On-farm demonstration and harvest mela at Utukuru village, Nellore district in Andhra Pradesh

Broodstock-bred *Penaeus indicus* shrimp seeds were given to shrimp farmers to assess their production potential at farmer's ponds. The demonstration was carried out in a 1.7-acre pond at Utukuru village, Nellore district in Andhra Pradesh with a stocking density of 23 nos/ m^2. The average body weight of the harvested shrimp was 21.2g with a survival rate of 72% and a yield of 2430 kg in 98 days. Further, an On-farm demonstration and harvest mela at Payyanur, Kerala recorded an average body weight of 18.50g in 93 days with a yield of 3330kg in 2-acre farming with cost-effective feed.

Genetic characterization of different stocks of *P. indicus* using SSR markers

The characterization of simple sequence repeats (SSR) of different stocks of *P. indicus* from different coasts of India has been assessed. High polymorphism rates and a broad distribution throughout the genome have made SSRs one of the most prominent genetic markers used in breeding programs. The whole genome of *P. indicus* assembled contains 44 scaffolds. Scaffolds 1 to 12 were screened for polymorphic SSRs. For each scaffold, tested four loci, one each from tri, tetra, penta, and hexa repeat SSRs.

Seed production of Indian white shrimp, *P. indicus*

Indian white shrimp, *Penaeus indicus,* has been identified as a national priority species for domestication and genetic improvement programs in India. To evaluate the reproductive performance, and generate a database for the founder population, wild *P. indicus* brooders were collected across different locations in India such as Puri (Odisha), Kakinada (AP), Chennai (TN), Kanyakumari (TN), and Quilon (KR). Three million seeds were produced in the year 2023 and distributed to the farmers of different locations all across the Indian coast.

Effect of hormonal administration in gonad development and spawning of captive-reared *P. indicus*

Although eyestalk ablation is the most common induced maturation technique used in commercial shrimp hatcheries, eye stalk ablation leads to stress, low survival, and increased moulting in captive-rearing shrimps. In this context, the role of sex steroid 17-β-estradiol injection in unablated *P. indicus* revealed 23.5% successful spawning compared with 35% spawning recorded in the eye stalk ablated group.

Artificial insemination of *P. indicus*

Artificial insemination is a tool used for controlled breeding of shrimp and is a prerequisite for genetic manipulation. To optimize the artificial insemination techniques for successful pairwise breeding and improved fertility, an experiment was conducted using intermoult *P. indicus* shrimps. The study revealed that by 9th day only 20% of the female brooders successfully accepted the spermatophore while 40% of the male brooders recorded regeneration of the spermatophore with normal sperm morphometry.

Nursery rearing of Indian white shrimp *P. indicus* in Biofloc culture technology

Biofloc (BFT) based nursery rearing system was designed to evaluate the efficiency of biofloc in *P. indicus* nursery at 3000 PL/m^3 for 30 days. An average body weight of 1.25g was achieved by the biofloc nursery-reared Indian white shrimp against 1.21g in control.

Effect of Bioaugmentation Process in Biofloc System

A seventy-day trial to observe the growth performance, and microbial dynamics of *P. vannamei* in the biofloc system revealed the highest average body weight of 15.22±0.24g in *P. vannamei* when bioaugmented with CIBAfloc compared with control (09.02±0.52g). Water quality metrics improved significantly in biofloc groups with a lower ammonia level (0.01±0.13 ppm) than control (0.83±0.06 ppm). The relative expression of immune genes and digestive enzyme-related genes showed an upregulation compared to the control

Copefloc-based nursery rearing of *P. indicus*

High-density nursery rearing of *P. indicus* (10,000 Pl/m^3) using monospecific and mixed copepod stocks exhibited the potential of mixed copepod cultures, specifically comprising *D. rigida, E. pygmea,* and *P. annandelei,* for optimizing *P. indicus* nursery rearing. Enhanced growth and survival was recorded in mixed copepod group.

Mudcrab seed production

Hatchery technology mud crab species of the genus *Scylla* (*S. serrata* and *S. olivacea*) have been improved using the modified seed production technology by resolving the basic issues in larval biology. During the period five larval cycles were carried out with 25.3% survival (52000 megalopa) for *S. olivacea* and 32% survival for *S. serrate*. About 60,000 to 1.6 lakh megalopa were produced.

Seaweed-assisted nursery-rearing techniques enhance survival in mud crab

The nursery-rearing phase from megalopa to instar is challenging owing to its cannibalistic behavior. Integration of seaweed during the nursery phase recorded 47-55% improvement in survival. The result provides valuable data for survival improvement in the nursery phase of mud crabs.

Planning Nucleus Breeding Centre for quality seed production and domestication

The pilot scale NBC (Nuclear Breeding Centre) has been designed for the entire Genetic Improvement Program (GIP) unit at KES, Kovalam consisting of the quarantine units, the nursery system, the pre-grow-out and grow-out system along with reservoir and treatment systems.

Seaweed calendar for Chengalpattu District

Seaweed field survey during November 2022 to November 2023 at Chengalpattu, Tamil Nadu revealed the prevalence and seasonal variations of species such as Agarophyton tenustipitatum, *Gracilaria salicornia, Ulva lactuca, Ulva prolifera* and *Ulva* intestinalis. During different seasons, seaweeds experience variations in their growth rates, reproductive cycles, and overall health.

Integration of shrimp farming with brackishwater water seaweeds

Integration of *P. vannamei* (40 individuals/m^2) with *G. salicornia* floating raft with horizontal and vertical ropes, initially holding 1.5kg and 0.5kg biomass recorded 260kg of shrimp with an 87% survival rate, while the control yielded 220kg with 77% survival in 41 days. The integrated pond also produced 170kg of seaweed biomass, indicating a fivefold increase and a productivity of 3.4 tons per hectare. Further, the integration of *P. vannamei* with *C. racemosa* resulted in shrimp productivities of 4.5 and 3.4 tons/ha for the seaweed-integrated and control ponds, respectively. Harvested seaweed biomass reached 6.8kg in the seaweed-integrated pond, indicating shrimp consumption of the green seaweed. The studies highlight the potential benefits of seaweed-shrimp integration in aquaculture systems.

Mapping of uncultivable salt-affected lands in Rajasthan

Mapping of salt-affected lands that are not suitable for agriculture will pave the way for alternate use. Mapping the uncultivable salt-affected lands using satellite data in a geospatial platform, Sentinel 2 B data of 2022 delineated in the selected seven districts of Rajasthan namely Sriganganagar, Hanumangarh, Pali, Jalore, Barmer Jodhpurand Cheru, covering 45 tehsils. The spatial location and spread of uncultivable salt-affected lands indicate the opportunities

to develop shrimp aquaculture with regulatory guidelines.

Assessment of soil characteristics in salt-affected lands

The field survey was made to assess the suitability of soil for aquaculture in inland saline areas of Rajasthan soil analysis revealed soils are non-saline, electrical conductivity <4 dS/m, alkaline range with pH values 7.53 to 9.9. Most of the soils were deficient in organic carbon available nitrogen, and available phosphorus content. As the soils in these areas are dominant with sand textural categories, the existing farms were with polythene lined ponds and it is suggested to line the ponds for brackishwater aquaculture in new areas.

Automated delineation of salt-affected lands and their progress in coastal India using Google Earth Engine and machine learning techniques

Assessment of salt-affected land (SAL) is still a major challenging task worldwide, especially in developing nations. The advancement of remotely sensed digital satellite images of different spectral bands has enabled the assessment of soil salinity. Twenty spectral indices have been used which include four vegetation indices, twelve soil salinity indices, four topographical characteristics, and their spectral bands. The Random Forest model was used to detect SAL. Of the electrical conductivity values of samples collected in the field, 70% of the soil samples were used for the model training, and the remaining 30% were used for validation. The present study demonstrated the strength of remote sensing techniques to assess the SAL, which will help quantify the unproductive lands at the state or national level for reclamation or other productive use.

Evaluation of the efficiency of nanominerals in shrimp culture

Low saline and inland saline water have mineral deficiency that affects the sustainability of shrimp culture. This problem can be effectively solved by applying minerals in nanoscale size, which enhances their assimilation by the shrimp. The analysis of prepared nanominerals showed that $CaCl^2$ contains 35% calcium and MCP contains 27.7% calcium and 13.6% phosphorus. In the nano calcium experiment, animal weight increased by 18.7% and in the nano MCP experiment, animal weight increased by 21.7%

First-time captive breeding of gold-lined spinefoot rabbitfish (*Siganus lineatus*) in India

The pioneering efforts in captive breeding of the gold-lined spinefoot rabbitfish, *Siganus lineatus*, mark a significant milestone in India's brackishwater aquaculture landscape. Broodstock fishes underwent meticulous captive maturation, successfully spawned through hormonal induction within 14 hours. The fertilized adhesive eggs were hatched within 12-14 hours under optimal conditions of 28-30 ppt salinity and 27-29°C water temperature. Larval rearing protocols, initiated with rotifers and microalgae, witnessed key developmental milestones within 58-62 hours post-hatching. About 10,000 numbers of advanced larvae produced.

Induced breeding, larval rearing, and seed production of mangrove red snapper and grey mullet

Meticulous monitoring and management of mangrove red snapper broodstock within tank-based systems resulted in successful gonadal maturation, with a notable 70% male and 30% female population. Larval rearing techniques were implemented to achieve a surviving population of 10,000 larvae by the 15th day and reached a size of one inch by the 45th day. The hatchery supplied seeds to a self-help group for further nursery rearing, with fish reaching a size of 6-8 inches after 90 days. The captive breeding program for grey mullet maintained broodstock in both RCC tanks and earthen ponds. Three sets of breeding trials were conducted, resulting in successful breeding in one instance. Larvae were successfully reared up to 15 days post-hatch following the successful breeding attempt.

Influence of salinity on egg buoyancy and larval survival of grey mullet, *Mugil cephalus*

Research elucidates the critical role of salinity in egg buoyancy and larval survival of grey mullet, offering practical insights for the breeding programme. Eggs maintained at 25-35 ppt salinity exhibited optimal buoyancy and hatching rates, ensuring embryo viability and larval fitness. Notably, larvae reared under suitable salinity conditions displayed superior growth and survival rates, emphasizing the importance of environmental factors in larval-rearing protocols.

Captive breeding of goldlined seabream (*Rhabdosargus sarba*)

The initiative in captive breeding of Goldlined seabream, *Rhabdosargus sarba*, underscores its potential and adaptability for brackishwater aquaculture. Initial measures to enhance broodstock condition and induce spawning reflect progress towards large-scale seed production. While a breeding trial yielded spawning, further developments are underway to optimize captive conditions. The broodstock were strengthened by the addition of about 70 fishes with a size range of 120-850g.

Seed production of Asian seabass to cater to demand

The consistent efforts in Asian seabass, *Lates calcarifer* breeding and seed production contribute significantly to the aquaculture industry of the country. In the current year, the breeding trials resulted in the spawning of 3.24 million eggs with an average fertilization rate of 81% and a hatching rate of 82.6%. Of these, 1.6 million fertilized eggs were provided to private hatcheries. Additionally, 1 lakh seeds were distributed to farmers and generated total revenue of Rs 4.1 lakh.

Captive seed production of milkfish

With 35 milkfish *Chanos chanos* broodstock sourced from Chennai and Kakinada, averaging 6.6 kg, secondary broodstock lines were established. Notably, twelve new stocks from the Chennai coast further enrich the breeding pool. Successful spawning events yielded 2 lakh fertilized eggs and 1.5 lakh larvae, demonstrating the efficacy of the breeding program. The distribution of 17,526 milkfish fry to farmers across Kerala, Tamil Nadu, and West Bengal underscores the practical impact of this endeavour, generating revenue of Rs. 100,017.

Effect of dietary vitamin E on growth and maturity in silver moony

Understanding the pivotal role of vitamin E in fish reproductive physiology, a comprehensive 120-day study was conducted on its effects on silver moony, *Monodactylus argenteus* growth and maturity. The study was with different dietary vitamin E levels (0, 100, 200, and 300 mg/kg diet), and the fish fed with a 200 mg/kg diet exhibited optimal weight gain and maturity, with females showing heightened maturation rates. Notably, vitamin E supplementation initiated earlier gonad development, facilitating timely reproduction. These findings underscore the importance of dietary vitamin E supplementation, particularly at 200 mg/kg diet, in enhancing reproductive performance and growth in silver moony.

Development of base population for selective breeding on growth in pearlspot

The research on developing a base population for selective breeding in pearlspot aims to address the challenge of slow growth in this species. The study utilized within-family selection using five full-sib families (F0 generation) of pearlspot, with phenotypic data on body weight recorded over 360 days. An inter-family crossing experiment resulted in 11 crosses, fostering genetic diversity. The F1 families were cultured individually and fed with pearlspot fish feed, resulting in an estimated genetic gain of 8 to 9% in body weight over 240 days. The commercial impact of this research is evident, with 3551 pearlspot sold to farmers during the current year, generating a revenue of Rs 32,367/-.

Milkfish monoculture using stunted stock

Milkfish fingerlings were densely stocked in a pond and reared for a year with minimal feed, to produce stunted stock. Stunted yearlings of 17g average body weight from this population were then stocked at a lower density in a lined pond and fed CIBA Milkfish GrowoutPlus. Over 210 days, these stunted yearlings exhibited remarkable growth, reaching an average weight of 589.4 g and a total length of 42.08 cm, with a feed conversion ratio of 1.2 and a productivity of 5.5 tons per hectare. Notably, stunted yearlings showed significantly higher daily weight gain and specific growth rates compared to non-stunted fingerlings.

Demonstration of hapa based nursery rearing for seabass in Gujarat

Nursery rearing of seabass (10000 nos., 1.8-4.6 cm) in pond-based hapas was demonstrated at multispecies hatchery unit of Mayank Aquaculture Private Limited, Navsari, Gujarat. The demonstration resulted in an overall survival of 62%. The harvested fingerlings were sold @Rs. 30-50 per fingerlings to local fish farmers.

Demonstration of asian seabass cage culture in brackihswater creeks of Gujarat

Demonstration of seabass and pearlspot cage culture

in brackishwater creeks and ponds was demonstrated at Mendhar, Shil and Jafarabad villages of Gujarat along with local communities. In creeks, at Jafarabad and Shil, a total of eight GI pipe fabricated cages of size 4 x 4 x 2 m (32 m^3) were installed. The demonstration resulted in the harvest of 1400Kg of 250-500 g seabass. The SHGs at three sites generated a total income of Rs. 13.72 lakhs through sale of harvested seabass.

Optimising husbandry practices for pearlspot rearing in pond-based cages

Pearlspot fry (4000 nos, 2.5-3.5 cm) nursery reared for 120 days in hapas (5 nos. x 2 sets) were sized sorted to three groups viz., small, medium, and large and subsequently on grown for 60 days. The percentage of individuals falling in to the three size groups were near identical in both sets indicating a population structure dominated by medium sized individuals (53%) followed by large (27%) and small individuals (19%). Rearing of size sorted fish resulted in similar weight gain for all three size groups in one set (10.65-11.65), whereas in the other set medium and large group demonstrated similar weight gain (11.12-12.21) and the smaller fish resulted in significantly lower ($p<0.05$) weight gain (7.13 g).

Effects of varying Mg^{2+}/Ca^{2+} ratio on growth and survival of *P. vannamei* reared in inland saline groundwater

P. vannamei PL (~0.08 g) were reared in inland saline groundwater test media of varying Mg^{2+}/Ca^{2+} ratios viz., 0.5:1, 0.75:1, 1:1, 1.25:1, 1.5:1, 1.75:1, 2.0:1 (Salinity 10 ppt, total hardness 2900 ppm were constant across treatments). Results of the study indicated that Mg^{2+}/Ca^{2+} ratio of less than 1.25:1 significantly affects growth performance of *P. vannamei* and saline groundwaters of Mg^{2+}/Ca^{2+} ratio, 1.25:1 and higher can be used for commercial inland saline shrimp farming.

Growth and survival of *penaeus vannamei* in a mixed ion environment in freshwater of tds<500 ppm

A 30-day experiment was carried out to evaluate the production characteristics of *P. vannamei* juveniles (~0.29g) reared in FW (TDS<500 ppm) supplemented with varying combinations of potassium (K^+), magnesium (Mg^{2+}), and calcium (Ca^{2+}) ions. At the end of 30 days, final mean body weight did not significantly vary between the FW treatments. Survival rate followed a linear relationship with aqueous Mg^{2+} levels, whereas a bell-shaped pattern was observed for aqueous K^+ levels.

Captive broodstock development and breeding trials for grey mullet *Mugil cephalus* in gujarat

Grey mullet broodstock maintained at NGRC farm was employed for the breeding trials. During the first week of December, 2023 a total of 19 oozing males (590-1005 g) and 44 mature females (870–2010 g) with oocyte diameter of 442-562.2 µm were obtained during biopsy sampling. The breeding sets were induced using commercial GnRHa formulations and held in muslin cloth hapas in ponds. Partial spawning was observed in one breeding set although the eggs were not fertilised.

Effect of Plankton^{plus} and Poly^{plus} on high density and low-density shrimp farming

A shrimp farming demonstration was conducted at KRC to assess the combined effect of plankton booster (Plankton^{plus}) and Poly^{plus} feed at two different stocking densities 60/m^2 and 40/m^2. At the end of 112 days bodyweight of 16.3g and 17.54g and productivity of 3.73 t/ha and 3.37 t/ha was achieved in 60/m^2 and 40/m^2 density, respectively.

Nursery rearing of *Scylla olivacea* in earthen ponds for crablet production

A nursery rearing experiment was conducted for *Scylla olivacea* at KRC to study the feasibility of earthen pond-based crablet production. Scylla olivacea baby crabs with 0.5-1g were stocked at different stocking density viz 5,10 and 15/m^2. At the end of 80 days culture, crabs attained a bodyweight and carapace width of 7-17g and 34-45mm respectively with an average survival of 20-30%.

Effect of crab box dimensions on the growth and molting of the mud crab *Scylla olivacea*

Growth and molting of mud crab, *Scylla olivacea* was recorded in two different types of HDPE crab boxes (large and small). *Scylla olivacea* of size 75-85 g, with a carapace width 70-80 mm in the intermolt stage was stocked into the crab boxes. After 60 days of rearing, significantly higher molting population and survival was observed in the larger box. The dimension of the crab box has significant effect on the molting and

growth of box reared crabs.

Refinement of grow-out rearing protocol of hilsa

The nursery rearing protocol of the hilsa fry (9-10g) was refined with advanced nursery management protocols and Plankton^{plus} application. Formulated growout feed Hilsa^{Plus} (CP- 36.6%) was used as feed. After six months of growout culture, fish attained a body weight/body length of 46.60±2.02 g/ 16.78±0.24 cm.

Sphingobacterium sp. SDKRC- 13, a potential isolate for reduction of TAN and nitrite in fish and shrimp rearing tank system

Efficacy of *Sphingobacterium* sp. SDKRC-13, isolated from the root of the French bean (*Phaseolus vulgaris*) in reduction of total ammonia nitrogen (TAN) and nitrite was analyzed. Inoculum was added @ 8×10^7 CFU at 7 days interval in the *P. indicus* and *M. gulio* rearing tanks. The addition of *Sphingobacterium* spp. significantly reduced the TAN and NO_2 levels.

Probiotic potential of *Bacillus pumilus*

To develop a suitable probiotic bacterium for shrimp culture, bacterial isolates were screened for antagonistic activity against pathogens. *Bacillus pumilus* isolate was found to have antagonistic effect against *Vibrio campbellii, V. mimicus* & *Edwardsiella tarda* and also has immunomodulatory properties as indicated through upregulation of Prophenol oxidase gene (PoPO), Beta-glucan binding protein (BGBP) gene, and hemocyanin (Hc) genes in shrimps administered with *Bacillus pumilus*.

Closing the life cycle of Bengal Yellowfin seabream (*Acanthopagrus datnia*) in captivity

Induced breeding protocols was standardized for *Acanthopagrus datnia* in RAS facility at KRC of ICAR-CIBA, Kakdwip. Broodstock was reared with formulated feed (CP-40%, EE 14%) along with trash fish. Adult males and females with body weight >100 g could attain gonadal maturity in water salinity of 10 – 14 ppt and for spawning salinity was raised to 26 – 27 ppt. Females with oocyte diameters >450 µm was induced with standardized dose of 2000 IU/Kg body weight/ female to achieve 3-5 times repeated spawning. Fecundity of 1-2 lakh was observed for females of bodyweight 200-300 g. Newly hatched larvae measured 1.92-1.98 mm in length and mouth opening was observed after 50 hours.

Captive maturation and first-time ovulation in Green Pufferfish (*Dichotomyctere fluviatilis*) in captivity

43 adults of Green Pufferfish were reared in RAS and attained maturity in captivity. Mature oocytes ranged from 500 – 600 µm before spawning. Hormonal induction with a single dose of LHRHa (female: 100 µg/ kg body weight; male: 50 µg/ kg body weight) was provided and sex ratio of 1:3 (F:M) was maintained. Spawning occurred post latency period of 24 hours and fertilized eggs were translucent, demersal, slightly adhesive, and contained numerous oil droplets with a size of 730 – 820 µm.

Assessment of maturity in Tade mullet (*Liza tade*) under captivity

To assess the maturity of Tade mullet in captivity, sub-adults/adults (1, 2, and 3 years of age) were collected and stocked in earthen ponds. Mature oocytes were observed at 2+ years of age with a maximum size of 559.01± 10.19 µm during July month. Milting males (1 year age group) were observed during the June – July months.

Artificial breeding of hilsa (*Tenualosa ilisha*)

Artificial breeding was performed through dry stripping on boat using mature hilsa brooders collected from Hoogly river at Godakhali. Fertilized eggs were transported in oxygenated polythene bag and incubated at 24±1.0°C temperature. The fertilization and hatching rate were 95.62±0.44% and 70.30±1.64%, respectively.

Broodstock development of hilsa in brackishwater pond system

Sub adult hilsa (158.84± 12.50 g/ 22.85± 0.72 cm) were collected and maintained with Hilsa^{Plus} feed (CP- 36.6% & EE- 13.1%). Prior to breeding season functional feed (CP-42.52±0.03%, EE-14.47±0.03%) was applied. Gonadal maturation was observed in 80% of the fishes in the month of October. GSI of 9.74 and fecundity of 2,09,085-2,67,211 was attained in fish size range of 406-551 g.

Black soldier fly larval meal in shrimp feed

The effect of BSF larval meal was tested in *P. vannamei* and *P. monodon* juveniles by including at different levels. Experiment was conducted in in-door wet laboratory. The results indicated that the BSF larval meal can be included up

to 7.5% and 6% in *P. vannamei* and *P. monodon*, respectively.

BSF frass as an aqua ingredient

BSF frass is the by-product of the larval meal industry and it includes larval excrement, exoskeleton sheds and residual feed ingredients. Two different sources of frass were analysed for its nutrient composition and the results indicated that crude protein and ether extract content ranged from 18.82 to 23.44% and 0.56 to 3.65%, respectively. This frass can be incorporated in shrimp (*P. vannamei*) and milk fish (*Chanos chanos*) up to 5%. Frass has been tested for microalgal growth by testing at different concentrations. The results of the 6-day growth experiment showed that 0.7g/L gave better growth of *N. occulata* and 0.6g/L gave better growth of *C. gracilis*.

High health feed with Probiotic

High health functional feed was prepared with *Lactiplantibacillus plantarum* probiotic @1011 CFU/kg of the feed and tested for growth, immune status, gut microbiome in *P. vannamei*. The results indicated positive growth, higher digestive enzyme profile in the shrimp fed with probiotic. Rhodobacteraceae and Flavobacteriaceae were beneficial core microbiome bacterial signatures observed predominantly in the LLP supplemented diet. At the end of the five days of the challenge experiment, LLP recorded significantly low cumulative mortality (30%).

Captively reared rabbit fish (*Siganus* sp.) on functional broodstock feed successfully responded for induced maturation and spawning

Rabbit fishes present a potential for brackishwater farming, but obtaining hatchery-produced seeds remains a challenge. Specialized diets were fed to adult *Siganus javus* (n=120) and *Siganus lineatus* (n=23) for a year. In October, both species exhibited maturation in ovaries and testes. Hormonal induction was attempted in CIBA FCD hatchery, leading to successful spawning and hatching of *Siganus lineatus* in late October 2023.

Enrichment of copepods for betterment of its nutritional value as live feed

A specialized facility for copepod culture was established to improve larval survival in finfish larval rearing. Five copepod species were isolated from brackishwater and marine ecosystems using different techniques. Results indicated the highest growth (copepods per ml) in the treatment with Tetraselmis and FWH (40 ppm) together.

Marine polychaete culture

The marine Polychaete worms, *Perineris* spp. were collected from the seashore area of Maraikayar pattinam at Mandapam. Perineris spp was subjected for DNA extraction , and around 700 bp of cytochrome c oxidase subunit I (COI) genes were amplified with the help of primers polyLCO and then sequenced and identified as Perineris nuntia. On attaining maturity, the head region of a female turns green and that of the male white. The matured worms were stocked in a 1:2 ratio (male and female) in FRP tank containing filtered seawater for spawning with continuous aeration. The free-swimming metatrochophore larvae hatched out, but their survival was very low, and their further development as nectosaeta did not happen.

Solid state fermented soybean meal with *Bacillus subtlis* or *Saccharomyces cerevisiae* in shrimp feed

In order to increase its inclusion level, soybean meal was fermented with *Bacillus subtlis* or *Saccharomyces cerevisiae* in the pilot scale fermentor. Experimental diets were prepared by incorporating different levels of raw and fermented soybean meal. Growth trial results indicated that fermented soybean meal can be included up to 35% in the grow-out feeds of *P. vannamei* and fermentation has improved the growth by 9.5 and 8.7% with Bacillus and yeast, respectively.

Precision nutrition for optimization of dietary protein through nutrigenomics approach in shrimp

Shrimp feeds containing five crude protein levels prepared and tested in the juveniles of *P. vannamei*. There are around 114 DEGs common to low crude protein groups and 31 DEGs common to high crude protein groups. Overall, there are 23 DEGs differentially altered due to changes in the crude protein levels compared to control group. One of the notable observations in enriched KEGG pathways for low protein groups was down-regulation of the citrate cycle and pyruvate cycle. This suggests impairment of mitochondrial functions of generating energy when the animal is fed with low protein feed. The other metabolism related down-regulated pathways in low protein fed shrimp indicate

disturbed cellular processes due to insufficient amount of crude protein in feed.

Diversity of fungi in the gut of *Penaeus vannamei* cultured with high protein, low protein and Azola based diets in brackishwater ponds were studied

The total viable plate count (TPC) of fungi revealed that the low-protein feed administered group showed higher TPC of $1X10^4$ CFU/ml. A total of 43 fungi isolates were identified based on molecular tools. *Parasarocladium breve* and *Penicillium osxalicum* were the most abundant species found in the high protein feed administered groups. Sakaguchia oryzae was most abundant in the low protein feed groups.

Broodstock feed of hilsa has been fine-tuned

By considering the biochemical composition of captive hilsa ovary and fully matured (running phase) wild hilsa ovary. Nutritionally balanced formulated feed (CP-42.52 ± 0.03% & EE-14.47±0.03%) was supplemented for brood stock rearing of hilsa. After feeding of fine-tuned broodstock feed, it was found that 90-95% female and 95-100% male were at different stage of maturity in brood stock pond. Amino acid profile of gonad in captive hilsa was found to be superior compared to gonad of wild hilsa.

Nursery feed tested for hilsa by preparing two types of larval feed i.e., Feed-I (CP- 51.57±0.05%, EE-13.37±0.05%): prepared with ingredients of animal origin and Feed-II (CP- 49.35±0.17%, EE-11.14±0.02 Feeds were evaluated and performance was compared with commercially available zooplankton (*Calanus finmarchicus*) powder (CP-37.51±0.25%, EE-24.71±0.48%). After 90 days growth performance of fry was 18.07% and 99.71% higher in pond supplemented with larval feeds compared to zooplankton powder.

Upgradation of fish waste

was done by reduction of moisture content of Plankton^{Plus} at different temperature i.e., at 70 and 80°C . It was found that after 24, 48 and 72 hours of drying at 70 and 80°C, moisture (%) reduction of Plankton^{Plus} were 20.73±2.97, 56.83±1.41, 70.80±0.46; and 25.20±2.39, 63.67±1.67, 72.17±0.92, respectively. To dry the Plankton^{Plus} completely, it takes 168 h and 120 h, respectively at 70 and 80 ° C temperature. There were no significant changes in the proximate composition (CP, EE, CF, Ash%) of the product dried at different temperature.

Fishwaste was evaluated as value added product (Horti^{Plus}) in vegetable production in Potato and vegetable crops by conducting in plots

It was found that potato yield was better when Horti^{Plus} was applied in soil, though differences were not statistically significant (P>0.05). Similarly, Horti^{Plus} was evaluated in yield and quality of different winter vegetables. It was found that yield of every vegetable was better when Horti^{Plus} was applied in soil, however, nutrient content did not differ significantly.

Genome assembly and full-length transcript resource for red snapper

The genome of red snapper is deciphered which has a length of 1.04 Gb, assessed to be 97.2% complete and predicted to contain 31,969 protein-coding genes. The transcript resource contained 57,100 isoform-level transcripts belonging to 19,144 unique genes.

Genome sequencing of brackishwater aquaculture candidate species

The genetic resources is being generated by assembling and annotation of whole genome of candidate of potential candidate brackishwater aquaculture species such as gold lined seabream (Rhabdosargus sarba),blacktip trevally (*Caranx heberi*), long whiskers catfish(*Mystus gulio*). The species confirmation was carried out using COI barcoding primers resulting in 690 bp amplification product. The genome size estimation was performed using BD Accuri™ C6 plus flow cytometer (BD Biosciences, USA), using propidium iodide which revealed genome size of 0.96 pg (*Rhabdosargus sarba*), 0.5 pg (*Caranx heberi*), 0.69 pg (*Mystus gulio*).

Isoform-level full-length transcript resource for Pearlspot

Isoform-level full-length transcripts along with their isoform categories and alternative splicing events have been reported for six adult tissues (brain, gill, kidney, liver, muscle and spleen) and two developmental stages (1- and 15-day old larvae) of pearlspot fish.

Core transcriptomic responses in *Penaeus vannamei* exposed to different stress conditions

Meta-analysis of 21 individual bioprojects related to abiotic and biotic stress conditions in shrimp aquaculture revealed significant insights on core molecular mechanisms underlying these stress conditions. For abiotic stress, pathways tied to energy production and immune responses were highlighted, while detoxification and immune response pathways were emphasized for biotic stress. Stress regulatory motifs identified through this study could be a valid resource for developing stress amelioration mechanisms in *P. vannamei* culture.

Techno-economic assessment of aquaculture systems

Techno-economic analysis of on-farm nursery revealed that nursery grown seed had an advantage in terms crop duration and growth which facilitated the farmer to have more than two crops and plan their crop vis-à-vis market demand. Similarly, adoption nursery helped in ensuring quality seed for grow out, efficient feed management, reducing manpower and energy cost thereby increases the technical efficiency of shrimp farming.

Integrated Multi-Trophic Aquaculture (IMTA) model comprised of seabass fish, seaweed and mussel farming demonstrated for the livelihood development of fisher families exhibited that both mussel and seaweed culture complimented the seabass farming with potential environmental benefits. The IMTA model was found to be income generative and economically viable.

Technology impact assessment of Asian seabass faming has shown that the key economic parameters viz. return on investment, benefit-cost ratio, internal rate of returns and technical efficiencies for the three different seabass fish production systems: nursery, pond and cage farming were estimated to be high and indicated that all the three systems are economically viable and technical efficient by converting the inputs to the output over 80%.

Market and trade analyses revealed that export performance of shrimp indicated that India's shrimp exports declined by 5.9% in dollar value and 2.3 per cent in quantity in 2023-24 vis-à-Vis 2021-22. The exports to USA declined by 19.5% compared to last year which was mainly due to competition from Ecuador.

Fishers' perceived that fish waste-to-wealth technology of CIBA has the potential in cleaning the fish markets, minimizing the environmental problems generated by the high amount of fish waste and could be an alternative livelihood activity for them on circular economy mode.

Aquaculture development and policy interventions

Shrimp crop insurance products developed with the technical support of ICAR-CIBA by the Oriental Insurance Company Ltd. and Agricultural Insurance Company Ltd. were launched and received a positive response from the shrimp farmers of Tamil Nadu and Andhra Pradesh with the availing of 650 policies from both the companies.

Shrimp aquaculture stakeholders were not adequately informed of fish farmer producer organization scheme of Govt. of India. Case studies on FFPOs functioning in fisheries sector revealed that they have the potential to enhance the farmers' bargaining power and efficiency in the fish food value chain. Therefore, a mass campaign to sensitize shrimp farmers on the merits of FPO scheme across the states, direct involvement of institutions working with shrimp farmers, relaxations in the FFPO member size, share capital requirements and credit guarantee ceilings would promote FFPOs in shrimp farming sector.

Influence of ageing on aquaculture pond soil fertility

The study on the effect of aquaculture pond ageing on soil fertility showed that the fertility status of aquaculture ponds deteriorated with ageing. Fresh ponds are highly fertile with the nutrient index of more than 1.75.

Risk and vulnerability assessment indicators

Indicators for risk and vulnerability assessment of brackishwater aquaculture to climate change was assessed as per AR5 of IPCC methodology, considering three pivotal factors viz., hazard, exposure, and vulnerability.

Effect of temperature on reproductive performance of pearlspot during winter months

The experiment on the effect of continuous exposure to elevated temperature (32^0C) on the reproductive performance of pearlspot during November to January period observed spawning inside earthen pots. This finding provides the lead to

develop a protocol for off-season breeding of pearlspot.

Effect of different salinities on milkfish hatching, larval survival & deformities

An experiment on the effect of different salinities on milkfish hatching, larval survival & deformities reported that the preferred salinity was 30-35 ppt with an average hatching rate of 75% without any noticeable deformities.

Impact of rainfall pattern variability

Impact of rainfall pattern variability on changes in water quality, immune parameters and incidence of white spot syndrome virus in shrimp growing environment indicated the need for the implementation of BMPs immediately after heavy rains to reduce stress to shrimp.

Growth characteristics of *Penaeus vannamei* and *Penaeus monodon* in commercial shrimp farms during heat wave period

During the heat wave period, the average daily growth rate of *P. vannamei* and *P. monodon* were significantly lower as compared to normal temperature periods. Prolonged heat wave conditions make shrimp susceptible to diseases.

Trends in surface weather parameters of coastal India and implications for brackishwater aquaculture

A generated heat map illustrated the spatial distribution of coastal grid mean values, complemented by future scenarios for 2020, 2050, and 2080 under RCP 4.5. These projections are useful in planning crop calendar activities such as pond preparation, species stocking and harvest.

Evaluating the environmental footprint of shrimp processing through Life Cycle Assessment approach

The environmental footprint of shrimp processing was evaluated through Life Cycle Assessment approach. The calculated emissions per ton of shrimp were 433 kg CO_2eq (global warming potential). Energy use through electricity emerged as the primary contributor to global warming potential.

Alternate energy scenarios to decrease global warming potential (GWP) from shrimp processing plant

Installation of photovoltaic panels in shrimp processing plants decreases GWP. The GWP was 339 kg CO_2eq with 50% PV and 222 kg CO_2eq with 100% PV compared to 433 kg CO_2eq under the typical conditions of complete grid electricity per ton of shrimp.

Activity of methane oxidising bacteria

Methane oxidising bacteria isolated from different environments with salinity ranging between 0 to 38 ppt were screened for the soluble methane monooxygenase activity.

Calibration of sensors and deployment of water buoy with sensor modules to test its efficiency

An aqua buoy prototype was developed with calibrated sensors mounted on it and deployed in the hatchery and culture systems to test the buoyancy and accuracy of the sensors. The captured data from the aqua buoy was compared with manual measurements. Deep learning support system methodology, architecture for water health classification and an android-based application have been developed to alert the farmers and provide specific advisories.

Genotyping and virulence analysis of white spot syndrome virus

With increasing number of White Spot Syndrome Virus (WSSV) sequences reported, WSSV shows high genetic variability with variable genome size. The primers based on Missing Regions Finder (MRF), were used for genotyping WSSV infected samples of Penaeus indicus. Genotyping of WSSV would help to study the molecular epidemiology, and to carry out precise diagnosis and control.

Estimating the dose (copy number) of WSSV in shrimp for disease reversal

An experiment was conducted in *Penaeus vannamei* shrimp to study the virulence pattern of WSSV. The viral copy number in gill and pleopod was estimated, the gill from 10^6 group gave positive signal from 24 hrs onwards indicating that the gill tissue is more appropriate for early WSSV diagnosis. The experimental groups inoculated with 10^1, 10^2 and 10^3 did not had mortality, however, 10^6 group had mortality from 6 hrs onwards.

Flow cytometry analysis of the immunological response of WSSV-infected *P. indicus* shrimp

Flow cytometry was used to analyse the immunological response of WSSV-challenged *P. indicus* shrimp, exposed

to different temperatures of 27 °C, 30 °C and 33 °C. The shrimp samples were collected at different time points viz., 12 hours post challenge (hpc), 24 hpc, and 48 hpc and used for flow cytometry analysis for cytoplasmic free Ca^{2+} concentration, respiratory burst activity, cell cycle analysis, apoptosis and phagocytosis. The present study indicates variations in the immunological response during course of WSSV infection in shrimp exposed to different temperature conditions.

Prevalence of *Enterocytozoon hepatopenaei* (EHP) in *Penaeus monodon* farms and its infectivity

A survey was conducted in 62 farms to understand the prevalence of EHP in *P. monodon* across Andhra Pradesh, Tamil Nadu, West Bengal, Gujarat and Kerala. The analysis revealed the prevalence of 30.6% (19/62 farms) with 94.7% of positive farms tested only in nested PCR level. Farms from West Bengal had the highest prevalence of EHP (53.85%; 7/13 farms). Challenge experiments in *P. monodon* and *P. vannamei* by oral infections revealed that the *P. monodon* is comparatively less susceptible to EHP compared to *P. vannamei*.

Susceptibility of crab species to *Enterocytozoon hepatopenaei* (EHP)

Hepatopancreatic microsporidiosis (HPM) and vibriosis caused by the microsporidian parasite EHP and *Vibrio* spp., respectively with slow growth, size variation, white feces syndrome (WFS) and mortality are considered to be important diseases in shrimp aquaculture. Hence, Multiple-dose oral challenge and susceptibility study experiment was conducted in crab species to understand the multiple interactions of hosts and pathogens. qPCR analysis of hepatopancreas (HP) revealed that there was very low level of EHP load with consistent decrease up to 42nd dpc and reaching zero after 42nd dpc. It is suggestive of no establishment and/or no proliferation of EHP spores in HP tissues in crab species.

Study on the shrimp species variation in susceptibility and resistance against *Enterocytozoon hepatopenaei* (EHP)

Multiple-dose oral challenge and susceptibility study experiment was conducted in juveniles of three economically important shrimp species such as *P. indicus, P. monodon* and *P. vannamei*. Quantitative PCR analysis of HP collected from different species of shrimp revealed that there was significant difference in EHP load. EHP copies in HP of *P. vannamei* was highest ($64.35x10^6$ copies g^{-1} of HP tissue) on 42nd day of experiment followed by $1.61x10^6$ copies g^{-1} of HP in *P. monodon* on 35th day and the least EHP load in HP of *P. indicus* was $0.02x10^6$ copies g^{-1} of HP tissue during entire 42 days of experiment.

Pathogenicity of *Vibrio parahaemolyticus* from White feces syndrome (WFS) affected shrimp

White feces syndrome (WFS) has emerged as major problem in shrimp culture worldwide. Compared to earlier reports of association of EHP with WFS, recent reports associated vibrios and other bacterial species along with EHP. Therefore, to understand the role of bacteria, a series of eight challenge trials were conducted with bacterial isolates originated from WFS ponds and isolates before the reports of WFS. The analysis suggests that bacterial isolates especially *V. parahaemolyticus* originated from the WFS affected ponds results in consistent mortality up to 15 to 25% by bath immersion in shrimp juveniles.

Prophylactics and therapeutics against EHP and *Vibrio* spp.

EHP in association with other opportunistic bacteria causes severe growth retardation, WFS and mortality leading to severe economic losses in shrimp farming nations. Three herbal extracts were found to be effective against Vibrio spp. They were green synthesised in to nanoparticles with tissue recognition ligands to increase their water solubility, absorption, bioavailability and longer half-life. In another study, different potential natural therapeutics were also evaluated for the treatment and control of EHP.

Assessment of the efficacy of silymarin compounds as hepatoprotectant in shrimp against EHP and co-infection with *Vibrio* spp.

EHP damages the HP resulting in impaired nutrient metabolism leading to clinical signs such as size variation, growth retardation, secondary bacterial infections and mortality. Hepatoprotectant such as silymarin compounds with cellular regeneration capacity was proved to prevent or reverse the hepatotoxicity

in animals and fishes. Hence the study was aimed to assess the efficacy of silymarin as feed supplementation in prevention and/or treatment of EHP infection in shrimp.

Prophenoloxidase activating peptidase interact with spore wall proteins (SWPs) of EHP

Spore wall proteins (SWPs) of microsporidians interact directly with host cells during infection and play important roles in host cell adhesion, ion channels, energy transfer, signal transduction, and enzymatic reactions. In silico protein-peptidase interaction study identified bio-enzymes (peptidases) against EHP SWPs to reduce the infection and spread in the target organ of *P. vannamei*.

Field evaluation of *E. hepatopenaei* (EHP) therapeutic CIBA EHP cura I

ICAR-CIBA developed 'CIBA EHP cura I' for the treatment and control of EHP. 'CIBA EHP cura I' is a combination of natural product and nutritional supplements which significantly reduced the EHP load and improved the shrimp immunity and growth in both lab and fields. Field evaluation of CIBA EHP cura I has been initiated in shrimp farms of Nagapattinam, Thiruvallur districts of Tamil Nadu, Bapatla and Bhimavaram districts of Andhra Pradesh and Navsari district of Gujarat. Around 1500 litres of CIBA EHP cura I have been used for the field evaluation and a revenue of Rs 7,47,450 has been generated.

Development of point of care diagnostics for the detection of major shrimp pathogens WSSV and EHP

For the development of EHP lateral flow immune assay, EHP spores were purified from EHP infected shrimp HP. The complete sequence of EHP SWP gene has been amplified, and cloned into pGEX-6P-1 by infusion cloning method. The purified recombinant SWP was concentrated and used for the polyclonal antibody production.

Application of gene editing technologies (CRISPR/Cas) for disease diagnosis

WSSV TATA box targeting gene was successfully cloned and the copy number was normalized, serving as a template for the CRISPR/Cas12 assay. The clones were verified through sequencing, and a standard curve of WSSV was established using quantitative reverse transcription polymerase chain reaction (qRT-PCR). Subsequently, in vitro transcription was conducted, and the amplified region of interest was detected using CRISPR/Cas12a. Trans-cleavage activity of CRISPR/Cas12a was standardized using a FAM-BHQ1-labeled reporter assay.

Development of multiplex LAMP assay for WSSV and EHP

ICAR-CIBA developed a multiplex LAMP for the simultaneous detection of EHP and WSSV. LAMP primers had been designed using VP28 region for WSSV detection and SWP region for EHP detection. This multiplex LAMP is a closed tube LAMP and did not cause cross contamination. It has been performed in a simple dry bath and do not need any expensive equipment. It can detect both WSSV and EHP up to 10 copies in 45 minutes.

Development of probiotics and immunostimulants for shrimp

Microbial strains were isolated from natural environment and culture systems and screened for potential bioremediation properties. Fifteen of the 34 isolates demonstrated amylase (starch), protease (gelatin and skim milk) and lipase (tributyrin and tween 80) activities. The efficiency in utilisation of ammonia and nitrite were assessed using media containing 10 ppm of ammonia and nitrite.

Development of species-specific quantitative real time PCR for important *Vibrio* species

Harveyi clade constitute a group of 13 closely related species of Vibrios namely *V. harveyi, V. campbellii, V. parahaemolyticus, V. alginolyticus, V. owensii, V. rotiferianus, V. natriegens, V. jasicida, V. diabolicus, V. aquamarius, V. sagamiensis, V. azureus* and *V. mytili*. Many of these species are pathogen of great importance in shrimps and finfishes. Therefore, to understand their pathogenesis and develop diagnostic markers whole genome sequences of these 13 species comprising 2244 isolates were analyzed.

A first report on mortalities associated with polyopisthocotylean monogenean, *Polylabris* sp. (*F. microcotylidae*) in captive stock of *Siganus javus*

Monogeneans are parasitic flukes in aquatic animals with high host specificity. Recurrent mortalities in wild collected Java rabbit fish were investigated. Morphological identification has shown their

close morphological similarity to polyopisthocotyledon of *F. Microcotylidae, Polylabris* sp. reported from *Siganus javus* from Visakhapatnam coast of India and the molecular characterisation of 28S rRNA gene of the monogenean revealed its 99.67% identity to *P. mamaevi* from Gulf of Oman, Arabian sea.

Disease Surveillance in *P. vannamei* shrimp farms at Thiruvallur district of Tamil Nadu

During 2023, 71 shrimp samples were collected from 30 *P. vannamei* farms in Thiruvallur district of Tamil Nadu. These farms were screened for WOAH (OIE) listed shrimp pathogens. Thirty six percent farms were infected with EHP, eight percent with IMNV and five percent with WSSV. The overall disease prevalence was found to be more during the month of June.

Immunomodulators were effective in providing higher growth and disease resistance to *P. vannamei*

The aim of the project was to determine effective dosage of immunomodulators (prebiotics, probiotics and immunostimulants) for providing better growth and disease resistance. The gene expression studies for immune and growth genes revealed that higher level of expression in all experimental groups as compared with control. The metagenome results clarified the abundance of more bacterial family in the gut of experimental animal than in control.

Development of microalgae based improved delivery method for control of shrimp WSSV in culture ponds

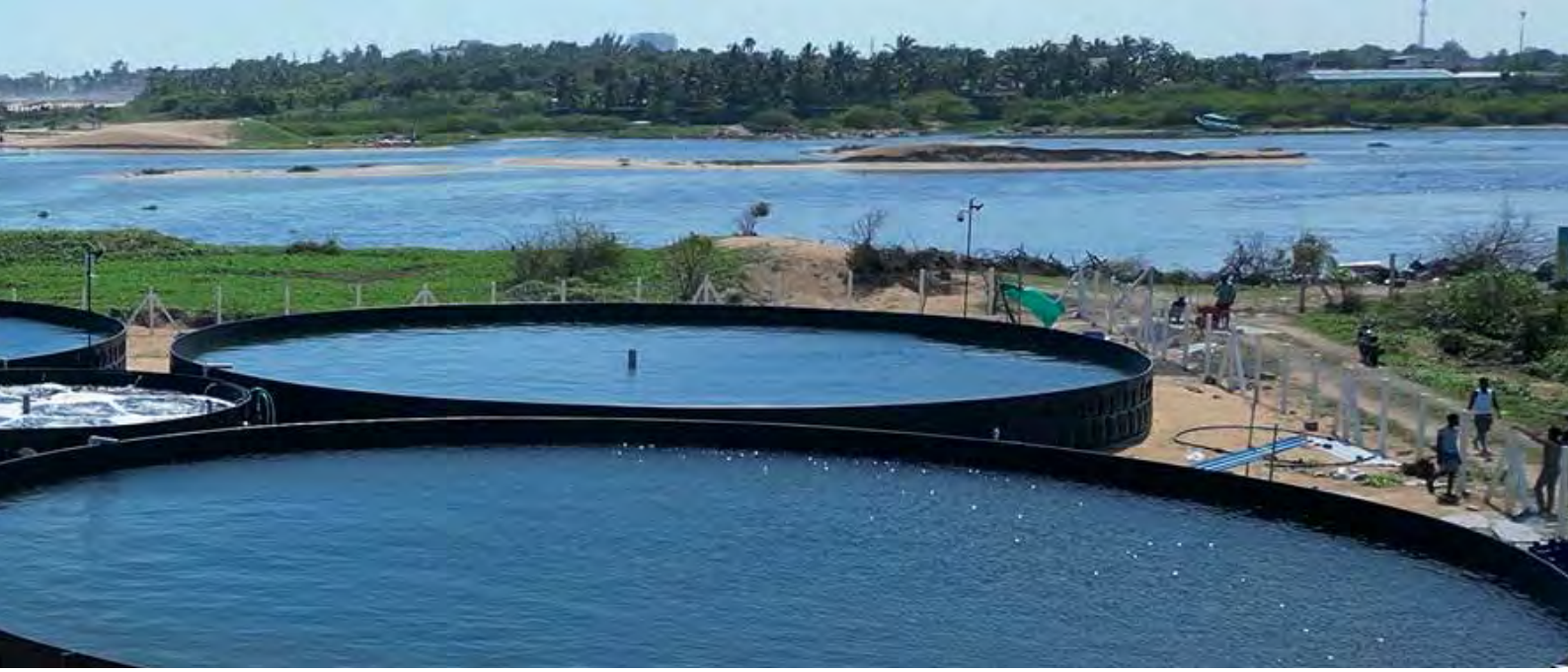
The aim of the project was to develop an algal based field delivery method for the treatment of WSSV. VP28 gene of WSSV was subjected to codon optimization based on microalgae sequence and restriction site insertion. The optimised sequence was synthesised custom made for further use. After PCR amplification, the same was restriction digested and ligated to the algal vector.

INTRODUCTION

The uniqueness of brackishwater ecosystem is equally challenging for the development of aquaculture practice . While both the land and water resource here are otherwise unusable for regular activities, these are most suitable for highly profitable aquaculture practice. As this ecosystem are frequently subjected to fluctuations, aquatic animals come under severe stress and therefore effectively equipped with specific biological molecules in the form of proteins, minerals, hormones etc to deal with the stress. This makes them nutritionally enriched and preferred seafood item usually having high economic value. Considering such importance of this ecosystem, Indian Council of Agricultural Research (ICAR) decided to further concentrate on it and expand the research activity and established Central Institute of Brackishwater Aquaculture (CIBA) in 1987 with its head quarter at Chennai, Tamil Nadu. The institute has also experimental stations at Muttukadu and recently expanded at Kovalam in Chennai. Apart from this, two regional stations, one at Kakdwip, West Bengal and other at Navsari, Gujarat are also located to cater the regional research need at east and west coast of India respectively. In this way, the institute tries to spread its research activities to maximum brackishwater ecosystem areas throughout India.

A significant amount of Indian seafood production is contributed by brackishwater sector. While brackishwater aquaculture has been synonym to shrimp production, finfish aquaculture is also picking up and contributes to the total production. Additionally, the system also provides a wide scope for diversity with the inclusion of mussel, seaweed etc. During 2022-23, Indian marine product export value reached all time high with $8.09 billion. In this frozen shrimp occupied a major share with a value of $5.48 billion from an amount of 7.1 lakh tons. However, the total farmed shrimp production during 2023 was more than 6 lakh tons. Farmed shrimp production is increasing steadily in spite of many hurdles. Though India has a huge potential for aquaculture expansion in brackishwater sector, only it has been subjected to partial utilization. As per the estimation, an area of 1.2 million ha is directly available from brackishwater coastal region. Additionally, substantial inland saline areas are also available from several states like Rajasthan, Punjab, Haryana, Uttar Pradesh etc. In this way, the sector has a huge scope for expansion and increase overall production to meet the demand of ever increasing world population. In addition to several other issues, disease continues to occupy as the primary hurdle and brings loss to Indian shrimp aquaculture. While the industry continues to feel the effect of white spot syndrome virus (WSSV), *Enterocytozoon hepatopenaei* (EHP) and white gut syndrome, emerging pathogens also show their effect.

As a premier research organization in the area of brackishwater sector, ICAR-CIBA has been playing major role for the overall improvement of aquaculture and ancillary activities of this sector. Supply of vannamei broodstocks appears to be a major issue for increased seed production and meet farmers demand. ICAR-CIBA has participated and provided major inputs for the risk assessment of importing



brooders from the South East Asian countries and suggested to resume the import with special precautions by applying modified protocols. Species diversity is also another aspect on which ICAR-CIBA has been providing major stress and in this direction work on indigenous species, *Penaeus indicus* is progressing well. Lack of insurance for shrimp famers was a major hurdle and ICAR-CIBA has put considerable effort to bring back affordable shrimp crop insurance for the farmers. In this way it is expected that the industry will have a better progress during the coming years.

During the last year, ICAR-CIBA has put considerable effort on several burning research issues to increase production, improve livelihood and introduce new technologies. While the focus has been on species diversity both for finfish and shrimp, work on other organisms like brackishwater sea weed is progressing well. Culture of indigenous species, *Penaeus indicus* in farmers ponds was taken up which was found to be very encouraging. Genetic improved programme of this species is also progressing well. Newer culture technology like smart aquaculture was conducted on experimental basis which also looks very promising. This is particularly important from disease point of view as it is a land based system and many aspects of its will be under control conditions. Additionally, efforts have also been initiated on the use of advanced technologies like sensor based water monitoring systema and possibility of using artificial intelligence in aquaculture. Genome based editing for improvement of growth and pathogen detection has also been initiated in the institute. Genome information of some of the brackishwater species has successfully been decoded which will help in designing methods for breeding as well as culture aspects. Sophisticated laboratory for quick and accurate detection of pathogens was developed and got accredited by NABL. A lot of inputs were also provided in policy decision matters to state as well as central Govt bodies.

The primary intension of ICAR-CIBA has been to focus and introduce newer and advanced technologies for seed production, feed development, culture and disease prevention. In this way the institute's primary aim has been to achieve sustainability in brackishwater aquaculture. This will ultimately help in increasing economy, providing more employment and increasing nutritional security. To achieve this goals ICAR-CIBA has been constantly and continuously working on laboratory field oriented based research aspects as well as providing valuable inputs for taking policy decisions by authorities associated with aquaculture. For all its activities, the institute always tries to go hand-in-hand with the farmers and stake holders to achieve the success.

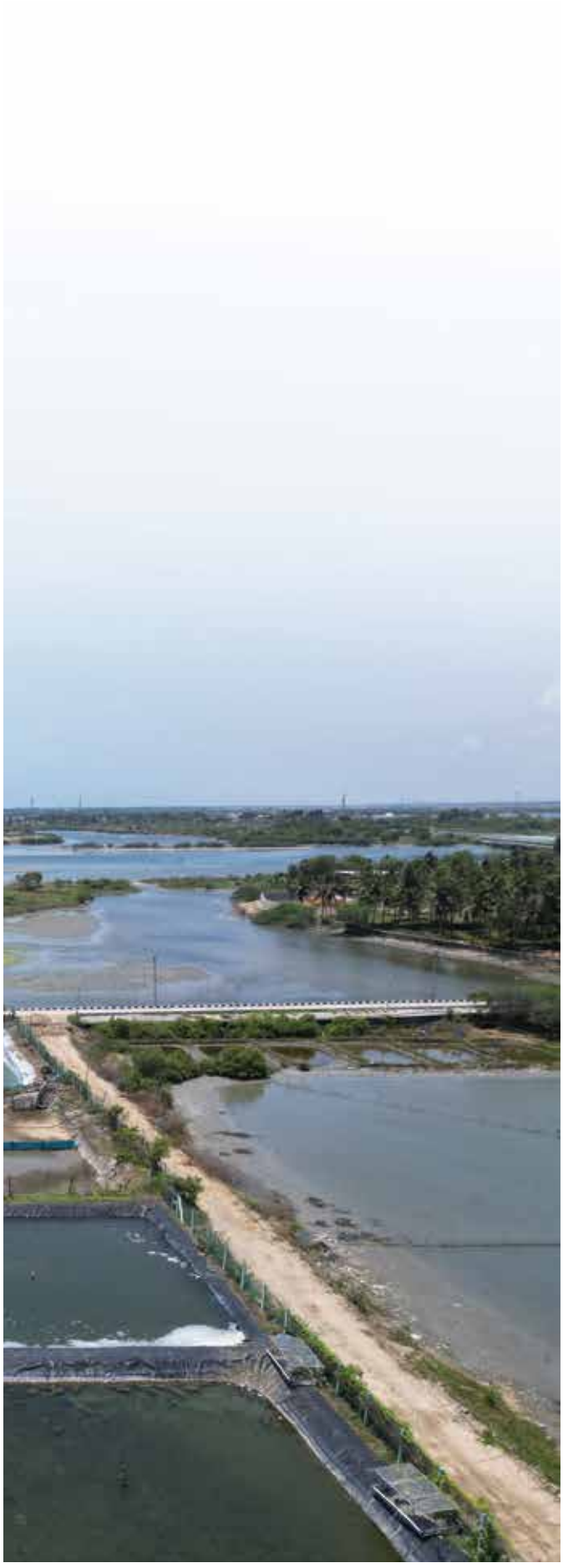
Through this annual report, ICAR-CIBA has tried to compile all the relevant activities those have been tried for overall progress in brackishwater aquaculture during the last one year. In addition to the main research activities, it has also compiled all the aspects related to infrastructure development, arrangement of meeting and training programmes for farmers, stake holders and researchers and conducting several other activities as per institute mandate. It is expected that this document will provide overall insight on the several institute activities.

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.



MANDATE

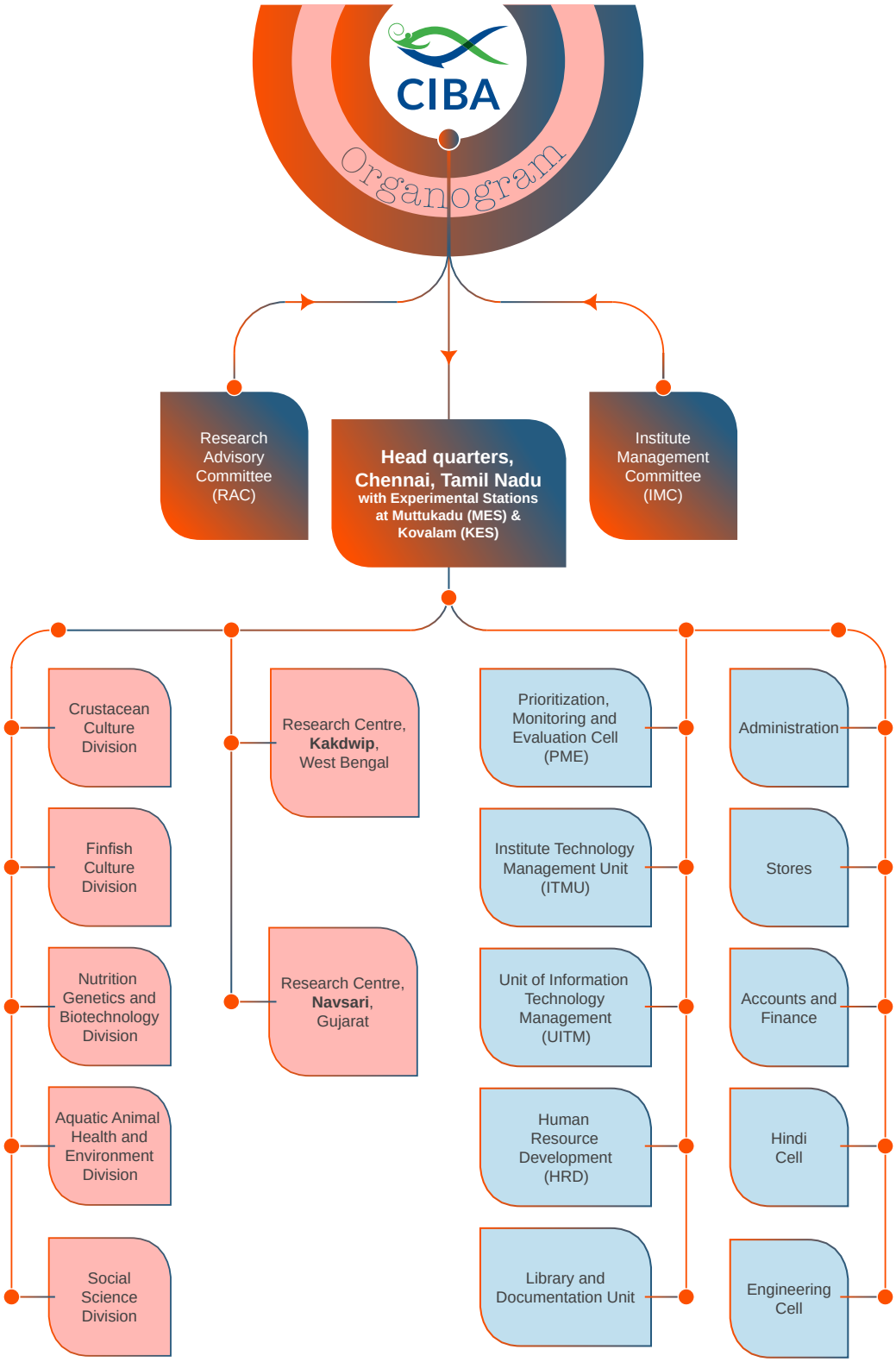
• Basic, strategic and applied research for techno-economically viable and sustainable culture systems for finfish and shellfish in brackishwater.

• Species and systems diversification in Brackishwater aquaculture.

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

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

ORGANOGRAM


CIBA
Organogram
Research Advisory Committee (RAC)
Head quarters, Chennai, Tamil Nadu
with Experimental Stations at Muttukadu (MES) & Kovalam (KES)
Institute Management Committee (IMC)
Crustacean Culture Division
Finfish Culture Division
Nutrition Genetics and Biotechnology Division
Aquatic Animal Health and Environment Division
Social Science Division
Research Centre, Kakdwip, West Bengal
Research Centre, Navsari, Gujarat
Prioritization, Monitoring and Evaluation Cell (PME)
Institute Technology Management Unit (ITMU)
Unit of Information Technology Management (UITM)
Human Resource Development (HRD)
Library and Documentation Unit
Administration
Stores
Accounts and Finance
Hindi Cell
Engineering Cell

UNIFIED BUDGET 2023-2024

S.No.	Sub-Head	RE 2023-24	Expenditure upto 29.02.2024
	Grants for creation of Capital Assets (CAPITAL)		
1	Works		
	i. Office building	52.04	52.04
2	Equipments	148.03	84.92
2	Information Technonogy	39.24	28.22
3	Library Books and Journals	1.52	1.52
4	Vehicles & Vessels	13.44	13.44
5	Furniture & Fixtures	15.73	3.26
6	Total Capital (Grants for creation of Capital Assets)	**270.00**	**183.40**
7	Grants in Aid - Salaries (Revenue)		
	Estabilishment Expenses		
1	(A) Salaries		
	i. Establishment charges	2711.19	2702.45
	Total -Establishment Expenses (Grants in Aid-Salaries)	**2711.19**	**2702.45**
	Grants in Aid - General (REVENUE)		
2	Pension & Other Retirement Benefits	**2610.33**	**2597.55**
1	Traveling Allowance		
2	(A) Domestic TA/Transfer TA	40.00	36.73
	Total - Travelling Allowances	**40.00**	**36.73**
	Research & Operational Expenses		
3	(A) Research Expenses	164.00	106.27
	(B) Operational Expenses	200.00	186.92
	Total - Res. & Operational Exp.	**364.00**	**293.19**
	Administrative Expenses		
4	(A) Infrastructure	290.00	280.39
	(B) Communication	3.00	1.96
	(C) Repairs & Maintenance		
	i. Equipments, Vehicles & others	60.00	33.86
	ii. Office building	80.00	72.83
	iii. Residential building		
	iv. Minor Works	30.00	21.69
	(D) Others (excluding TA)	172.00	171.34
	Total - Administrative Expenses	**635.00**	**582.07**
	Miscellaneous Expenses		
5	A. HRD	16.00	11.53
	B. Other Item (Fellowships, Scholarships etc.)		
	C. Publicity & exhibitions	10.00	6.93
	D. Guest House - Maintenance	5.00	0.74
	E. Other Miscellaneous (TSP)	100.00	85.33
	F. Other Miscellaeous (SCSP)	150.00	137.06
	Total - Misellaneous Expenses	**281.00**	**241.59**
	Total Revenue (Grants in Aid-salaries + Grants in Aid - General)	6641.52	6453.58
	Grand Total (Capital + Revenue)	**6911.52**	**6636.98**
	AINP - FH Project	**250.00**	**221.19**
	Grand Total	**7161.52**	**6858.17**

STAFF POSITION

CADRE STRENGTH OF CIBA AS ON 31.12.2023

Position	Sanctioned	Filled	Vacant
Director (R.M.P)	1	1	0
HOD	4	4	0
HoRs	1	1	0
Principal Scientist	2	0	2
Sr. Scientist	14	7	7
Scientist	52	47	5
Technical Officers/ Technical Assistant	31	19	12
Chief Administrative Officer	1	1	0
Senior Administrative Officer	1	0	1
Administrative Officer	1	1	0
CFAO/Dy. Director Finance	1	0	1
Senior Finance & Accounts Officer	1	1	0
Assistant Finance & Accounts Officer	1	1	0
Assistant Administrative Officer	4	3	1
Principal Private Secretary	1	0	1
Private Secretary	2	1	1
Personal Assistant	3	2	1
Assistant	13	2	11
Upper Division Clerk (UDC)	5	3	2
Lower Division Clerk (LDC)	6	3	3
Skilled Support Staff (SSS)	30	8	22
TOTAL	**175**	**105**	**70**

Position	Sanctioned	Filled	Vacant
DIRECTOR	1	1	0
SCIENTISTS (HOD/HORs/PS/Sr.Sci./Sci)	73	59	14
TECHNICAL	31	19	12
ADMINISTRATION	40	18	22
SSS	30	8	22
TOTAL	**175**	**105**	**70**

RESEARCH PROJECTS

IN-HOUSE PROJECTS

S.No	Project Code	Project Title	Principal Investigator	Associated scientists
Crustacean Culture Division				
1.	FISHCIBASIL 202300100152	Evaluation of aquaculture potential of diversified crustacean species: *Penaeus japonicus, Scylla* spp and ornamental crustaceans	Dr C.P. Balasubramanian	Dr P. Nila Rekha Dr Shyne Anand, Dr Raymond Jani Angel, Shri R. Aravind, Shri C. Siva
2.	FISHCIBASIL 202300200153	Amelioration of soil and water under different geographical regions for sustainable aquaculture production	Dr R. Saraswathy	Dr C.P. Balasubramanian, Dr M, Jayanthi, Dr Akshaya Panigrahi, Dr Satheesha Avunje Shri R. Aravind, Dr M. Muralidhar Dr T. Ravisankar, Dr K. Ambasankar, Dr M. Kumaran Dr P Kumararaja, Shri Jose Antony, Shri Pankaj Amrut Patil, Dr Moumita Ash
3.	FISHCIBASIL 202300300154	Captive broodstock development and induced maturation techniques of kuruma shrimp, *Penaeus japonicus* Form II through hormonal/ environmental & dietary approaches	Dr Shyne Anand	Dr C.P. Balasubramanian, Dr J. Raymond Jani Angel, Shri C. Siva, Dr T. Sivaramakrishnan,
Finfish Culture Division				
4.	FISHCIBASIL 202300400155	Upscaling the breeding and seed production of grey mullet (*Mugil cephalus*) and Magrove Red snapper (*Lutjanus argentimaculatus*)	Dr M. Kailasam	Dr R. Jayakumar, Dr T. Senthil Murugan, Dr M. Makesh Dr Aritra Bera, Shri Dani Thomas, Dr K. P. Sandeep, Dr T. Sivaramakrishnan, Dr R. Subburaj
5.	FISHCIBASIL 202300500156	Characterizing and developing the indigenous fish cell lines to prove stemness and proliferation in seafood cell culture	Dr M. Makesh	Dr Kuldeep Lal K, Dr T Bhuvaneswari, Dr Aritra Bera, Dr N. Lalitha
6.	FISHCIBASIL 202300600157	Application of assisted reproductive techniques in breeding programmes for *Lates calcarifer*	Dr Sherly Tomy	Dr Kuldeep Lal K, Dr M. Kailasam, Dr M. Makesh , Dr T. Senthil Murugan, Dr B. Sivamani, Dr Aritra Bera, Shri Dani Thomas, Dr R. Subburaj, Dr K. Ambasankar, Dr T. Bhuvaneswari
7.	FISHCIBASIL 202300700158	Broodstock development and captive maturation of Streaked spine foot *Siganus javus* & *S. lineatus*	Dr R. Jayakumar	Dr K.P. Kumaraguru Vasagam, Dr M Kailasam, Dr Sherly Tomy, Dr K.P. Sandeep, Dr Aritra Bera, Shri Dani Thomas;
8.	FISHCIBASIL 202300800159	Optimization of larval rearing protocol and mass scale seed production of Goldlined Seabream *Rhabdosargus sarba*	Dr T. Senthil Murugan	Dr K.P. Sandeep, Shri Dani Thomas
9.	FISHCIBASIL 202300900160	Development of base population for selective breeding on growth in pearlspot	Dr B. Sivamani	Dr M. Kailasam, Dr Aritra Bera, Shri Dani Thomas, Dr T. Sivaramakrishnan, Shri Pankaj Amrut Patil, Shri Jose Antony
10.	FISHCIBASIL 202301000161	Reliable seed production of brackishwater finfishes Seabass (*Lates calcarifer*), Milkfish (*Chanos chanos*) Mono angel (*Monodactylus argenteus*)and Scat (*Scatophagus argus*)	Dr R. Subburaj	Dr Aritra Bera, Shri Dani Thomas

Aquatic Animal Health & Environment Division				
11.	FISHCIBASIL 202301100162	Genotyping and virulence analysis of white spot syndrome virus	Dr M. Shashi Shekhar	Dr Subhendu Kumar Otta, Dr P. Ezhil Praveena, Dr M. Poornima, Dr T. Sathish Kumar,
12.	FISHCIBASIL 202301200163	Evaluation of stress mediated immunological and physiological response in brackishwater candidate species by flowcytometry	Dr M. Shashi Shekhar	Dr M. Muralidhar, Dr P.K. Patil, Dr Sujeet Kumar, Dr P .Kumararaja
13.	FISHCIBASIL 202301300164	Application of gene editing technologies (CRISPR/Cas) for disease diagnosis	Dr M. Poornima	Dr Sujeet Kumar, Dr J. Joseph Sahaya Rajan
14.	FISHCIBASIL 202301400165	Interaction of *Enterocytozoon hepatopenaei* (EHP) and *Vibrio* spp. in disease outcome and their therapeutics	Dr R. Ananda Raja	Dr K. P. Jithendran, Dr Sujeet Kumar, Dr P. Kumararaja, Dr T. Bhuvaneswari, Dr Vidya Rajendran, Dr T. Sathish Kumar, Dr M. Shashi Shekhar, Dr Vinaya Kumar Katneni, Dr J. Joseph Sahaya Rajan, Shri N. Jagan Mohan Raj
15.	FISHCIBASIL 202301500166	Aquaculture pond ageing on soil, water quality and crop productivity in shrimp culture ponds	Dr P. Kumararaja	Dr M. Muralidhar, Dr R. Saraswathy, Dr P. Ezhil Praveena, Dr R. Geetha, Dr A. Nagavel, Dr J.Joseph Sahaya Rajan
16.	FISHCIBASIL 202301600167	Fish diseases and their management with special reference to *Amyloodinium ocellatum* and other parasites	Dr Vidya Rajendran	Dr T. Bhuvaneswari, Dr R. Ananda Raja, Dr P.K. Patil, Dr M. Makesh
17.	FISHCIBASIL 202301700168	Field evaluation of *Enterocytozoon hepatopenaei* (EHP) therepeutic CIBA EHP cura I	Dr T. Sathish Kumar	Dr M. Kumaran, Shri Jose Antony, Dr N. S. Sudheer
Nutrition & Genetics Biotechnology Division				
18.	FISHCIBASIL 202301800169	Identification and evaluation of diversified feed ingredients for their utility in shrimp and fish feeds for sustainability	Dr K. Ambasankar	Dr J. Syama Dayal, Dr N. Lalitha, Dr K. P. Sandeep, Dr T. Sivaramakrishnan
19.	FISHCIBASIL 202301900170	Development, testing and demonstration of newer feeds and feed management strategies	Dr K. Ambasankar	Dr J. Syama Dayal, Dr S. Kannappan, Dr K .P. Kumaraguru Vasagam, Dr N. Lalitha, Dr Sherly Tomy, Dr T. ;Sivaramakrishnan
20.	FISHCIBASIL 202302000171	Collection and breeding of wild marine polycheat worms	Dr S. Kannappan	Dr R. Jayakumar, Dr C. P. Balasubramanian, Shri R. Aravind R;
21.	FISHCIBASIL 202302100172	Production and management of live feeds for use in aquaculture	Dr K.P. Kumaraguru Vasagam	Dr R. Jayakumar, Dr S. Kannappan, Dr T. Senthil Murugan, Dr K.P. Sandeep, Shri R. Aravind
22.	FISHCIBASIL 202302200173	Molecular approaches for solutions directed towards the management of diseases and feed for aquaculture species	Dr Vinay Kumar Katneni	Dr Ashok Kumar, Dr B Sivamani, Mrs Mary Lini, Shri C. Siva, Dr K. Ambasankar

Social Science Division				
23.	FISHCIBASIL 202302300174	Demonstrations of ICAR-CIBA nursery and grow-out technologies for livelihood upliftment and skill development of SC and tribal communities of coastal Odisha	Dr T. Ravisankar	Dr P. Mahalakshmi, Dr Akshya Panigrahi, Dr Aritra Bera, Shri Biju IF
24.	FISHCIBASIL 202302400175	Economic Analysis in brackishwater aquaculture production marketing and trade sectors	Dr C. V. Sairam	Dr T. Ravisankar, Dr R. Geetha R, Dr P. Mahalakshmi
25.	FISHCIBASIL 202302500176	Brackishwater Aquaculture Technologies Integrated with Agro-Based Technologies for Livelihood Development of Communities	Dr B. Shanthi	Dr P. Mahalakshmi
26.	FISHCIBASIL 202302600177	Brackishwater aquaculture led integrated livelihood development for the coastal SC families in Mayiladuthurai district of Tamil Nadu	Dr M. Kumaran	Dr C. V. Sairam, Dr K. P. Kumaraguru Vasagam, Dr R. Ananda Raja, Shri Dani Thomas, Shri C. Siva, Shri R. Aravind
27.	FISHCIBASIL 202302700178	Diversification of farming activities for alternate sustainable livelihood of fisherfolk in Tamil Nadu and Karnataka	Dr R. Geetha	Dr Deboral Vimala, Dr R. Jayakumar, Dr M. Kailasam, Dr P. Nila Rekha, Dr T. Bhuvaneswari, Dr T. Sivaramakrishnan, Dr Aritra Bera, Dr P. K. Patil, Dr R. Subburaj R
INTERDIVISIONAL PROJECTS				
Kakdwip Research Centre				
28.	FISHCIBASIL 202302800179	Demonstration and dissemination of brackishwater aquaculture technologies for livelihood development of SC and ST communities of Sundarban	Dr Debasis De	Dr Sanjoy Das, Shri I.F. Biju, Dr Babita Mandal, Dr N. S. Sudheer, Dr Moumita Ash
29.	FISHCIBASIL 202302900180	Captive breeding and seed production of candidate brackishwater species of eastern region of India	Dr Debasis De	Dr Sanjoy Das, Dr Babita Mandal, Dr N. S. Sudheer, Shri Biju I.F, Dr Moumita Ash,
30.	FISHCIBASIL 202303000181	Field validation and economic evaluation of effectiveness of Plankton Plus in agriculture, horticulture and aquaculture for livelihood improvement of SC and ST communities of India	Dr Debasis De	Dr K. P. Sandeep, Dr P. Mahalakshmi, Shri Biju I.F, Dr Moumita Ash, Dr N. S. ;Sudheer
31.	FISHCIBASIL 202303100182	Development and demonstration of sustainable and economically viable brackishwater aquaculture models for Eastern region of India	Dr Sanjoy Das	Dr Debasis De, Dr Babita Mandal, Dr N. S. Sudheer, Shri Biju I.F, Dr Moumita Ash, Dr C.V. Sairam
Navsari Gujarat Research Centre				
32	FISHCIBASIL 202303200183	Development of sustainable and cost-effective brackishwater farming technologies for shellfish and finfish in the western region	Dr Akshaya Panigrahi	Shri Jose Antony, Shri Pankaj Amrut Patil, Dr Ritesh Tandel, Mrs Pragyan Dash
33	FISHCIBASIL 202303300184	Demonstrations of brackishwater aquaculture technologies for livelihood upliftment and skill development of tribal communities of Western region	Shri Pankaj Amrut Patil	Shri Jose Antony, Dr P. Mahalakshmi, Dr Akshya Panigrahi;
34	FISHCIBASIL 202303400185	Livelihood enhancement and skill development of SC communities in Gujarat through demonstration of brackishwater aquaculture technologies	Shri Jose Antony	Shri Pankaj Amrut Patil, Dr Akshya Panigrahi, Dr P. Mahalakshmi

NATIONAL PRIORITY PROJECTS (SPONSORED/PLAN SCHEME)

S.No	Project Code	Project Title	Funding Agency	Collaborative Inter-divisional / Inter institutional	Principal Investigator	Co-PI's	Duration of the Project	Budget Outlay (Rs. in Lakhs)
Crustacean Culture Division								
1.	FISHCIBACOP 201100100057	**National initiative on climate resilient agriculture (NICRA)**-Impact of climate change on aquaculture and mitigation option for minimizing greenhouse gases from aquaculture sector	ICAR – NICRA	**Inter institutional**	Dr M. Muralidhar	Dr (Mrs) M. Jayanthi, Dr J. Syama Dayal, Dr A. Panigrahi, Dr M. Kumaran, Dr R. Saraswathy, Dr S. K. Otta, Dr J .Ashok Kumar, Dr P. Kumararaja, Dr Aritra Bera, Dr Satheesha Avunje, Dr Sathish Kumar, Shri Jose Antony, Dr A Nagavel	Apr. 2021 – Mar. 2026	40.75
2.	FISHCIBASOL 201800400096	**INFAAR - Network Project on Anti**-microbial resistance	ICAR -CIBA SFC Plan Scheme (21-23)/ ICAR-Plan (23-26)	**Inter institutional (Lead: ICAR-NBFGR)**	Dr S.K. Otta	Dr P. Ezhil Praveena, Dr T. Bhuvaneswari, Dr Vidya Rajendran	Apr. 2021 – Mar. 2026	-
3.	FISHCIBASOL 201800700099	**Network on Ornamental fish:** Development of brackishwater aquaculture through optimisation of captive breeding protocols of potential and emerging ornamental fish species, technology transfer and livelihood generation	ICAR -CIBA SFC Plan Scheme (21-23)/ ICAR-Plan (23-26)	**Inter institutional (Lead: ICAR-CMFRI)**	Dr M. Kailasam	Dr M. Makesh, Dr K. P. Kumaraguru Vasagam, Dr T. Senthil Murugan, Dr Krishna Sukumaran, Dr Prem kumar, Dr Aritra Bera, Ms Babita Mondal, Shri Dani Thomas, Shri Tanveer Hussain	Apr. 2021 – Mar. 2026	-
4.	FISHCIBASOL 202000100104	**CRP-Genomics -Genomic** resources for augmentation of economic traits in Indian white shrimp *Penaeus indicus* and whole genome sequencing of brackishwater aquaculture candidate species	ICAR-Plan Scheme	**Inter institutional (Lead: ICAR-NBFGR)**	Dr K. Vinaya Kumar	Dr M. Shashi Shekhar, Dr J. Ashok Kumar, Dr Raymond, J. Angel, Dr M. Kailasam, Dr Krishna Sukumaran	Apr. 2021 – Mar. 2026	60.00
5.	FISHCIBASOL 202000200105	**All India Network Project on Fish Health**	ICAR -Plan Scheme	**Inter institutional (Lead: ICAR-CIBA)**	Dr P.K. Patil	Dr S. K. Otta, Dr R. Ananda Raja, Dr T. Bhuvaneswari, Dr Satheesha Avunje, Dr R. Saraswathy, Dr P. Kumararaja, Dr J. Ashok Kumar, Dr P. Ezhil Praveena, Dr T. Ravisankar, Dr R Geetha	Apr. 2021 – Mar. 2026	50.00
6.	FISHCIBASOL 202000300106	**Centre for Agricultural Bioinformatics (CABin)** - Network Project on Investigations on dietary alterations in shrimp for abiotic stresses using nutrigenomics approach	ICAR Plan Scheme	**Inter institutional (Lead: ICAR-IASRI)**	Dr Ashok Kumar Jangam	Dr J. Syama Dayal, Dr M. Shashi Shekhar, Dr K. Vinaya Kumar, Dr K. P. Sandeep	Apr. 2021 – Mar. 2026	112.50

7.	FISHCIBASOL 202200600123	**National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)** - 1. National Surveillance Programme for Aquatic Animal Diseases in Tamil Nadu	PMMSY	**Inter institutional (Lead: ICAR-NBFGR)**	Dr P. Ezhil Praveena	Dr S.K.Otta, Dr R. Ananda Raja, Dr T. Bhuveneswari, Shri Dr T. Sathish Kumar	Apr. 2022 – Mar. 2025	53.70
8.	FISHCIBASOL 202200700124	**National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)** - 2. National Referral Laboratory for Brackishwater Fish Diseases.	PMMSY	**Inter institutional (Lead: ICAR-NBFGR)**	Dr S. K. Otta	Dr M. Poornima, Dr P. Ezhil Praveena, Dr R. Ananda Raja, Dr Joseph Sahayarajan	Apr. 2022 – Mar. 2025	29.10
9.	FISHCIBASOL 202200500122	**All India Network on Mariculture:** Production Systems, Agribusiness and Institutions - Component 1: Impact of Agricultural Technology	ICAR Plan Scheme	**Inter institutional (Lead: ICAR-CMFRI)**	Dr R. Geetha	Dr T. Ravisankar, Dr P. K. Patil	Apr. 2021 – Mar. 2026	13.20
10.	FISHCIBASOL 202201100128	**CRP on Vaccines and Diagnostics**- Development of improved vaccines, diagnostics and probiotics for brackishwater aquaculture	ICAR Plan Scheme	**Inter institutional (Lead: ICAR-IVRI, Bareli)**	Dr M. Makesh	Dr Kailasam, Dr S. K. Otta, Dr T. Sivaramakrishnan, Dr Sujeet Kumar	Apr. 2021 – Mar. 2026	
11.	FISHCIBASOL 202201200129	**CRP on Vaccines and Diagnostics**- Development of probiotics and immunostimulants for shrimp	ICAR Plan Scheme	**Inter institutional (Lead: ICAR-IVRI, Bareli)**	P. K. Patil	Dr Satheesha Avunje, Dr Vidya Rajendran	Apr. 2021 – Mar. 2026	
12.	FISHCIBASOL 202201300130	**CRP on Vaccines and Diagnostics**- Development of microalgae based improved delivery method for control of shrimp White Spot Syndrome Virus (WSSV) in culture ponds	ICAR Plan Scheme	**Inter institutional (Lead: ICAR-IVRI, Bareli)**	Dr S. K. Otta	Dr M. Makesh, Dr K.P. Sandeep	Apr. 2021 – Mar. 2026	10.00
13.	FISHCIBASOL 202201400131	Development of molecular diagnostics for differentiation of pathogenic and non-pathogenic Vibrio species in aquaculture	ICAR Plan Scheme	**Inter institutional**	Dr Sujeet Kumar	Dr Vidya Rajendran, Dr T. Sathish Kumar	Apr. 2021 – Mar. 2026	24.6
14.	FISHCIBASOL 202201500132	Development of point of care diagnostics for the detection of major shrimp pathogens WSSV and EHP	ICAR Plan Scheme	**(Lead: ICAR-IVRI, Bareli)**	Dr T. Sathish Kumar	Dr P. Ezhil Praveena, Dr Subhendu Kumar Otta, Dr M. Makesh M, Dr K.P. Jithendran	Apr. 2021 – Mar. 2026	30.00

EXTERNALLY FUNDED PROJECTS

S.No	Project Code	Project Title	Funding Agency	Collaborative Inter-divisional / Inter institutional	Principal Investigator	Co-PI's	Duration of the Project	Budget Outlay (Rs. in Lakhs)
1.	FISHCIBASOL 202100100109	Captive Breeding of Hilsa, *Tenualosa ilisha*: Phase II	NASF		Dr Debasis De	Ms. Babita Mandal	Mar. 2021 – Feb. 2024	169.68
2.	FISHCIBASOL 202100200110	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		Dr S.Kannappan	Dr C. P, Balasubramanian, Dr R. Jayakumar Shri R. Aravind	Apr. 2022 – Apr. 2024	61.79
3.	FISHCIBASOL 202100400112	Solid state fermentation technology for development of cost effective customized plant protein products as fishmeal alternate for shrimp feed	DBT		Dr J. Syama Dayal	Dr K. P. Sandeep, Dr Sujeet Kumar	Jul. 2021 – Jul. 2024	72.77
4.	FISHCIBASOL 202100500113	Unravelling signatures of growth and salinity adaptation in *Etroplus surentensis* through omics approaches	DBT		Dr Vinay Kumar Katneni	Dr Kuldeep Lal K Project Co-ordinator, Dr M. Shashi Shekhar, Dr K. P. Kumaraguru Vasagam, Dr Ashok Kumar Jangam, Dr Raymond Jani Angel	Jul. 2021 – Jul. 2024	258.57
5.	FISHCIBASOL 202100800116	Precision brackishwater aquaculture using Machine Intelligence	DBT		Dr M. Muralidhar	Dr Ashok Kumar Jangam, Dr P. Kumararaja	Nov. 2021 – Nov.2024	63.80
6.	FISHCIBASOL 202100900117	Pilot Project on cage culture of Asian seabass, *Lates calcarifer* and Pearlspot *Etroplus suratensis* in brackishwater creeks as an alternate livelihood for coastal fisher folks of southern Gujarat	DOF, Gujarat		Shri Pankaj Amrut Patil	Shri Jose Antony, Dr Kumaraguru Vasagam, Dr R. Jayakumar,	Aug. 2021 – Jul. 2023	45.10-

7.	FISHCIBASOL 202200100118	Promotion of Integrated Multi-trophic Aquaculture (IMTA) Technology for income generation and optimum use of bio-resources	DBT		Dr D. Deboral Vimala	Dr T. Ravisankar, Dr P. Nila Rekha, Dr M. Kumaran, Dr P.Mahalakshmi, Dr T. Senthil Murugan, Dr Kumaraguru Vasagam, Dr S. Kannappan, Shri R. Aravind	Feb. 2022 – Feb. 2024	35.45
8.	FISHCIBASOL 202200200119	Development of indigenous shrimp (Indian white shrimp) aquaculture : Genetic improvement Program of *Penaeus indicus*, Phase - I	PMMSY		Dr Akshaya Panigrahi	Dr M. Jayanthi, Dr C.P. Balasubramanian, Dr S. Kannappan, Dr P. Nila Rekha, Dr Shyne Anand, Dr T. N. Vinay, Shri Jose Antony, Shri I. F. Biju, Shri R. Aravind, Dr M. Shashi Shekhar, Dr K. Vinaya kumar, Dr B. Sivamani, Dr S. K. Otta, Dr R. Ananda Raja, Dr M. Kumaran, Dr P. Mahalakshmi, Dr Ambasankar, Dr J. Syama Dayal, Dr K. P. Kumaraguru Vasagam, Dr M. Muralidhar	Jun. 2022 – Mar. 2025	250.44
9.	FISHCIBASOL 202200300120	Novel approaches for disease-free health certification in finfish and development of high health shrimp for sustainable aquaculture	NASF		Dr Subhendu Kumar Otta	Dr Akshaya Panigrahi, Dr P. Ezhil Praveena, Dr T Bhuvaneswari	May 2022 – Apr. 2025	47.2575
10.	FISHCIBASOL 202200400121	Establishment of DBT Rural Bioresources Complex at Ramanathapuram District, Tamil Nadu	DBT		Dr P. Mahalakshmi	Dr K. P. Sandeep, Dr Debasis De	Feb 2022-Feb. 2024	10.15
11.	FISHCIBASOL 202201100127	Demonstration of viable farming protocols for indigenous brackish water seaweed species for income generation among coastal folks	NFDB		Dr P. Nila Rekha	Dr R. Jayakumar, Shri R. Aravind	Nov. 2022 – Nov. 2024	21.95
12.	FISHCIBASOL 202300100133	Biofortification of trace elements in biofloc based aquaculture -microbial mediated approach for value added healthy shrimp and fish production	DBT		Dr Akshaya Panigrahi	Dr Kumaraguru Vasagam, Dr N. S. Sudheer, Dr Aritra Bera, Dr J. Syama Dayal	Jan. 2023-Jan 2026	82.08

13.	FISHCIBASOL 202301300130	Development and demonstration of artificial intelligence based precision aquaculture technologies	NABARD		Dr P. Nila Rekha	Dr K. Ambasankar, Dr Deboral Vimala, Dr Kumaraguru Vasagam	Mar 2023-Mar 2025	24.79
14.	FISHCIBASOL 202300300135	Genome sequencing and its application for Brackishwater Aquaculture	DBT		Dr M. S. Shekhar	Dr Ashok Kumar Jangam, Dr Vinay Kumar Katneni, Dr Raymond Jani Angel	Sept 2023-Sept 2026	245.42
15.	FISHCIBASOL 202300400136	New age shrimp rearing system for precise use of land, water and feed	PMMSY, DoF, New Delhi		Dr Kumaraguru vasagam	Dr K. Ambasankar, Dr S. Kannappan, Dr Akshaya Panigrahi, Dr M. Kumaran, Shri R. Arvind	Apr 2023-Mar 2026	221.00
16.	FISHCIBASOL 202300500137	Development and pilot scale implementation of crop insurance solution for sustainable shrimp farming	NFDB		Dr Ravisankar	Dr C.V. Sairam, Dr M. Muralidhar, Dr M. Kumaran Dr R. Ananda Raja, Dr R. Geetha	Nov. 2023-Nov. 2024	13.25
17.	FISHCIBASOL 202300600138	Atlas of Climate Adaptation in South Asian Agriculture	ICAR-BISA		Dr Ashok Kumar Jangam	Dr M. Muralidhar, Dr M. Kumaran	Apr 2023-Mar 2026	27.86
18.	FISHCIBASOL 202300700139	Unravelling signatures of dietary protein sparing and fibre tolerance in Penaeus vannamei for development of cost effective feeds through omics approaches	DBT		Dr Syama Dayal	Dr K. Ambasankar, Dr Vinaya Kumar Katneni Dr J. Ashok Kumar	Sept 2023-Sept 2026	86.10
19.	FISHCIBASOL 202300800140	Evaluation and Refinement of biofloc based new age farming technology through effective microbial management, recirculation and input optimization for sustainable intensification across different aquaculture system			Dr Akshaya Panigrahi	Dr Kumaraguru Vasagam, Dr T. Sivaramakrishnan Dr M. Kumaran Dr P. Kumararaja Shri R. Aravind	Apr. 2023-Mar. 2025	

DIVISIONAL PROFILES

CRUSTACEAN CULTURE DIVISION

Crustaceans are the most traded and valuable seafood commodity. The evolution of crustacean farming, particularly Indian shrimp farming, from an embryonic industry of 1980 to today's mature and sophisticated industry has been spectacular. Crustacean culture Division of CIBA is one of the pioneering divisions that focus on sustainable crustacean aquaculture. The division is mandated to develop focused research and development in order to improve knowledge and technologies needed for increasing the efficiency of production of currently farmed crustaceans, and increasing the number of species farmed and diversifying the farming system for sustainable brackishwater aquaculture We constantly renew and refine our technologies to deliver technology-backstopping and services based on the latest scientific knowledge. The division provides high quality research, training, knowledge partnership programmes and consultancy on brackishwater crustacean farming. The stake holders of research outputs of the division include farmers, entrepreneurs, regulatory agencies industrialists, young professionals and students. For the last thirty seven years, this division has contributed and led the way in advancing crustacean aquaculture in India. The division works on captive maturation, induced maturation, issues in larval rearing, growth physiology, stock improvement and various aquaculture production systems from monoculture to integrated multi-trophic aquaculture systems. The major focuses are: how high quality stockable seeds are produced; how reproduction is controlled at organismic and functional level, and how efficiently can manage the crustacean husbandry by using science based management strategies. The division has been actively collaborated with various national and international agencies. The division has well established research hatcheries, wet laboratory facilities, sophisticated advanced laboratories and grow-out production systems. The multi-disciplinary team of the division includes crustacean biologists, farming system researchers, biotechnologists, and aquaculture engineers.

FINFISH CULTURE DIVISION

The division is actively engaged in developing comprehensive practices for captive breeding, larval rearing, nursery management, and grow out culture of candidate brackishwater finfish species. These include Asian seabass (*Lates calarifer*), Mangrove red snapper (*Lutjanus argentimaculatus*), Milkfish (*Chanos chanos*), Grey mullet (*Mugil cephalus*), golden-lined spine foot rabbitfish (*Siganus lineatus*), Goldlined Seabream (*Rhabdosargus sarba*), Pearlspot (*Etroplus suratensis*), as well as ornamental finfish species like Silver moony (*Monodactylus argentimaculatus*), spotted scat (*Scatophagus argus*), among others. The division plays a crucial role in enhancing species diversification in brackishwater aquaculture to effectively utilize the brackishwater resources by adopting different farming systems such as cage culture, pen culture, IMTA and RAS based rearing systems. The division is also associating closely with the stakeholders/ farmers and provides technical guidance to establish fish hatcheries, nursery rearing and farming systems on consultancy basis. Furthermore, it conducts tailored training programs/interaction meets to address the specific needs of stakeholders.

NUTRITION, GENETICS & BIOTECHNOLOGY DIVISION

Nutrition, Genetics and Biotechnology Division of Central Institute of Brackishwater Aquaculture is the pioneer in Aquaculture Nutrition research in India. Feed being the major and critical input in aquaculture considerable thrust was given to feed development programmes. The division has developed cost-effective, environmentally sustainable, efficient, and indigenous feed processing technologies for the brackishwater aquaculture candidate shell and finfish species for their all-life stages. Functional feeds for broodstock, larvae, and specialty feeds to address the niche markets are also being developed by the division. The division is having complete nutritional data base of various feed resources available in India and this helped in use of novel feed ingredients and custom made feed formulations. The division has carried out extensive research on fishmeal replacement by using customized enzyme mixtures and solid state fermentation technology. The focussed research programmes implemented by the division

lead to the development and commercialisation of several feed technologies in the country to benefit the small and medium scale farmers. Currently, the division is focusing on sustainable and functional feeds and nutrigenomic applications for improving the efficiency of feed.

In Genetics and Biotechnology, the division focused on genetic characterization of candidate aquaculture species, development and utility of markers and genes for improving economic traits. Whole genome of *Penaeus indicus, Mugil cephalus* and *Lutjanus argentimaculatus* were sequenced and assembled. Pathogens like *Vibrio campbelli* and *Vibrio parahaemolyticus* genomes were completely sequenced and assembled. The division is having in–house capability for bioinformatics and developed a bioinformatics tool 'Missing Regions Finder' (MRF) which rapidly tabulates and depicts complete and partial missing CDS in a query genome when compared to a reference genome. Division also developed first open-access SNP search database 'dbVAST' for shrimp. The division is actively involved in Population genetics and genetic improvement programme of *P. indicus*.

AQUATIC ANIMAL HEALTH AND ENVIRONMENT DIVISION

Aquatic Animal Health and Environment Division constitutes multi-disciplinary expertise in Biotechnology, Parasitology, Microbiology, Pathology, Fish health and Soil chemistry/fertility. The division is engaged in surveillance for aquatic animal diseases, development of diagnostics, prophylactics and therapeutics. In addition, the division is also involved in various research aspects of climate change impacts on aquaculture production systems, soil health and water management. The division has developed and commercialised many products related to disease diagnosis and therapeutics and soil and water quality parameter analysis kits for aquaculture industry. The division has a state of art NABL accredited disease diagnostic laboratory which offers service to aquaculture farmers for timely detection and screening of pathogens which helps to maintain the best management practice and biosecurity protocols required for sustainable brackishwater aquaculture production. With an aim towards capacity building and skill development, the division also undertakes suitable and regular training programmes, demonstrations and consultancy programmes for the aquaculture farmers and stakeholders.

SOCIAL SCIENCE DIVISION

Aquaculture extension and policy interventions buttress need-based technology development and sustainability of aquaculture sector. The research and extension activities of the division aim to develop system specific pragmatic extension approach/ strategy and good practices intend to improve the knowledge and skill capacities of the end users and facilitate forward and backward linkages that would contribute for the increased aquaculture production, income and societal development. Similarly, techno-socio-economic assessment of aquaculture systems, feedback on technologies and their impact at the micro and macro levels, market and trade analyses are given due thrust which contribute for evolving appropriate policy advisories for refinements in aquaculture planning, regulation and supportive mechanisms for sustainable development of the sector. The social science research also give adequate focus on "reaching the unreached" viz., small scale aquaculture farmers, socio economically vulnerable communities and entrepreneurs through front-line extension, Information and Communication Technology (ICT) applications and outreach programmes.

KAKDWIP RESEARCH CENTRE

The Kakdwip Research Centre (KRC), one of the oldest research centres of ICAR-CIBA, is located in Kakdwip, West Bengal, between two tributaries of the sacred river Ganga, in the natural scenic grandeur of Sundarban (21° 51' 28.8" N, 88° 11' 1.9"). The Kakdwip Research Centre (KRC) was established in 1968 as a brackishwater experimental fish farm under the Central Inland Fisheries Research Institute (CIFRI), Barrackpore. It was then transferred to the ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai, on April 1, 1987, to promote research and offer technological support to the country's developing brackishwater aquaculture industry. The KRC is well

connected to the rest of the country via road, rail, and air. Netaji Subhash Chandra Bose International Airport in Kolkata is 130 kilometres from the centre and can be reached by road NH 117 or by local suburban train via the Namkhana-Sealdah route. The centre has cutting-edge farm facilities, and well-equipped laboratories to meet the demands of brackishwater aquaculture research, training (HRD), outreach, and demonstration. The centre now has Head of Regional Centre with 6 scientists, 1 technical officer, and 1 support staff to administer the centre's research activities. KRC covers a total of 17 hectares, which includes a bheri. The office building, library, seminar hall and laboratories are all placed in the same block at the centre's entrance. The centre also features a visitor accommodation facility, the Hilsa trainees' hostel, as well as well-maintained quarters for in-house scientists and personnel. The farm facilities are separated into three sectors: A, B, and C, each having its own set of earthen ponds used for diverse research purposes. The wet lab complex includes three experimental yards including one hatchery unit, an indoor and outdoor live feed unit. The centre also has state of art feed mill facilities equipped for preparing sinking and floating pellet feed for experiments and demonstrations on farmers' fields. The center's recent additions include a farm sale counter called "The Kiosk" for selling farm product, as well as a recreation area with indoor games and a badminton court. The centre has various farming technology and goods to its name. Biosecured zero water exchange shrimp farming, polyculture technique for brackishwater fishes, breeding and seed production of Hilsa, Yellowfin bream, *Mystus gulio*, and products such as Plankton plus, Horti plus, and Poly plus are among the most notable.

NASARI-GUJARAT RESEARCH CENTRE

Navsari Gujarat Research Centre (NGRC) is the regional station of ICAR-CIBA on the Indian West coast, strategically located in the South Gujarat region, which has developed as one of the most intensive shrimp farming hubs in the country. The centre is located in the Navsari district of Gujarat, 30 km south of Surat city, within the Navsari Agricultural University campus at Eru Char Rastha. The centre also has an experimental station with a 10 ha brackishwater research farm, situated on the Dandi heritage road, in Matwad village, 4 km west of the historical Dandi village that played a key role in the Indian freedom struggle. The centre was established in 2018 to carry out cutting-edge research on frontier areas of brackishwater aquaculture. The centre mainly focuses on developing location-specific farming and breeding technologies for the Gujarat coast, field testing of CIBA technologies before disseminating to the farming community, capacity building, and livelihood enhancement activities for aqua farmers, coastal, tribal, and economically weaker communities. Cage-based community spawning of pearlspot, *Etroplus suratensis*, and a simple and cost-effective recirculatory system for large-scale seed production have been developed at the centre. The technology is found suitable for small homestead ponds and women SHGs where 20,000 fries can be easily produced in a month. The technology overcomes several key constraints in broodstock maintenance and spawning of the species. On the industry front, the centre has successfully demonstrated the commercial farming of Indian white shrimp (*Penaeus indicus*), whiteleg shrimp (*P. vannamei*), and the giant tiger prawn (*P. monodon*).

RESEARCH HIGHLIGHTS

BRACKISHWATER PRODUCTION SYSTEM

BRACKISHWATER PRODUCTION SYSTEM

MILKFISH MONOCULTURE USING STUNTED STOCK: A WAY TO ENHANCE THE PRODUCTIVITY

Milkfish (*Chanos chanos*) fingerlings weighing 17 grams with a total length of 11.7 cm were stocked in the pond at a high density of 3 individuals per square meter and reared for one year with minimal feed, resulting in a stunted population with an average body weight of 120.75 grams and a total length of 23.56 cm. In the second year, an experiment was conducted with these stunted milkfish yearlings, stocking them at a rate of 1 individual per square meter in a 450 square meter lined pond at Muttukadu Experimental Station. The fish were fed CIBA Milkfish GrowoutPlus at 3% of their tbody weight throughout the period, achieving a feed conversion ratio (FCR) of 1.2. After 210 days of culture, the fish reached an average body weight of 589.4 grams and a total length of 42.08 cm, with an average productivity of 5.5 tons per hectare. During the initial 210 days of the monoculture period, the daily weight gain of fish from stunted yearlings was significantly higher at 2.23 grams per day compared to non-stunted fingerlings at 1.43 grams per day. Similarly, the specific growth rate (SGR) was also higher in the stunted group at 1.5 compared to non-stunted fingerlings at 1.34. The harvested fish were sold in the domestic market at Rs. 150 per kilogram (deboned fish at Rs. 150 per piece), generating a total revenue of Rs. 22,770. Therefore, it can be inferred from the experiment that stunted yearlings of milkfish can lead to higher productivity and reduced production costs.

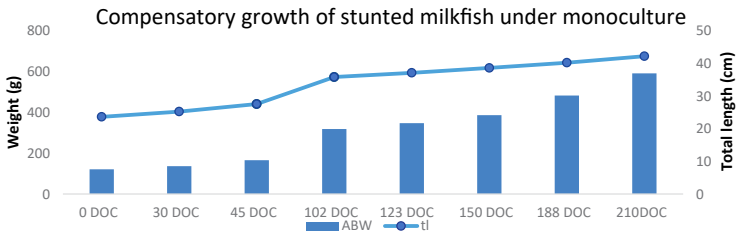


Fig. 1

Stunted milkfish growth under monoculture

Fig. 2

Partial harvest of milkfish and purchase of produce by local fishermen

Fig. 3

Harvested milkfish and different post-harvest forms including de-boning

REFINEMENT OF BIOFLOC BASED NEW AGE FARMING TECHNOLOGY THROUGH EFFECTIVE MICROBIAL MANAGEMENT AND RECIRCULATORY MODEL WITH TWO DIETERY FEEDING REGIME FOR MILK FISH *Chanos Chanos*

A biofloc experiment was initiated to evaluate the dietary protein sources in the feed with different percentage in each treatment and commercial feed as control. Further the effect on the protein source in the production performance will be evaluated for finding the optimal protein percentage in the diet.

An experiment was initiated to evaluate various dietary protein source in control and biofloc system on the growth, water quality and immunomodulation of Milk fish *Chanos chanos*. Briefly, treatments used were: control (C0) Molasses (MLC), Rice bran (RBC), Wheat flour (WFC), Sugar (SGC). Stocking density was maintained @15 no's /m^3 with a initial weight of10.0 ± 0.1 g. The experiment was carried out using Control Diet 25% (without carbon and biofloc); Biofloc 25% (BFT25); Control Diet 30% (without carbon and biofloc); and Biofloc 30% (BFT30).

Fig. 4

Milk fish (*Chanos chanos*)

DEMONSTRATION OF HAPA BASED NURSERY REARING OF ASIAN SEABASS

Nursery rearing of seabass (10000 nos, 1.8-4.6 cm) in pond-based hapas was demonstrated at multispecies hatchery unit of Mayank Aquaculture Private Limited, Maroli (Fig. 5). After 48 days of rearing, around 3500 nos of 4-5 inches seabass fingerlings were produced from larger sized fry and sold to farmers. The smaller sized fry was nursery reared for 75 days to produce 2700 nos of 3–5-inch fingerlings. The demonstration resulted in an overall survival of 62%. The harvested fingerlings were sold @Rs. 30-50 per fingerlings to local fish farmers.

Fig. 5

Supply of 10,000 nos of seabass fry to Mayank Aquaculture Pvt. Ltd., for demonstration of seabass nursery rearing

CAGE CULTURE OF ASIAN SEABASS AND PEARLSPOT IN BRACKISHWATER CREEKS

Demonstration of seabass and pearlspot cage culture in brackishwater creeks and ponds was demonstrated at Mendhar, Shil and Jafarabad villages of Gujarat along with local communities (Fig. 6). In creeks, at Jafarabad and Shil, a total of eight GI pipe fabricated cages of size 4 x 4 x 2 m (32 m3) were installed. In the pond-based cage culture site at Navsari, four cages of size 6 x 4 x 1.5 m (36 m3) were installed. Seabass fingerlings (20-40 g) were stocked at 1000 nos/ cage, whereas pearlspot seed (5-8 g) were stocked at 2400 nos/cage during December, 2022 (Fig. 7). During the first week of July, all the cages in three sites were harvested and large sized seabass (1400 Kg, size 250-500g) and pearlspot (393.2 Kg, size 100-150 g) were sold to local market whereas small sized seabass (2750 nos. 180-220 g) and pearlspot (74.5-92.5 g) were sold to local farmers as stocking material. The average survival of seabass and pearlspot at all three sites were 73.47% and 80.5%, respectively. Around 200 kg (300-500 g) of seabass was sold to a premium seafood restaurant in Surat viz., Zhingalala at Rs. 450/Kg to produce seabass chunks in the restaurant. The SHGs at three sites generated a total income of Rs. 13.72 lakhs through sale of harvested seabass and pearlspot. To exhibit technology and create awareness among potential fish farmers, a harvest cum interaction meet was organized at farming site at Shil, Mangrol, Gujarat on 26th June, 2023 (Fig.8).

Fig. 6

Seabass and pearlspot cage units in creeks at Shil and Jafarabad, Gujarat

Fig. 7

Seabass and pearlspot fingerlings stocked in caged installed in creeks

Fig. 8

Fish harvest cum farmers interaction meet held at Shil, Mangrol, Gujarat

POLYCULTURE OF MILKFISH, PEARLSPOT, SEABASS AND MUD CRAB

Polyculture is an important brackishwater farming system that optimizes resources utilization while reducing risk and increasing productivity. A 105 days experiment trial was undertaken to compare the growth performance of two polyculture models viz., mutli-polyculture and conventional polyculture. Multi-polyculture treatment comprised of pond-based cage culture of seabass and pearlspot, floating mud crab box culture and polyculture of milkfish and pearlspot directly stocked in the same pond (Fig 9). Conventional polyculture comprised of milkfish and pearlspot directly stocked in the pond. The details of cage, species stocked, stocking density, initial and final body weight during the trial is given in the table. Seabass was fed with 45% CP feed whereas milkfish and pearlspot fingerlings were fed using 32% CP feed twice daily. Crabs were fed with trash fish every alternate day. The results from the trial indicated that the growth performance of pearlspot in cages and ponds did not vary significantly.

Fig. 9

Multi-polyculture pond at NGRC of CIBA

EXPERIMENTAL TRIALS TO OPTIMIZE POND-BASED CAGE CULTURE OF PEARLSPOT, *Etroplus suratensis*

Natural breeding of pearlspot in ponds prior to attainment of marketable size is the major bottleneck in its farming that can be potentially overcome through pond-based cage culture. Pearlspot fry (4000 nos, TL: 2.5-3.5 cm), nursery reared for 120 days in two sets of 5 nos of 2m x 2m hapas resulted in a size group ranging from 16-72 g (Fig. 10 a,b,c). Both sets were size sorted to create three size groups viz Large (L:34.5 g; 40.7 g), Medium (M:24.9 g; 29.2 g) and Small (S:17.5 g; 23.75 g) and on-grown in cages (2m x 2m x 1.75 m) at 100 nos./m^3 for 90 days. The percentage of individuals falling in to the three size groups were near identical in both sets indicating a population structure dominated by medium sized individuals (53%) followed by large (27%) and small individuals (19%) (Fig. 11). Rearing of size sorted fish resulted in similar weight gain for all three size groups in one set (10.65-11.65), whereas in the other set medium and large group demonstrated similar weight gain (11.12-12.21) and the smaller fish resulted in significantly lower ($p<0.05$) weight gain (7.13 g) (Fig.12). Survival rate was 100% in all the treatment groups. The study indicates that rearing of the fish following size sorting results in similar growth across size groups and size sorting can be repeated during the growout phase for continuous production of table sized fish and prevention of stunting.

Fig. 10 a,b,c.

Nursery rearing of pearlspot fry in hapas (a,b) and pond-based cage culture (c)

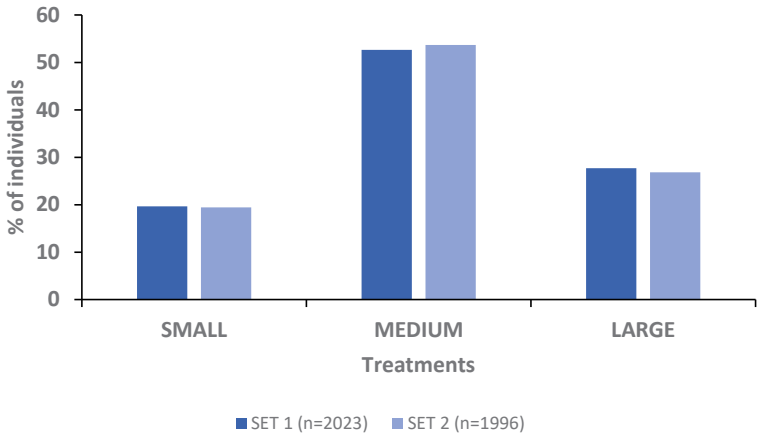


Fig. 11

Percentage of pearlspot juveniles falling in to three size groups viz., small, medium, and large at the end of 120 days of nursery rearing.

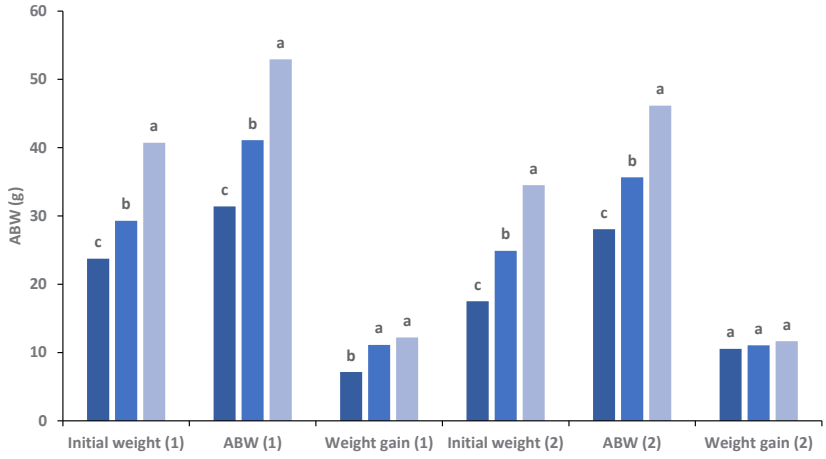


Fig. 12

Initial weight, final weight (ABW) and weight gain of size sorted pearlspot juveniles reared in cages for 50 days in two sets (1 & 2).

EFFECT OF VARIOUS CARBON SOURCES IN BIOFLOC-BASED CULTURE OF FIN FISH GREY MULLET *Mugil cephalus* FOR GROWTH, WATER QUALITY, AND IMMUNE RESPONSES

A study was conducted to investigate the effect of biofloc with different carbon source and their effect on Mugil cephalus growth, immune response, and their microbial diversity.

A 42-day experiment was carried out to analyze the growth, water quality, and immunomodulation of grey mullet Mugil cephalus using various carbon sources in a biofloc system. Briefly, the treatments were control (C0), molasses (MLC), rice bran (RBC), wheat flour (WFC), and sugar (SGC). Stocking density was kept at 70/m^3, and the initial weight was 1.0 ± 0.1 g. Water exchange was performed once a week, replacing 5% of the water in both control and treatment tanks when nitrogen metabolites were abundant and evaporation was significant. The study found that rice bran (7.6±0.2 g) and wheat flour (7.1±0.26 g) treatments resulted in significantly greater average body weight (ABW) compared to the control group (4.1±0.5 g) (Fig. 13, 14).

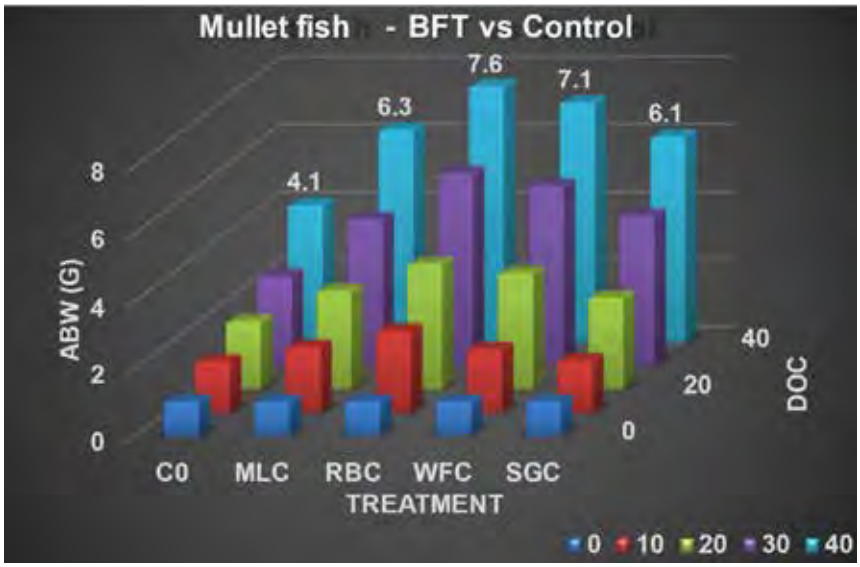


Fig. 13

Average body weight of grey mullet fish *Mugil cephalus* in control and biofloc groups on different days of culture (mean ± SD). C0 (without carbon and biofloc)), Molasses (MLC), Rice bran (RBC), Wheat flour (WFC), Sugar (SGC).

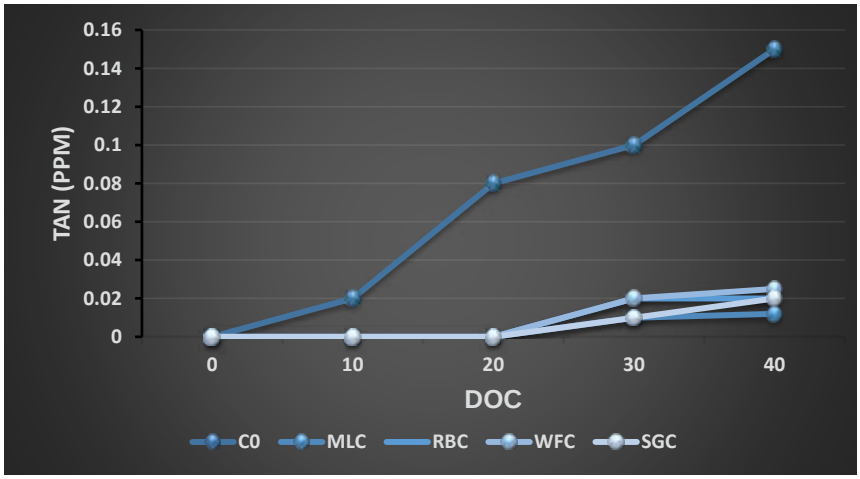


Fig. 14

Average value of total ammonia nitrogen in different days of culture of grey mullet fish *Mugil cephalus* reared in control and biofloc groups (Mean ± SD). C0 (without carbon and biofloc)), Molasses (MLC), Rice bran (RBC), Wheat flour (WFC), Sugar (SGC).

REFINEMENT OF GROW-OUT REARING PROTOCOL OF HILSA

Nursery reared hilsa fry (9.51 ± 1.58 g/8.22 ± 0.93) were stocked in growout pond (0.15 ha,) after pond preparation. To maintain adequate plankton growth Plankton^{plus} (80L/ha) along with fermented rice bran juice (50L/ha) were applied twice a week and fermented mustard oil cake (100kg/ha) was applied at 15 days interval. Calcium oxide was applied @100kg/ha at monthly interval to maintain pH range 7.5-8.0. Formulated grow-out feed (Hilsa^{Plus} ;CP-36.6% & EE- 13.1%) was applied @10-5% BW. After six months of growout culture, fish attained a body weight/ body length of 46.60±2.02g/ 16.78±0.24cm (Fig. 15).

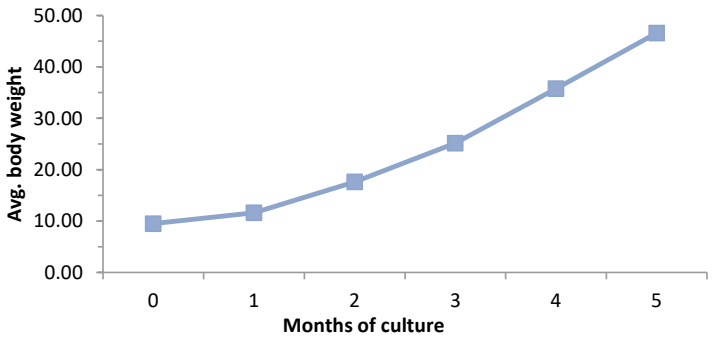


Fig. 15

Growth of hilsa in growout pond

HILSA CULTURE IN RAS SYSTEM

Effort was taken to study the possibility of rearing hilsa in recirculatory aquaculture system (RAS). Hilsa fry (11.41±0.96g / 11.93±0.27cm) were stocked @0.5 nos/ m^3 in 30 m^3 RAS with 20 m^3 brakish water (Salinity: 10-12 ppt). Fishes were fed with Hilsa^{Plus} feed (CP- 36.6% & EE- 13.1%). After six months of culture final body weight/length was 66.52±5.03g / 18.16±0.58 cm (Fig. 16, 17).

Fig. 16

RAS system

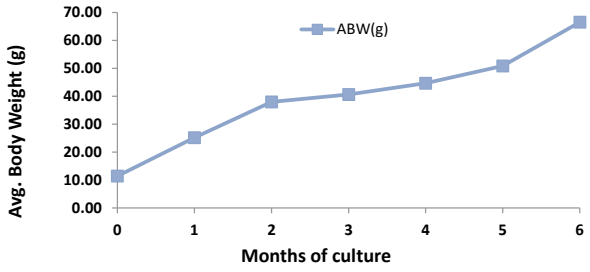


Fig. 17

Growth curve in RAS reared hilsa

PLANNING NUCLEUS BREEDING CENTRE FOR QUALITY SEED PRODUCTION AND DOMESTICATION FOR *Penaeus indicus*

The pilot scale NBC (Nuclear Breeding Centre) has been designed for the entire Genetic Improvement Program (GIP) unit at KES, Kovalam consisting of the quarantine units, the nursery system, the pre-grow-out and grow-out system along with reservoir and treatment systems. Series of discussion with CPWD and consultant engineers were organized to arrive at the optimum design criteria.

Fig. 18

Design of Nuclear Breeding Centre of *P. indicus*

GROWTH PERFORMANCE OF *P. indicus* IN ECO-BASED FARMING SYSTEM

The experiment was carried out to assess the effect of periphyton based system on the growth and survival of *P. indicus* juveniles. A 60-day grow-out trial was carried out using *P. indicus* juveniles (0.5g) at 50 numbers in 500L FRP tanks under three different rearing systems, autotrophic, mixotrophic, and heterotrophic-based culture units with and without integration of submerged substrates. At the end of the trial, the highest growth (5.6 ±0.13 g) and survival (81.66 ± 7.6%) were obtained in the heterotrophic-based substrate integrated system, while the lowest survival was noticed in autotrophic (56.1 ± 12.5%) based system without submerged substrate (Fig. 19). The incorporation of substrate resulted in 12 to 50% increase in ABW and 32 - 50% increase in survival in Indian white shrimp, suggesting the positive role of periphyton as an eco-based farming system in Indian white shrimp farming system.

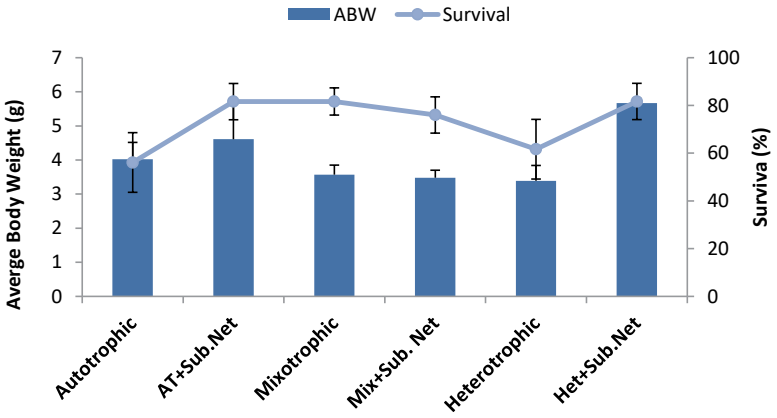


Fig. 19

Average body weight and survival (mean±SE) of *P. indicus* under diverse rearing system

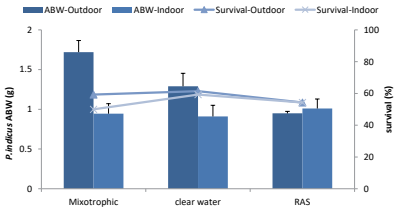
NURSERY REARING OF INDIAN WHITE SHRIMP *P. indicus* IN BIOFLOC CULTURE TECHNOLOGY

Biofloc (BFT) based nursery rearing system help provides an additional food source, healthy juvenile production with better survival and an avenue for nitrogen removal through eco-friendly approach. The present study was designed to evaluate the efficiency of biofloc for nursery rearing in *P. indicus*. Biofloc technology was tested using *P. indicus* at 3000 PL/m^3 in 20 ton tank for 30 days. No water exchange other than the addition of water to refill the water level after siphoning off wastes was followed. Green vibrio was less than 30 CFU/ml reported on 30 DOC, implying that the biofloc system is effective in preserving water quality in the culture system. The average body weight was 0.47g and 0.34g in 15 DOC, and 1.25g and 1.21g in 30 DOC in biofloc and control tanks, respectively. The average total length was 4.2 cm and 3.7 cm in 15 DOC, and 5.78 cm and 5.66 cm in 30 DOC in biofloc and control tanks, respectively. A substantial difference between control and treatment was noticed when the CIBAfloc consortium was used.

GROWTH PERFORMANCE OF *P. indicus* AND *P. vannamei* IN INDOOR AND OUTDOOR SYSTEMS

To understand the comparative performance of *P. indicus* and *P. vannamei* in different rearing systems, an 8-week study was carried out using post-larvae of *P. indicus* and *P. vannamei* at 175 no. m^{-3} in indoor and outdoor units in three rearing systems namely mixotrophic units dominated by both autotrophic and heterotrophic communities, a clear water flow through system where water was exchanged weekly intervals, and a recirculatory unit (RAS) developed from sand-based in situ biofiltration media where no water exchange was carried out until the end of the study. Both *P. vannamei* and *P. indicus* recorded the highest ABW, 3.55g and 1.72g, respectively in the mixotrophic system (Fig. 20 a and b) and the lowest body weight in RAS units (*P. vannamei*: 1.8-2.6g *P. indicus*: 0.9g). The shrimps reared in the outdoor units recorded better growth compared with indoor units indicating the role of environmental cues in better growth of penaeid shrimps.

20a



20b

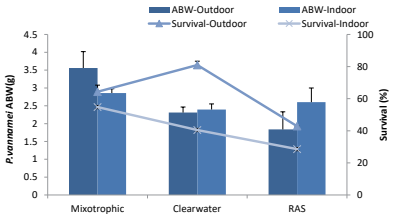


Fig. 20 a and b

Growth performance (mean±SE) under three different rearing systems in the indoor and outdoor units. Fig. 20 a: growth performance of *P. indicus* and Fig. 20 b: growth performance of *P. vannamei*

NEW AGE SHRIMP FARMING SYSTEM TARGETING PRECISE MANAGEMENT OF INPUT RESOURCES AND HIGH PRODUCTIVITY

A new-age shrimp farming system is being developed at the Muttukadu Experimental Station to demonstrate the precise management of input resources and achieve high productivity. Under the funding support of PMMSY scheme, this project was conceptualized and developed with modern farming amenities such as a smart aeration system, feeding, and waste disposal tools to have better control of the inputs and better productivity by effectively utilizing natural feed and other resources. Construction of 4 grow out tanks; 640 m^3 + 1 centrally placed nursery; 100 m^3 has been completed (Fig 21). A trial run on the nursery was completed with a low stocking density (15,000 PL). The juvenile shrimps reached 1 g in 28 days and they were stocked to one of the growout tank using a gravity-based transfer method. The nursery was again stocked to its full capacity (1.1 lakh seeds) and rearing is underway. The farm is set to operate at full capacity in 2024-25.

Fig. 21

New Age shrimp farming infrastructure facility created at MES of CIBA

BIOAUGMENTATION PROCESS IN BIOFLOC SYSTEM BY USING VARIOUS BIOLOGICAL CONSEQUENCES TO IMPROVE GROWTH INDICES, WATER QUALITY AND IMMUNOMODULATION OF SHRIMP *P. vannamei*

The experiment was carried out to analyse the performance of *P. vannamei* in different startup material and system-based biofloc and its influence on the growth performance, water quality, and microbial population. A seventy-day trial was carried out to observe the growth performance, water quality, and microbial dynamics of *P. vannamei* in the biofloc system. The experiment included four groups: control (without biofloc, C0), biofloc with CIBAfloc (BFCF), biofloc with CIBAfloc liquid (BFWP), and biofloc with periphyton and CIBAfloc (BPCF). The result revealed that biofloc system BPCF (15.22±0.24) had the highest average body weight than control (09.02±0.52) (Table 1). Water quality metrics improved significantly in biofloc groups with a lower ammonia level (0.01±0.13 ppm) than control (0.83±0.06 ppm). Treatments showed higher heterotrophic and lower *vibrio* counts, while control had a higher vibrio count (Table 2). The relative expression of immune genes in the hepatopancreas and digestive enzyme-related genes from the gut of *P. vannamei* reared in the biofloc systems showed an upregulation in BFCF, followed by BWCF and BPCF, compared to the control (Fig. 22 and 23). Overall, biofloc treatments showed better health and production than conventional systems.

	pH	TAN	Nitrite	Nitrate	TA	TSS	FV
C0	8.40±0.06	0.83±0.06	5.0±0.0	6.0±2.9	230.0±10.0	22.66±1.5	0.0±0.0
BFCF	8.26±0.12	0.13±0.05	0.13±0.05	0.66±0.57	203±5.70	125.9±11.33	11.33±1.15
BFWP	8.20±0.20	0.20±0.03	0.02±0.0	1.0±0.0	210.0±10.0	145.0±5.0	14.0±11.0
BPCF	8.13±0.11	0.01±0.0	0.0±0.0	0.0±0.0	213.0±15.2	128.3±5.7	14.3±0.57

* Control (without biofloc – C0), biofloc with CIBAfloc (BFCF), biofloc with CIBAfloc liquid (BFWP), and biofloc with periphyton and CIBAfloc (BPCF).

Table. 1

Mean value of water quality parameters. TAN-Total ammonia nitrogen; TA-Total alkalinity; TSS – Total suspended solids; FV – Floc volume.

Treatments	TPC (CFU/104ml)	TVC (CFU/ 102ml)
C0	7.33±1.15	13.6±1.52
BFCF	26.6±7.63	1.33±0.59
BFWP	63.33±11.01	0.66±0.57
BPCF	57.0±8.8	0.83±0.0

Table. 2

Microbial counts in Biofloc and Control system

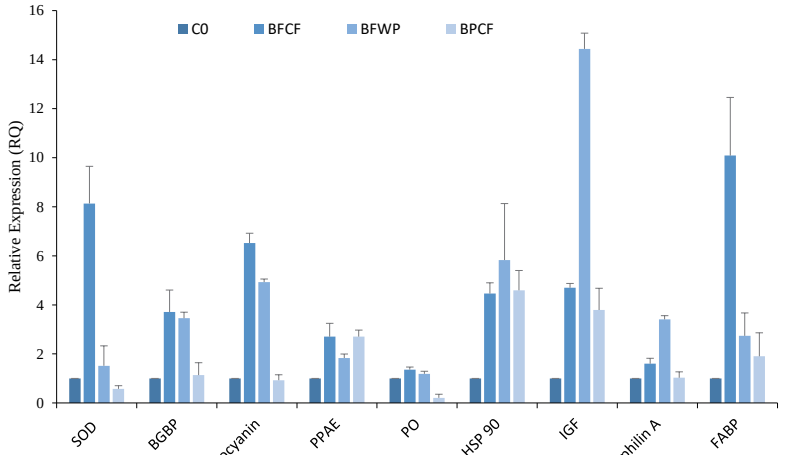


Fig. 22

Relative expression of immune genes *proPO, PPAE, hemocyanin, beta-glucan binding protein, sodium oxide dismutase, insulin-like growth factor, cyclophilin A, and fatty acid-binding protein* in the hepatopancreas of *P. vannamei* reared in the control and biofloc system.

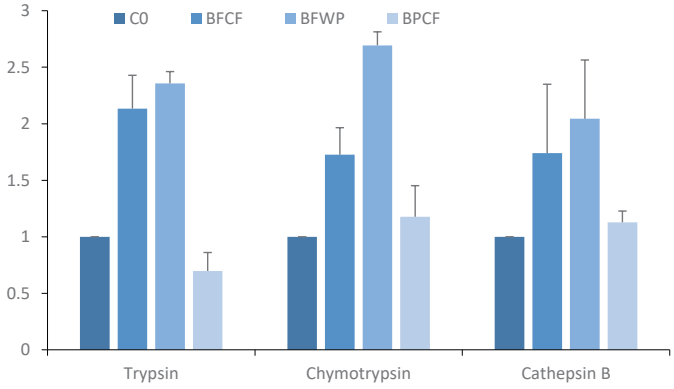


Fig. 23

Relative expression (mean±SE) of trypsin, *chymotrypsin*, and *cathepsin B* in the hepatopancreas of *P. vannamei* reared in the control and biofloc system.

HIGH DENSITY NURSERY REARING OF *P. indicus* USING MONOSPECIFIC AND MIXED CULTURE OF COPEFLOC

An experiment optimizing high-density nursery rearing of *P. indicus* in indoor FRP tanks evaluated monospecific and mixed copepod stocks. Post larvae were stocked at 10,000 individuals per cubic meter for 30 days across various treatments: control, mono-culture of *Dioithona rigida, Evansula pygmea, Pseudodiaptomus annandelei,* and a mixed culture of all three copepod species. Monospecific treatments showed improved growth and survival compared to the control (Fig. 24 and Fig. 25). However, the mixed culture exhibited significant enhancement in both parameters compared to the control, surpassing even the monospecific treatments. This indicates the potential of mixed copepod cultures, specifically comprising *D. rigida, E. pygmea, and P. annandelei,* for optimizing *P. indicus* nursery rearing. Further exploration into the mechanisms and broader applications of this strategy in aquaculture is recommended. The findings underscore the viability of mixed copepod cultures in enhancing the rearing process in indoor FRP tanks.

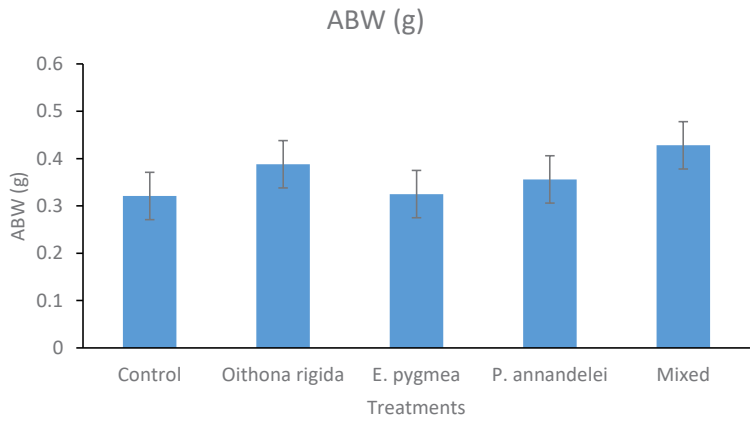


Fig. 24
Average body weight (mean±SE) of *P. indicus* in monospecific and mixed culture of copefloc

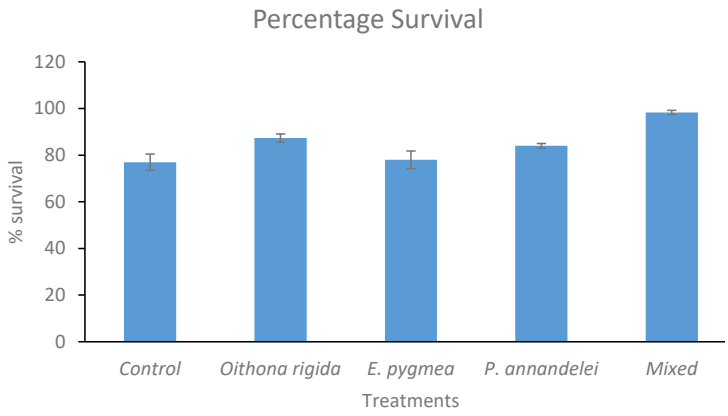


Fig. 25
Percentage survival (mean±SE) of *P. indicus* in monospecific and mixed culture of copefloc

EFFECT OF PLANKTON^{PLUS} AND POLY^{PLUS} ON HIGH DENSITY AND LOW-DENSITY SHRIMP FARMING

A shrimp farming demonstration was conducted at KRC with two different stocking densities 60/m^2 and 40/m^2 respectively. Ponds were fertilized with Plankton^{plus} initially and periodic application of Plankton^{plus} was done to sustain the plankton density. During the initial months of the culture, heavy rain caused the salinity to drop to 2ppt and reduced the algal bloom in the pond. Higher transparency resulted in the development of severe macrophyte bloom, which led to reduction in the survival of the shrimp. At the end of 112 days culture, the shrimps reached an average bodyweight of 16.3g and 17.54g and productivity of 3.73 t/ha and 3.37 t/ha in the high-density and low-density culture, respectively.

GROWTH AND PRODUCTION CHARACTERISTICS OF *P. vannamei* JUVENILES REARED IN FW (TDS<500 PPM) SUPPLEMENTED WITH POTASSIUM (K^+), MAGNESIUM (MG^{2+}), AND CALCIUM (CA^{2+}) IONS IN VARYING COMBINATIONS

Farming of *P. vannamei* in freshwater is an emerging area of interest as shrimp can be raised further away from the coast. Poor success rates and low predictability are major issues in FW shrimp farming which needs to be addressed. A 30-day experiment was carried out to evaluate the production characteristics of *P. vannamei* juveniles (~0.29g) reared in FW (TDS<500 ppm) supplemented with varying combinations of potassium (K^+), magnesium (Mg^{2+}), and calcium (Ca^{2+}) ions. The aqueous K^+ and Mg^{2+} levels were increased sequentially by a factor of 5 up to three levels (K^+: 10, 15, 20 ppm; Mg^{2+}: 20, 25, 30 ppm) and all possible combinations were tested whereas for Ca^{2+}, a single treatment was tested along with the highest combination of K^+ and Mg^{2+} (K:Mg:Ca 0:30:25ppm) (Table 3). Seawater (SW) of 31 ppt was used as the control. At the end of 30 days, final mean body weight did not significantly vary between the FW treatments, whereas SW demonstrated significantly lower final mean weight. Survival rate followed a linear relationship with aqueous Mg^{2+} levels, whereas a bell-shaped pattern was observed for aqueous K^+ levels (Fig. 26). The treatment wherein Ca^{2+} levels were raised by 5 ppm along with highest levels of K^+ and Mg^{2+} (K20M30C25) resulted in significantly higher ($p<0.05$) survival rate (81.67%) over other treatments except SW, K15M25 and K15M30 (69.33-71.67%) ($p>0.05$). The study provides valuable leads on the requisite ionic supplementation for commercial farming of *P. vannamei* in inland regions using freshwater of TDS<500 ppm.

Treatment	TDS (ppm)	pH	Hardness (ppm)	CaH (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	K+ (ppm)	Na^+ (ppm)
K10M20	439.5	8.47	133.33	50	20.04	20.32	11	154
K15M20	443.9	8.45	128.33	50	20.04	19.1	15.4	156
K20M20	451.6	8.40	133.33	48.33	19.37	20.73	20.1	156.5
K10M25	452.2	8.39	148.33	43.33	17.36	25.6	10.5	156.5
K15M25	458	8.43	151.66	48.33	19.37	25.2	15.2	151.5
K20M25	468.5	8.40	155.00	46.66	18.70	26.42	20.2	154.5
K10M30	470.6	8.47	168.33	45	18.03	30.08	10.2	154
K15M30	479.5	8.45	173.33	48.33	19.37	30.48	15	156
K20M30	491	8.42	171.66	48.33	19.37	30.08	20.7	157
K20M30C25	503.4	8.46	181.66	61.66	24.71	29.26	20.8	156.5

Table. 3

Ionic parameters of different FW treatment media supplemented with varying combinations of mineral ions potassium (K^+), magnesium (Mg^{2+}), and calcium (Ca^{2+})

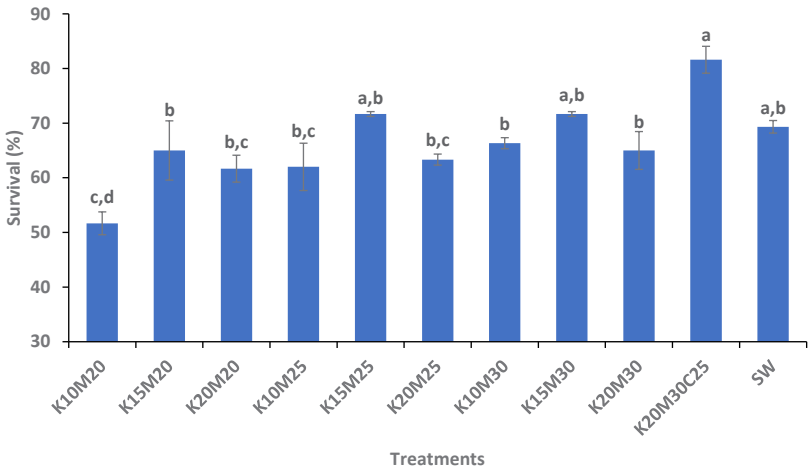


Fig. 26

Survival rate of *P. vannamei* juveniles reared in FW treatment media supplemented with varying combinations of K^+, Mg^{2+} and Ca^{2+} at the end of 30 days.

EFFECTS OF VARYING MG^{2+}/CA^{2+} RATIOS ON THE PRODUCTION CHARACTERISTICS OF *P. vannamei* REARED IN AMENDED INLAND SALINE GROUNDWATER

Mg^{2+}/Ca^{2+} ratio of inland saline groundwater is highly variable and is one of the principal criteria for selection of source water for inland shrimp farming. Inland saline groundwater is generally characterised by a higher total hardness and the effects of varying Mg^{2+}/Ca^{2+} ratios on the growth and survival of *P. vannamei* in a high total hardness environment is generally lacking. Inland saline groundwater (Salinity: 10 ppt) of varying Mg^{2+}/Ca^{2+} ratios viz., 0.5:1, 0.75:1, 1:1, 1.25:1, 1.5:1, 1.75:1, 2.0:1 and reconstituted seawater of 10 ppt salinity (Mg^{2+}/Ca^{2+} ratio: 3.4:1) was artificially prepared (Table 4). The total hardness of all the treatment media were approximately 2900 ppm (Relative hardness of 1.5:1 for 10.0 ppt salinity). P. vannamei PL (~0.08 g) were reared in different treatment media in triplicate at 30 nos./tank for 49 days. At the end of the trial, the treatment with Mg^{2+}/Ca^{2+} ratio of 0.5:1 resulted in significantly lower ($p<0.05$) survival rate (4.3%) and final mean body weight (0.10 g). The Mg^{2+}/Ca^{2+} ratios 0.75:1 and 1:1 resulted in significantly lower ($p<0.05$) survival (15.17 -40%) and final mean body weight (0.57-0.72 g) as compared to those with ratios, 1.25,1.5,1.75 and 2.0:1 (Fig. 27). The final mean body weight, weight gain (%) and survival rate of shrimp reared in inland saline ground water of Mg^{2+}/Ca^{2+} ratios varying from 1.25:1 to 2:1 and reconstituted seawater did not vary significantly, although the ratio of 2:1 and seawater resulted in numerically higher growth. The study clearly indicates that Mg^{2+}/Ca^{2+} ratio of less than 1.25:1 significantly affects growth performance of *P. vannamei* and saline groundwaters of Mg^{2+}/Ca^{2+} ratio, 1.25:1 and higher can be used for commercial inland saline shrimp farming.

Sample ID	Mg^{2+}/Ca^{2+} ratio	pH Salinity	Total hardness	Ca^{2+}	Mg^{2}	Mg^{2+}/Ca^{2+} ratio	Na^{+}	K^{+}	Na^{+}/K^{+} ratio
T1	0.5:1	10	2900.5	631.28	322.5	0.51	2500	87.5	28.57
T2	0.75:1	10	2903.0	514.12	394.56	0.76	2530	89.5	28.26
T3	1:1	10	2901.3	429.45	445.78	1.03	2620	94.2	27.81
T4	1.25:1	10	2902.1	376.56	478.23	1.26	2680	97.8	27.40
T5	1.50:1	10	2903.0	330.19	506.72	1.53	2720	99.7	27.28
T6	1.75:1	10	2901.8	298.93	525.48	1.75	2730	100.2	27.24
T7	2.00:1	10	2903.1	269.46	543.76	2.01	2750	101.5	27.09
T8	3.4:1	10	1910.8	115.34	395.72	3.43	3020	110.5	27.33

Table. 4

Final mean body weight, survival, and weight gain (%) of *P. vannamei* PL reared in amended saline groundwater treatment media for varying Mg/Ca ratios at the end of 49 days. Different superscript letter within the same column indicates a significant difference.

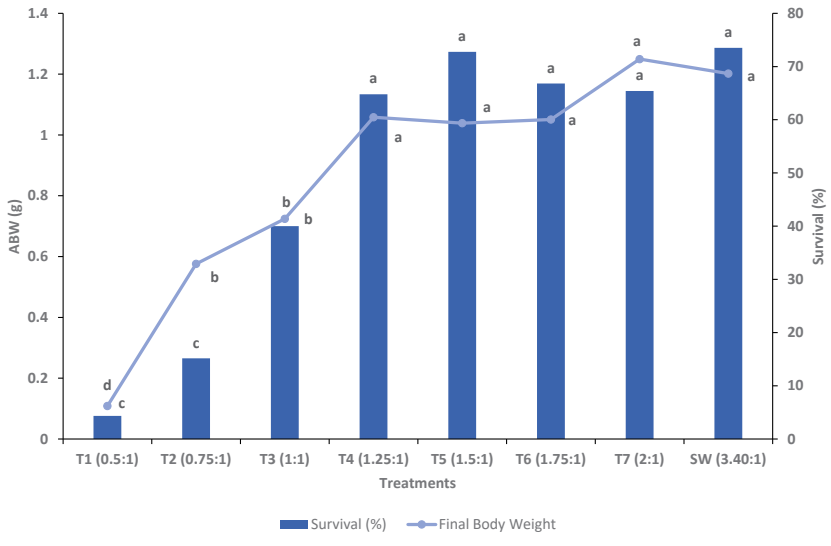


Fig. 27

Final mean body weight, survival, and weight gain (%) of *P. vannamei* PL reared in amended saline groundwater treatment media for varying Mg/Ca ratios at the end of 49 days. Different superscript letter within the same column indicates a significant difference.

EVALUATION OF MULTI-PHASE-BASED FARMING OF PENAEID SHRIMP *P. vannamei*

Nursery integration in the shrimp farming with two-phase farming was successfully demonstrated in the farmer's pond for penaeid shrimp *P. vannamei*. Nursery rearing prior to growout have advantage in terms of higher survival and health, compensatory growth, resource planning, and multiple crops in a year. The experimental trial in the partnering farm resulted in a survival rate of 85 to 91% at a stocking density of 1000 - 2000 no PLs/m^3. The average growth obtained was 600 mg to 1000 mg depending on stocking density. The ideal stocking was found to be 1000 to 1500 nos/m^3. In pre-growout, a stocking density of 100 to 500 nos/m^3 with a final weight of 5-9 g was observed. The nursery reared shrimp executed good compensatory growth in the pre-grow out and grow-out phase. In the growout phase, shrimps attained an ABW of 25 g -28 g in 40 days with an ADG 0.25 to 0.28 g as compared to 0.20 to 0.22 in conventional farming. Multi-phase farming approach resulted in a productivity of 12-15 tonnes/ha as compared to 6-8 tonnes/ha in the case of conventional farming.

NURSERY REARING OF *Scylla olivacea* IN EARTHEN PONDS FOR CRABLET PRODUCTION

A nursery rearing attempt was made for orange mud crab *Scylla olivacea* at KRC to study the feasibility of earthen pond-based crablet production. *Scylla olivacea* baby crabs produced in the hatchery with 0.5-1g body weight were stocked into earthen ponds at different stocking density viz 5,10 and 15/m^2. The crabs were fed twice a day with minced meat of low-value fish @ 10% of the bodyweight. At the end of 80 days culture, crabs attained a bodyweight and carapace width of 7-17g and 34-45mm respectively. The average survival was 20-30% which was not significant among different stocking density. The average bodyweight was higher in 15/m^2 stocking density, which may be a result of cannibalism. All the treatments exhibited 25-30% crabs with missing chelipeds or appendages with bigger size class crabs contributing the highest numbers (Fig 28 & 29).

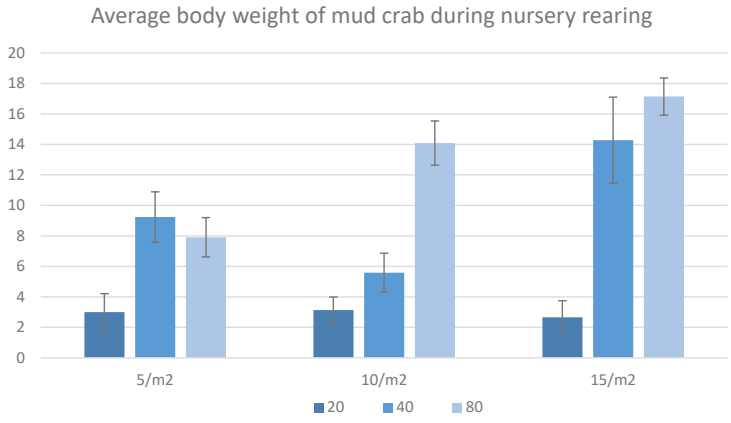


Fig. 28
Body weight distribution of *Scylla olivacea* during nursery rearing

Fig. 29
Nursery reared *Scylla olivacea* – Left (2-3 g, 30 DOC) and crablet (20-25 g, 80 DOC)

EFFECT OF CRAB BOX DIMENSIONS ON THE GROWTH AND MOLTING OF THE MUD CRAB *Scylla olivacea*

Rearing of immature *Scylla olivacea* in crab boxes for 25-30 days for gonad development (Fattening) is a farming activity in coastal West Bengal and Bangladesh. To analyze the effect of the crab box dimensions on growth and molting of mud crab (*Scylla olivacea*), two different types of HDPE crab boxes (Type 1 (LXWXD) 29 X 21.5 X 22.5cm and Type 2-20 X 18 X 16cm) popular among the farmers were used. *Scylla olivacea* of size 75-85 g, with a carapace width70-80 mm in the intermolt stage was stocked into the crab boxes (n=10) in triplicate. The mud crabs were reared on low-value fish meat at 10% of the body weight daily in two meals throughout 60 days of the experiment. The type 1 box was larger and had a volume of 14 liters, whereas the type 2 box was smaller with a volume of 5.8 liters. The depth of water level achieved inside the box while placed on a raft was the major difference between the two designs. The type 1 box had an inside water depth of 12.5 cm whereas the type 2 box had a much lower water depth of 8cm. Higher algal biofouling on the exoskeleton of crabs stocked in type 2 boxes was a key observation in the study. At the end of the experiment, crabs stocked in the type 1 box had a significantly higher ($P<0.05$) molting population (43.33 ± 2.35%) than the type 2 box (23.33 ± 3.33%). However, the number of days taken for the 1st molt and body weight gain was not significantly different ($P<0.05$) among the two designs. Significantly ($P<0.05$) higher survival was achieved in the type 1 box than the type 2 box. The present study indicated that the mud crab fattening in larger boxes with higher water depth is beneficial for molting and improved survival (Fig 30&31).

Fig. 30
Crab reared in Type 1 box (Large box)

Fig. 31
Crab reared in type 2 box (Small box)

SEAWEED CALENDAR FOR CHENGALPATTU DISTRICT

Seaweeds hold immense potential and are a vital source of nutrition and have a wide range of applications including the Food Industry, Cosmetics, Medicine, Agriculture, Industrial Uses, and Biofuel Production. For expansion of seaweed farming, understanding their distribution patterns is crucial for obtaining initial seedlings for seaweed farming. One year field survey was conducted from November 2022 to November 2023 and documented the prevalence and seasonal variations of species in the study area it was observed species viz *Agarophyton tenustipitatum, Gracilaria salicornia, Ulva lactuca, Ulva prolifera* and *Ulva intestinalis* were found to be distributed seasonally in the study area as shown in Fig. 32. During different seasons, seaweeds experience variations in their growth rates, reproductive cycles, and overall health. Seasonal distribution of seaweeds with its respective water quality is a crucial factor for seaweed farming.

Seaweeds	Nov 22	Dec 22	Jan 23	Feb 23	March 23	April 23	May 23	June 23	July 23	Aug 23	Sep 23	Oct 23	Location
Agaropinton tenustipitatum	√			√	√	√	√			√	√	√	Muttukadu, Kalpakkam, Palar bar mouth, Kottaikadu, Kolathur
Gracilaria salicornia			√		√	√	√	√					Muttukadu
Ulva lactuca			√	√			√	√	√	√	√	√	Muttukadu, Kalpakkam, Kolathur
Ulva Prolifera			√	√			√	√	√	√	√	√	Muttukadu, Kalpakkam, Palar bar mouth, Kolathur
Ulva intestinalis			√	√			√	√	√	√	√	√	Muttukadu, Kalpakkam, Palar bar mouth, Kolathur

Fig. 32
Chengalpattu district seaweed calendar

Seaweed awareness program in Pulicat Lake

An awareness program for brackishwater seaweed farming has been conducted in Annamalaicherry village, Pulicat Lake on 10th June 2023 organized by the ICAR – CIBA funded by National Fisheries Development Board (NFDB), Hyderabad under PMMSY Scheme, in collaboration with M/S Pinnacle Biosciences and the Department of Fisheries, Government of Tamil Nadu. This Program provided an important awareness and the benefits of seaweed farming as a livelihood activity among coastal villagers and fishermen. Brackishwater seaweed farming is proposed to take up in 10 villages under this scheme near Pulicat Lake. More than 100 coastal fisher folks attended and benefitted from this Program. This Program delivered a huge impact among the farmers, especially women folks and accepted the seaweed farming proposal made by ICAR-CIBA. A total revenue of ₹ 1,26,000 is expected from 40 rafts of size 3m × 3m in a cluster per annum using G. salicornia and A. tenuistipitatum. The dried seaweed with 30% moisture can get a market price of ₹ 20-25 per Kg.

Fig. 33
Demonstration of brackishwater seaweed farming at Annamalaicheri, Pulicat Lake

COMPARATIVE ANALYSIS OF *Gracilaria salicornia* CULTIVATION METHODS IN SHRIMP PONDS WITH LOW WATER DEPTH.

G. salicornia cultivation has been carried out in shrimp pond following shrimp culture, using the tube net bag (pouch method) and the monoline tube net method. The cultivation was carried out in a low water depth of 30-40 cm with a salinity of 25 ppt. In the pouch method, the initial biomass of 50 g per bunch distributed across 9 units of 1-meter-long rope, with a 15 cm distance between each pouch. In the monoline tubenet method, *G. salicornia* cultivation was carried out with 9 numbers of 1-meter-long tube nets, with an initial biomass of about 350 g per tube net. Results showed a consistent growth pattern throughout the cultivation period. On the 45th DOC the biomass has increased to 15 times in pouch method and 12 times in monoline tubenet method (Fig. 34).

Fig. 34

Gracilaria salicornia cultivation and harvesting in shrimp ponds

INTEGRATION OF SHRIMP FARMING WITH BRACKISHWATER WATER SEAWEED

A.) Integration of *Penaeus vannamei* with *Gracillaria salicornia*

A research experiment at ICAR-CIBA utilized *G. salicornia* seaweed in a lined pond, exploring its integration potential with *P. vannamei* shrimp farming. *P. vannamei* post larvae were stocked at 40 individuals/m2 for 41 days. A floating raft with horizontal and vertical ropes, initially holding 1.5kg and 0.5kg biomass (Fig. 35) respectively, was installed at the pond's centre. In a control pond without seaweed, shrimp were stocked at an equivalent density for comparison. After 41 days, the seaweed-integrated pond harvested 260 kg of shrimp with an 87% survival rate, while the control yielded 220 kg with 77% survival (Fig. 36). The integrated pond also produced 170kg of seaweed biomass (Fig. 37), indicating a fivefold increase and a productivity of 3.4 tons per hectare. This not only showcased enhanced productivity but also introduced an additional income source for farmers. The study highlights the potential benefits of seaweed-shrimp integration in aquaculture systems.

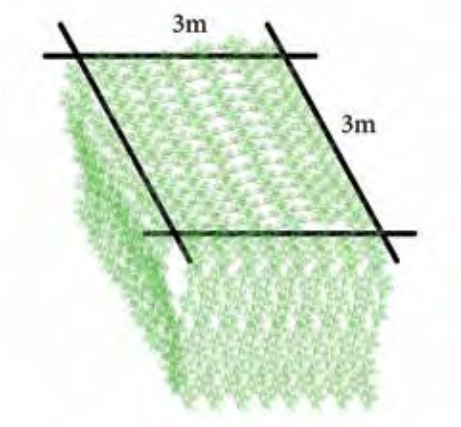


Fig. 35

Floating raft with horizontal and vertical ropes for *Gracillaria salicornia* culture in shrimp ponds

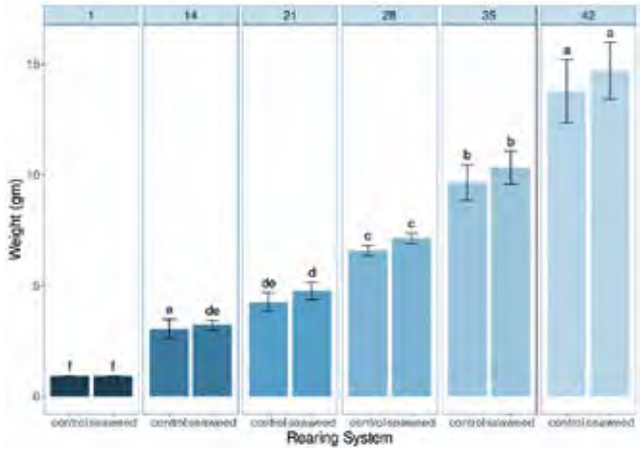


Fig. 36

Mean body weight of *P. vannamei* in seaweed, *Gracillaria salicornia* integrated and control pond

Fig. 37

Harvested biomass of *P. vannamei* and *G. Salicornia*

B.) Integration of *P. vannamei* with *Caulerpa racemosa*

A similar study was conducted using *C. racemose* in 100m^2 lined ponds over a 42-day period, resulting in shrimp productivities of 4.5 and 3.4 tons/ha for the seaweed-integrated and control ponds, respectively. Harvested seaweed biomass reached 6.8 kilograms in the seaweed-integrated pond (Fig. 38), indicating shrimp consumption of the green seaweed. Feed Conversion Ratios (FCR) were 1.52 for the control pond and 1.47 for the seaweed-integrated pond, with slightly higher survival rates in the seaweed pond at 85% compared to 83.5% in the control pond (Fig. 39). Notably, no substantial variation in *C. racemosa* biomass occurred when integrated with shrimp, as it was consumed during both juvenile and adult stages. However, a significant growth difference ($P<0.05$) was observed when integrating edible seaweed, suggesting potential benefits of incorporating such species in shrimp farming practices. These findings shed light on the implications of seaweed integration for shrimp cultivation.

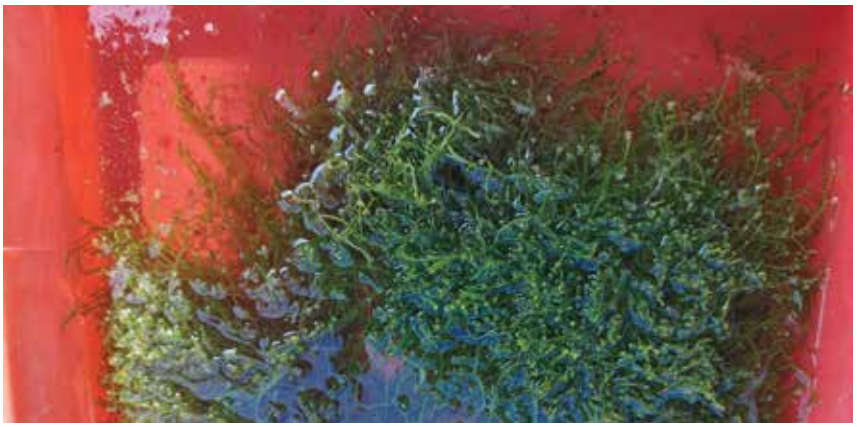


Fig. 38
Harvested mass of *Caulerpa racemosa*

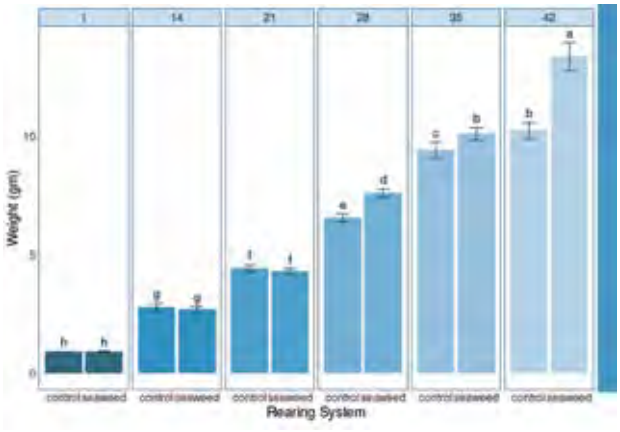


Fig. 39
Mean body weight of *P. vannamei* in seaweed, *Caulerpa racemosa* integrated and control pond

SEAWEED FARMING SITE SELECTION IN CHENGALPATTU DISTRICT USING FAHP.

Seaweeds are valuable resources with rising demand and limited natural sources, seaweed farming is being explored. This study identifies suitable sites for brackishwater seaweed farming using FAHP method. Water samples were analysed at monthly intervals. Optimal conditions yield good growth and high biomass. Salinity ranges from 0-30 ppt in the study area. Wind speed in the study area ranges from 2.8 – 4.7 m/s. Moderate wind speed generates current flow and provides a healthy ecosystem for seaweed growth, and high wind speed damages raft and seaweed seedlings. The water current in the study area ranges from 0.10-0.52 m/s. Ideal water current helps in nutrient exchange and keeps the system sustainable. The result shows 141.56 ha in Chengalpattu district is potential for seaweed farming (Fig. 40). This model can aid in promoting an alternative livelihood for coastal fisherwomen in India.

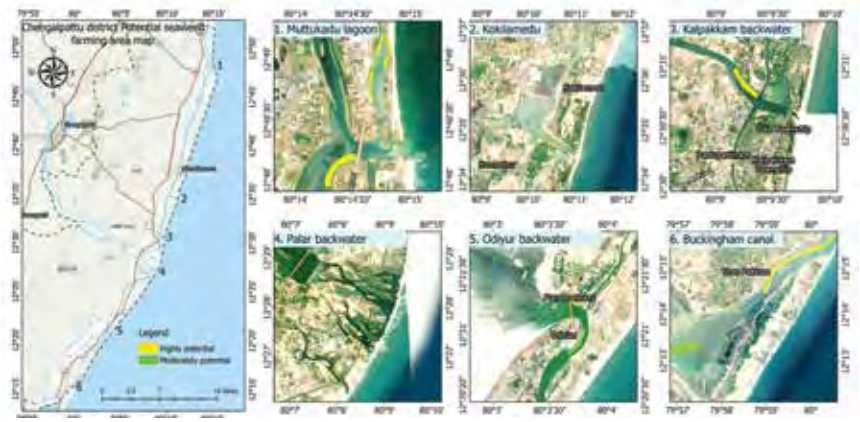


Fig. 40
Seaweed farming potential area map

Ulva lactuca ABUNDANCE IN MUTTUKADU LAGOON DURING SUMMER 2023

The spatial distribution of *Ulva lactuca* bloom in Muttukadu was mapped using Sentinel 2. The bloom exhibited notable temporal dynamics, with peak coverage observed in the last week of May 2023 with a spread area of about 100.05 ha, the bloom intensity was found to be high till the last week of June 2023, after which it gradually declined. The mineral concentration was in the order Ca > Na > Mg > K > P. Iron (Fe) was observed to be high compared to other micronutrients, with a concentration of 1164.40 mg/kg. The *U. lactuca* distribution and collection is given in (Fig. 41 and 42).

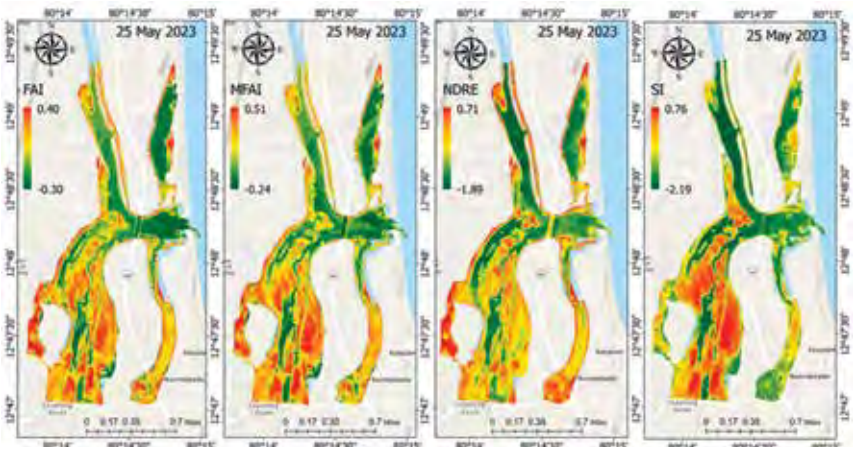


Fig. 41
Ulva lactuca distribution during May 2023

Fig. 42
Ulva lactuca harvest as an additional livelihood activity for coastal community

MAPPING OF UNCULTIVABLE SALT AFFECTED LANDS IN RAJASTHAN

Soil salinization is a global environmental issue particularly in coastal countries, and is expected to be more intense in the future due to climate change scenarios. Mapping of salt affected lads that are not suitable for agriculture will pave the way for alternate use. The project was carried out to map the uncultivable salt affected lands using satellite data in geo spatial platform. Sentinel 2 B data of 2022 has been used to map the salt affected lands and verified in the field. The existing aquaculture farms have been delineated in the selected seven districts of Rajasthan namely Sriganganagar, Hanumangarh, Pali, Jalore, Barmer Jodhpur.and Cheru, covering 45 tehsils (Fig. 43). The uncultivable salt affected lands as classified by National Remote Sensing Centre were mapped, suitable buffer zones were provided from other productive land types. The spatial location and spread of uncultivable salt affected lands indicates the opportunities to develop shrimp aquaculture with regulatory guidelines.

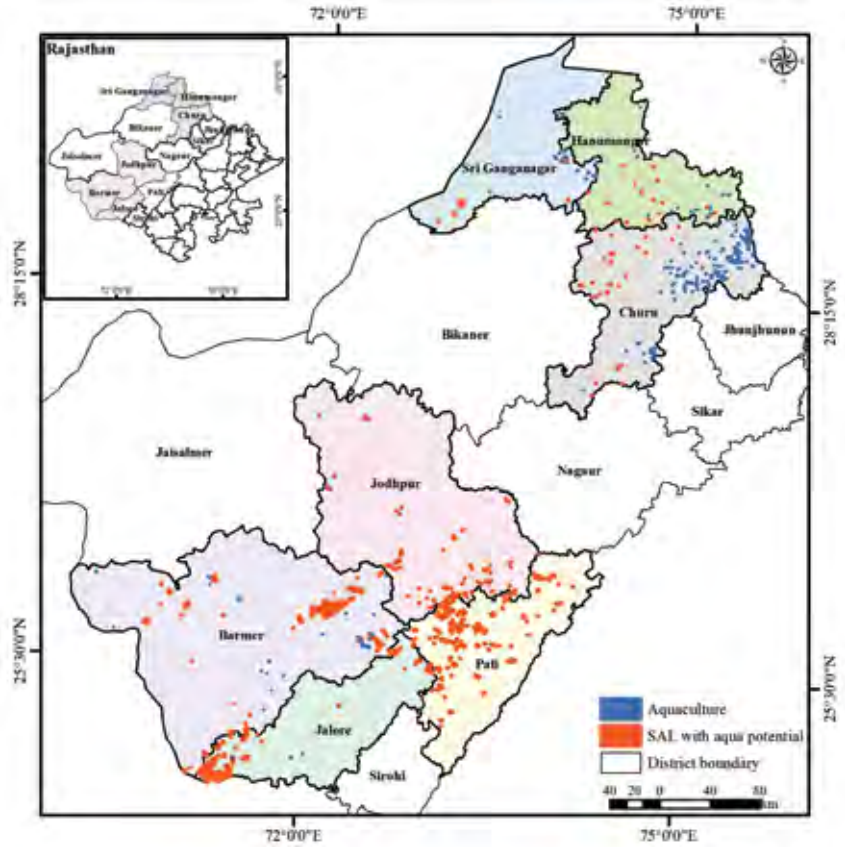


Fig. 43
Mapping of existing aquaculture and uncultivable salt lands for potential aquaculture in Rajasthan

ASSESSMENT OF SOIL CHARACTERISTICS IN SALT AFFECTED LANDS

Field survey was made to assess the suitability of soil for aquaculture in inland saline areas of Rajasthan. The soil samples (n=51) were collected from inland saline areas located in different Tehsils. Soils were in alkaline range with pH values ranged from 7.53 to 9.9. About 95% of samples are non-saline in nature with electrical conductivity value of less than 4 dS/m. Most of the soils were deficient in organic carbon and available nitrogen, except for 17.6% soils in the category of 0.5 to 1% organic carbon content and 31% in the category of above 50 mg/100 g available nitrogen. All the soils were deficient in available phosphorus content. As the soils in these areas are dominant with sand textural categories, the existing farms were with polythene lined ponds (Fig. 44) and it is suggested for lining the ponds for brackishwater aquaculture (BWA) in new areas.

Fig. 44
Shrimp aquaculture farm in inland saline regions of Rajasthan

AUTOMATED DELINEATION OF SALT-AFFECTED LANDS AND THEIR PROGRESS IN COASTAL INDIA USING GOOGLE EARTH ENGINE AND MACHINE LEARNING TECHNIQUES

Assessment of salt-affected land (SAL) is still a major challenging task worldwide, especially in developing nations. The advancement of remotely sensed digital satellite images of different spectral bands has enabled the assessment of soil salinity (Fig. 45). Sentinel-2, Landsat 8, and 5 images of 2020, 2015, and 2009, and Shuttle Radar Topographical Mission data of 2014 were obtained from the Google Earth Engine data catalog (Fig. 46 and 47). Twenty spectral indices have been used which include four vegetation indices, twelve soil salinity indices, four topographical characteristics and their spectral bands. The Random Forest model was used to detect SAL. Of the electrical conductivity values of samples collected in the field, 70% of the soil samples were used for the model training, and the remaining 30% were used for validation. The predicted SAL extent identified during 2020 was 134.4 sq.km with an overall accuracy of 91%. In 2015, and 2009 the total SAL were 128.42, and 120.41 sq. km, respectively. The total SAL has increased by 11.6% during the study period. The present study demonstrated the strength of remote sensing techniques to assess the SAL, which will help quantify the unproductive lands at the state or national level for reclamation or other productive use.

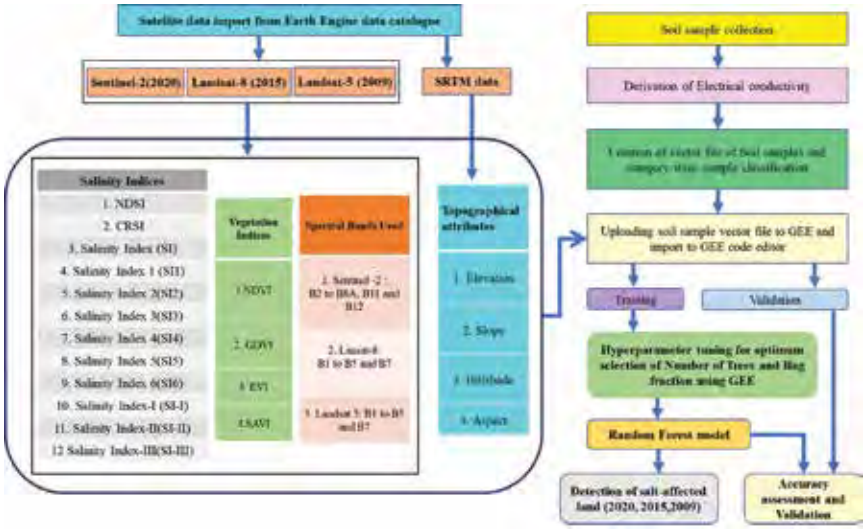


Fig. 45
Methodology flow chart of automated delineation of SAL

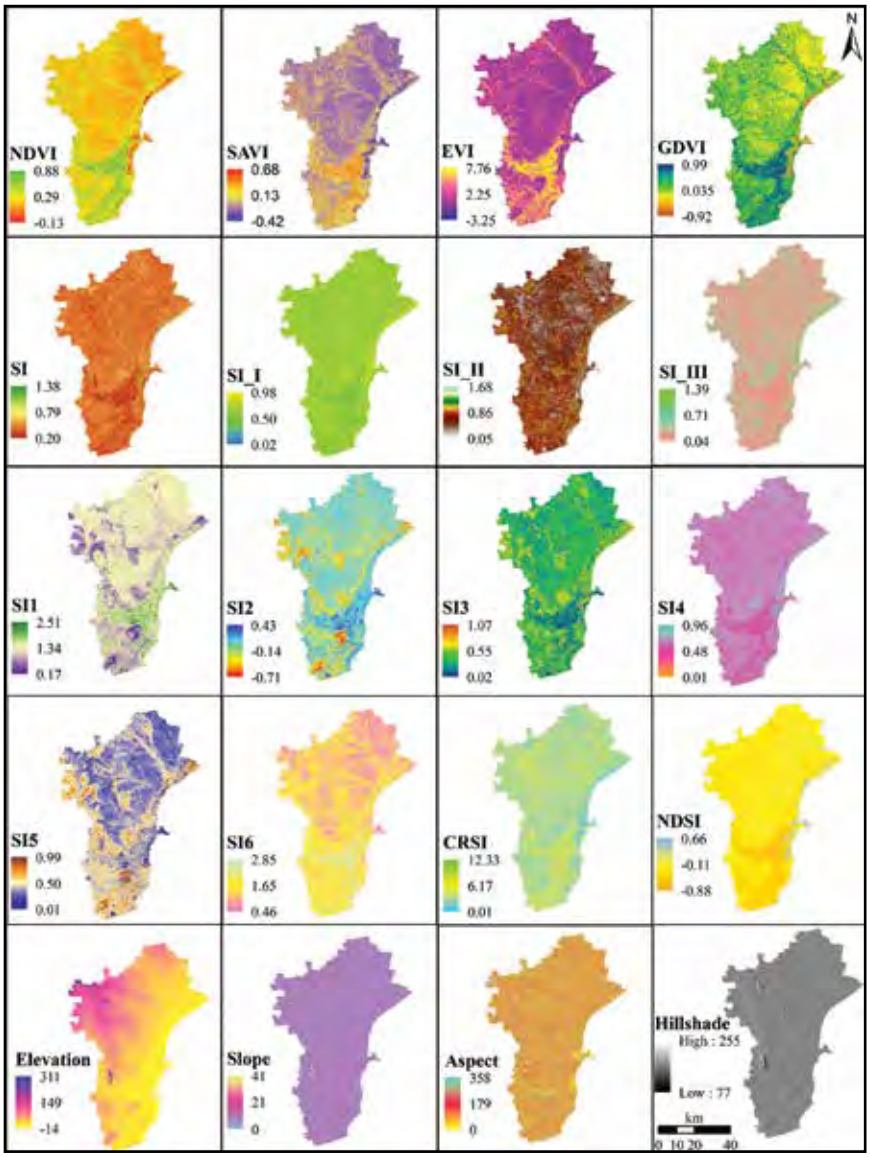


Fig. 46

Soil salinity predictors for the 2020 model for Thoothukudi District, India

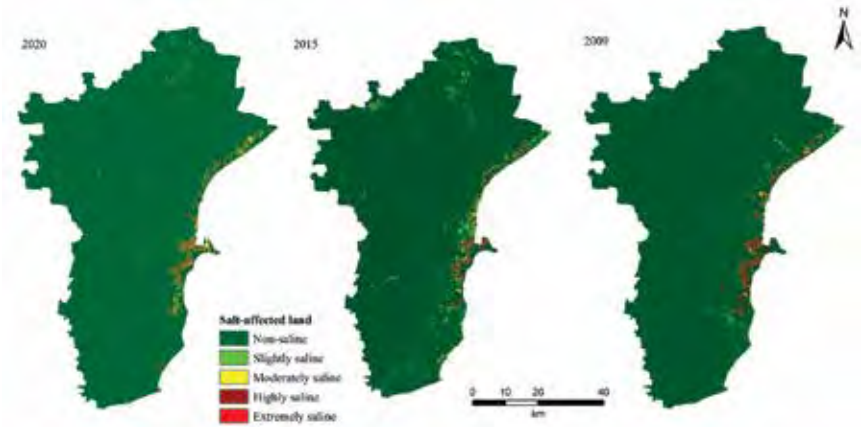


Fig. 47

Soil salinity prediction of Thoothukudi District in 2009, 2015 and 2020

SUCCESSFUL ON-FARM DEMONSTRATION AND HARVEST MELA OF *P. indicus*

I. On-farm demonstration and harvest mela at Utukuru village, Nellore district in Andhra Pradesh

Broodstock bred *indicus* shrimp seeds were given to shrimp farmers by ICAR – CIBA to assess its production potential at farmer's ponds. The demonstration was carried out in 1.7-acre earthen pond with a stocking density of 23 pieces per square meter, accounting 160,000 Pl. Over a cultivation period of 98 days, the pond yielded an impressive total biomass of 2430 kilograms. The average body weight (ABW) of the harvested shrimp was 21.2 grams with a survival rate of 72%. The water quality parameters remained optimal throughout, with a pH level of 7.7, dissolved oxygen (DO) levels 5.82 ppm, and minimal levels of ammonia (0.25 ppm) and nitrite (0.31 ppm), and a salinity of 15 ppt. an on-farm harvest of Indian white shrimp indicus was held on 10th Dec 23 under the Matsya Sampada Jagrukta Abhiyan scheme at Utukuru village, Nellore district in Andhra Pradesh (Fig. 48).

Fig. 48

Harvest of *P. indicus* at Utukuru village, Nellore district

II. On-farm demonstration and harvest mela at Payyanur, Kerala

An on-farm harvest of Indian white shrimp indicus was held on 14-12-2023 under the Matsya Sampada Jagrukta Abhiyan scheme at Kandagali village, Payyanur, Kannur District in Kerala. The demonstration of *P. indicus* farming was carried out in a 2-acre pond area, with a stocking of of 240,000 stocked PLs. The pond's clay bottom facilitated the support of a total biomass of 3330 kilograms, with an average body weight of 18.50 grams in 93 days of farming with cost effective feed. Throughout the farming cycle, salinity recorded at 18 ppt, dissolved oxygen levels at 5.59 ppm, and ammonia and nitrite levels within acceptable limits of 0.65 ppm and 0.071 ppm, respectively (Fig. 49). The success of the harvest was evident with a survival rate of 76% and a favorable feed conversion ratio of 1.5:1. To popularize indian white shrimp seed production and farming farming, ICAR-CIBA made MOU with progressive farmers, hatchery operatores and stake holders.

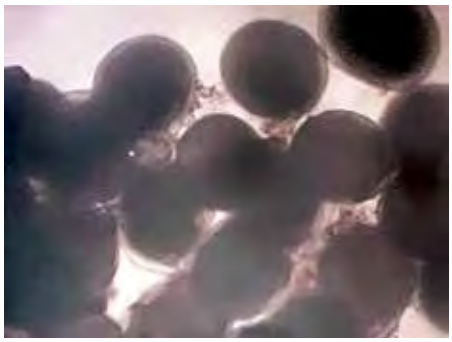
Fig. 49
Harvest of *P.indicus* at Payyanur, Kerala

REPRODUCTION, BREEDING & LARVAL REARING

FIRST-TIME CAPTIVE BREEDING OF GOLD-LINED SPINE FOOT RABBIT FISH *Siganus lineatus* IN INDIA

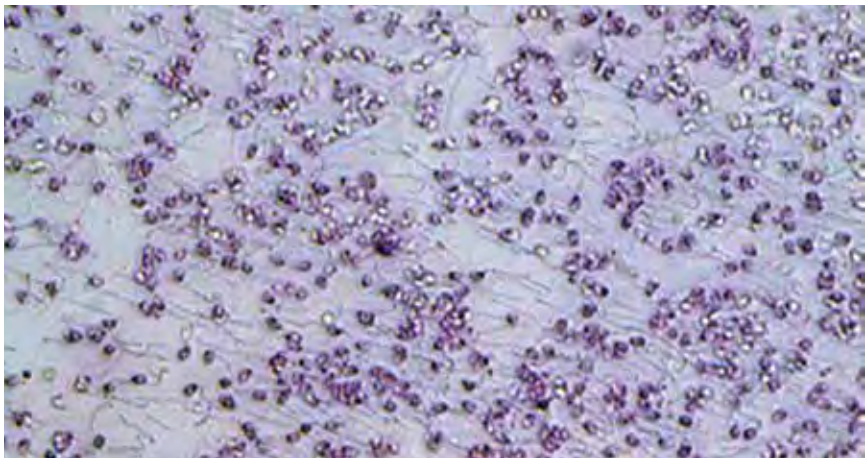
Enhancing our basket of potential species for brackishwater aquaculture stands as a critical priority, given the substantial demand for high-quality fish seed among farmers. The golden-lined spinefoot rabbitfish, *Siganus lineatus*, emerges as a promising candidate due to its rapid growth and ability to thrive across varying salinities. Against this backdrop, ICAR-CIBA has made significant strides in cultivating the broodstock of this species. Our efforts involved sourcing and nurturing sub-adults, weighing between 250 to 500 grams, from trawl and hook-and-line fisheries in Kovalam, Tamil Nadu. Through meticulous captive maturation, broodstock pairs were successfully induced with LHRH for spawning, marking a groundbreaking achievement in the nation's aquaculture landscape. Notably, spawning occurred within a short timeframe of 14 hours post-hormonal induction, with fertilized eggs adhering to tank walls and hatching within 12-14 hours. These processes were under optimal conditions of 28-30 ppt salinity and 27-29 °C water temperature. The cycle continued with larval rearing, initiated with rotifers sized under 100 µm, at a density of 12-15 individuals per ml. Supplementing this, microalgae marine *Chlorella* sp. was introduced to tanks at a concentration of 25,000 cells per ml. Key developmental milestones, such as mouth and anus opening, were observed within 58-62 hours post-hatching. Newly hatched larvae were 2.57 mm in length and with a gut length of 747 µm. Yolk sac size measured as 210 x 255 µm and oil droplet size was 203 x 216 µm. On the third day, the mouth was opened and its diameter measured 172 µm. The Yolk sac completely resorbed on the third day of post-hatch. Larvae were reared up to the 7th day, and standardization of larval rearing protocol is under progress.

Fig. 1
Siganus lineatus brooders



Intraovarian oocytes

Male with oozing milt



Sperms cells wet mount stained with Eosin- nigrosine

0 dph Larvae

1 dph Larvae

2 dph Larvae

4 dph Larvae

Fig. 2
Larval development of *Siganus lineatus*

INDUCED BREEDING, LARVAL REARING AND SEED PRODUCTION OF MANGROVE RED SNAPPER AND GREY MULLET

The mangrove red snapper (*Lutjanus argentimaculatus*) holds a pivotal role in brackishwater aquaculture due to its significant aquacultural and economic importance. Renowned for its delicious taste and high market demand, this species represents a lucrative opportunity for aquafarmers. Its adaptability to varying salinities and robust growth characteristics make it well-suited for cultivation in brackishwater environments. At the Muttukadu Experimental Station, the broodstock of red snapper was carefully nurtured

within a tank-based system, with meticulous monitoring of their development. Quarterly assessments focused on tracking gonadal maturation progress, revealing initial signs of maturity over three years. Notably, 70% of the mature population comprised males, with females accounting for the remaining 30%. The maturity period extended from March to October, with an overall maturity rate of 60%. Hormone application facilitated spawning induction, leading to spontaneous spawning occurring 30 hours post-induction, followed by larvae hatching within 16 to 17 hours post-fertilization. Larval rearing practices involved stocking larvae at a density of 5 per L, with the introduction of rotifers as initial feed after 24 hours, and artemia nauplii from 15 days post-hatch (dph). By the 15th day, a surviving population of 10,000 larvae was achieved, marking the beginning of artificial feed supplementation from 25 dph. By the 45th day, larvae had reached a size of one inch. The hatchery produces seeds that were supplied to a self-help group from Kottaikkadu, Tamil Nadu, for nursery rearing and after 90 days fish reached a size of 6-8 inches.

Fig. 3
Hatchery produced juveniles of mangrove red snapper.

The captive breeding and seed production of grey mullet (*Mugil cephalus*) was continued at our experimental station. The broodstock was maintained in two distinct systems: a 100-ton capacity RCC tank housing 56 individuals ranging from 900 to 1500 grams, and an earthen pond with a total of 60 individuals. Biopsy analysis revealed the presence of oocytes from the final week of October to the second week of December. Notably, appropriately sized oocytes exceeding 500 µm in diameter were only observed during the second and third weeks of November 2023. Throughout the observation period from October to December, the population structure included 13 confirmed mature males and 15 confirmed mature females. Additionally, three individuals with body weights below 700 grams were identified as immature.

Three sets of breeding trials were conducted, resulting in successful breeding in one instance. Larvae were reared up to 15 days post-hatch (dph) following the successful breeding attempt.

Sl.no	No fish observed in different months			
1	Stages of maturity	3	13	44
2	Matured male	6	15	25
3	Matured female	44	25	50
4	maturing fishes	3	3	3

Table: 1.
Maturity of *Mugil cephalus* observed in different months.

Fig. 4
Hormone administration, stripping, fertilized eggs and larvae of *Mugil cephalus*

To strengthen the broodstock, mullet brooders were procured from the farm, Andhra Pradesh as well as from the wild. A total of 162 nos mullets in the size range of 300 g to 2.5 kgs were procured from various sources and transported to the hatchery successfully with 90% survival during transportation.

Fig. 5
Collection of wild *Grey Mullet* broodstock, loading, unloading, prophylactic treatment and releasing in quarantine tanks.

INFLUENCE OF SALINITY ON EGG BUOYANCY AND LARVAL SURVIVAL OF GREY MULLET, *Mugil cephalus*

To understand the effect of salinity on egg buoyancy and larval survival of grey mullet, the fertilised eggs were incubated at different salinity levels (0, 5, 10, 15, 20, 25, 30, 35 and 40 ppt), and then the buoyancy, hatching performances, morphological parameters, survival and growth of larvae until total absorption of yolk sac were assayed. Eggs were buoyant at salinities above 25 ppt while eggs below this salinity sank. The highest hatch rates were observed for eggs maintained at 20, 25, 30 and 35 ppt and were significantly greater than other lower and higher salinity treatments. There were significant differences in survival rate after 12 h of hatching between higher salinity treatments (25, 30, and 35) and the rest of the treatments (0, 10, 15, 20 and 40). The data indicated that 25 to 35 ppt was a suitable salinity range for the survival of embryos. At hatch, the mean total lengths of larvae maintained at 25, 30 and 35 were significantly greater than larvae at other salinities. Larvae that hatched at 5 ppt were deformed, died at hatch, and were not measured. In conclusion, the salinity level should be maintained at 25–35 ppt during embryogenesis and at 20–35 during early larval development for this species.

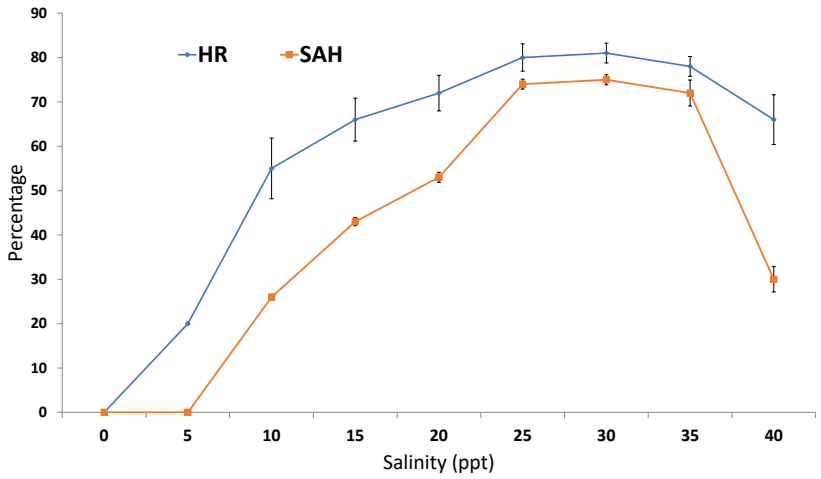


Fig. 6
Observation on larval hatching rate (HR) and survival rate after (SAH) 12 h of hatching of grey mullet at different salinities after hatching.

Fig. 7

Normal larvae at higher salinities and unhatched eggs and deformed larvae at lower salinities (0, 5 and 10 ppt).

SEED PRODUCTION TRIAL FOR GREY MULLET, *Mugil cephalus* IN GUJARAT

Seed production of grey mullet, *Mugil cephalus* an important candidate brackishwater finfish species, is a major challenge globally due to its short breeding season. Seed production of grey mullet was attempted at NGRC in Navsari. A total of 100 adult grey mullets (0.61-1.8 kg) were maintained in cages (4 x 4 x 2 m) @ 20 no.s/cage in an earthen pond for maturation and breeding trials. Fish were fed with 6-7 mm artificial feed (CP: 47%, lipid: 10%). During the first week of December, a total of 19 oozing males (590-1005 g) and 44 mature females (870–2010 g) with oocyte diameter of 442-562.2 µm were obtained during biopsy sampling. Females with oocyte diameter 507-550 µm were selected for the induced breeding. Two sets of brooders with a sex ratio of 1:3 and 1:4 (Female, 1.15 Kg – 1.45 Kg: Male, 0.61 Kg – 0.79 Kg) were stocked in to a muslin cloth hapa (3 x 2 m) installed in 2000 m^2 pond (salinity: 28 ppt) . Water showers were placed above each hapa and a dose of HCG was given to male and female (0.5 ml/Kg) for conditioning. OVAFISH was injected to female at 0.5 ml/kg and male at 0.25 ml/kg after 24 hrs of conditioning. After 14 hrs of injection, partial spawning was observed in one hapa and around 2000 nos of non-fertilized eggs were released. The partial spawning obtained through this methodology provides a basis for developing a farmer friendly breeding approach for the species in future.

Fig. 8

Grey mullet brooders used for seed production trial

Fig. 9

Grey mullet brooders released in to pond-based muslin cloth hapas for seed production trials

Fig. 10

Tank based breeding setup of *Grey mullet*.

THE CAPTIVE BREEDING OF GOLDLINED SEABREAM *Rhabdosargus sarba*

Rhabdosargus sarba, commonly known as the Goldlined seabream, possesses considerable aquaculture potential owing to its adaptability to diverse environmental conditions, rapid growth rates, and market desirability for its firm texture and mild flavour. With its omnivorous feeding habits, the species can utilize various feed sources, contributing to cost-effective production. In pursuit of optimizing larval rearing protocols and enabling large-scale seed production of Goldlined seabream, initial measures were taken to enhance and condition the broodstock. Sub-adults and adult fishes were collected from the wild. These fishes exhibit a size range between 110 and 1200 grams, with an average weight of 313 grams. The broodstock comprises 32 females and 46 males, maintaining a ratio of 1 female to 0.4 males. Various rearing systems, including RCC tanks, RAS facilities, and small rectangular PVC cages, are being utilized to maintain the broodstock. As an RAS facility is an important factor in finfish hatchery to obtain captive maturation, a dedicated RAS has been established, incorporating photo-period and temperature manipulation. One breeding trial was conducted utilizing HCG hormonal administration, which resulted in spawning; however, fertilization did not occur. Further developments are being monitored under captive conditions.

Fig. 11
Goldlined Seabream *Rhabdosargus sarba* brooder

Fig. 12
Dedicated RAS for captive maturation of Goldlined Seabream *Rhabdosargus sarba*

SEED PRODUCTION OF ASIAN SEABASS TO CATER THE DEMAND

Since the inception of successful breeding of Asian seabass in 1997, ICAR-CIBA has been consistently producing seeds and distributing them to farmers across the country. In the current year, eighteen breeding trials were conducted, resulting in the spawning of 3.24 million eggs with an average fertilization rate of 81% and a hatching rate of 82.6%. Of these, 1.6 million fertilized eggs were provided to private hatcheries with technical support from CIBA. Additionally, 1 lakh seeds were distributed to farmers for culture demonstrations in various locations. The seed sales generated total revenue of Rs 4.1 lakh, showcasing the successful contribution of ICAR-CIBA in supporting the aquaculture industry.

To strengthen the broodstock of seabass, farm-reared seabass fishes procured from a farm, in Machilipatnam, Andhra Pradesh. A total of 25 fishes of average size 3.4 kgs with a total of 86 kgs biomass transported successfully in 1 ton Sintex tanks. 100% survival was achieved during transportation. Matured hatchery-raised seabass brooders were procured from Kakinada and a total of 13 fishes in the size range of 8 to 14 kgs (Average 9 kgs) were transported successfully in 1-ton tank provided with oxygen in seawater with 100% survival.

Fig. 13
Seabass broodstock procurement and transportation.

CAPTIVE SEED PRODUCTION OF MILKFISH AND RECRUITMENT OF NEW BROODSTOCKS IN A BREEDING POOL

In total, 35 milkfish broodstock (Chennai and Kakinada stocks) fishes with an average body weight of 6.6 kg and a total biomass of 303 kg are being maintained in three tanks with 100-ton capacity each. Additionally, twelve new stocks sourced from the Chennai coast, with an average body weight of 4.5 kg and a total length of 82 cm, have been maintained for the last two years and were recruited this year. Furthermore, a second line of broodstocks (n=30) with an average weight of 2.99 kg and a total length of 77 cm is being maintained in the pond. The maturation percentages ranged from 23.5% to 81.81%. Maturation was assessed based on the presence of running milt and vitellogenic oocytes with diameters ranging from 450 to 720 µm. Three spawning, one from the Chennai population and two from the Kakinada population, were observed between March and September 2023, with the production of 2 lakh fertilized eggs and 1.5 lakh larvae. A total of 17,526 milkfish fry were produced and distributed among farmers and entrepreneurs in Kerala, Tamil Nadu, and West Bengal, generating a revenue of Rs. 100,017 from seed sales.

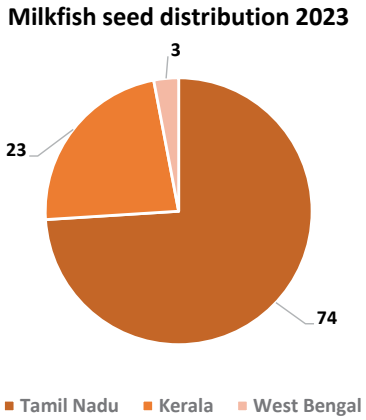


Fig. 14
Milkfish seed distribution

AUGMENTING THE LIVE FEED CULTURES FOR BETTER FINFISH LARVAL SURVIVAL

Live feeds are the inevitable source of nutrition to the marine and brackishwater finfish larvae during their critical development phase. The focus of the present study was on devising an improved feeding regimen for the larvae of candidate finfish species for brackishwater aquaculture like *Mugil cephalus*, *Lutjanus argentimaculatus*, and *Siganus javus*, by enhancing the nutritional content of live feeds, particularly copepods and ciliates. Understanding the importance of copepods and ciliates in finfish larval rearing a specialized facility was established at the Muttukadu Experimental Station to enhance larval survival rates in finfish larval rearing. Through different isolation techniques, five copepod species and one ciliate were successfully isolated from both brackishwater and marine environments, encompassing three cyclopoid, one harpacticoid, and one calanoid species. Identification of these species was carried out based on their morphological characteristics.

Species	Class	Size (Micron)	
Copepods		**Adult**	**Nauplii**
Apocyclops sp	Cyclopida	650-910	56-75
Oithona sp	Cyclopida	900-1100	70-100
Apocyclops sp	Cyclopida	800-1000	60-85
Parvocalanus sp	Clanaoida	670-750	55-75
Euterpina sp	Herpacticoida	700-850	55-78
Ciliate		**Adult**	
Euplotes sp	Euplotida	55-72	

Table. 2
Different isolates of copepods and ciliates and their size.

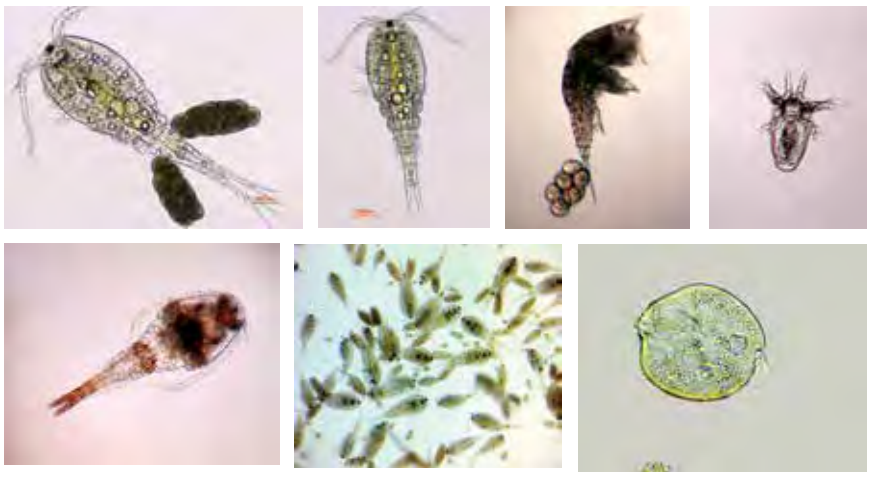


Fig. 15
Copepod species and ciliate isolated from brackishwater areas

The growth of three isolated copepod species was observed for 12 days (*Parvocalanus* sp, *Apocyclops* sp and *Oithona* sp). The copepods were fed with Tetraselmis sp on alternate days. The number of adults, copepodites and nauplii were counted daily. The results showed that *Apocyclops* sp has significantly higher growth rates and shorter generation times than the other two species. The results of the experiments also showed that it has the shortest average generation time (5±1 days) and smallest naupliar stages (Nauplii 1 is 50-70 microns). Moreover, Apocyclops sp showed a significantly higher number of copepod adults and nauplii on the 12th day of the culture compared to the other two species. *Oithona* sp showed the lowest density compared to the other two species. The selected species were produced on a mass scale for further experiments (500L and 1-ton FRP tanks).

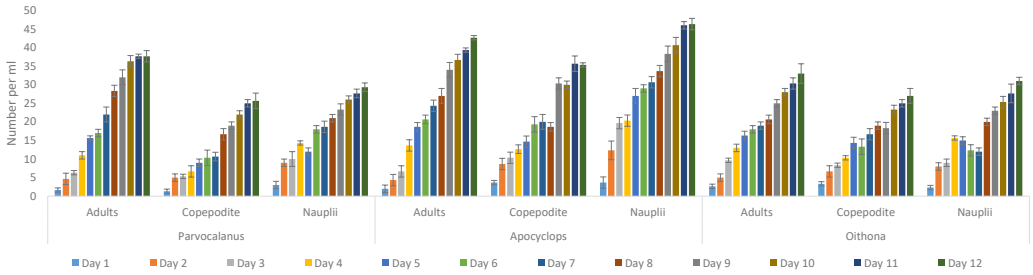


Fig. 16

Growth of different species of copepods

Fig. 17

Copepod culture units established at MES

An experiment was conducted utilizing *Apocyclops* sp to assess its growth potential under various enrichment media conditions over 12 days within a copepod culture facility. The experiment comprised three treatments: T1, where copepods were fed Tetraselmis sp culture on alternate days; T2, where copepods were fed 40 ppm fish waste hydrolysate (FWH) on alternate days; and T3, where copepods were fed both *Tetraselmis* and FWH (40 ppm) on alternate days. Results indicated that the growth, measured by the number of copepods per millilitre, was significantly higher in the treatment fed with both *Tetraselmis* sp and FWH together on alternate days compared to the other treatments. Following this, the treatment fed solely Tetraselmis sp exhibited the next highest growth rate, while the lowest growth was observed in the treatment fed solely FWH. These findings underscore the potential for enhancing copepod growth through a combination of microalgae and FWH, indicating promising opportunities for optimizing copepod culture techniques.

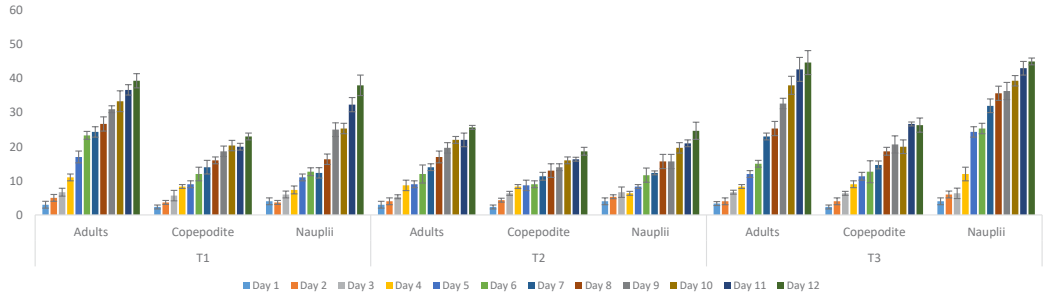


Fig. 18

Abundance of copepods in different media.

DEVELOPMENT OF BASE POPULATION FOR SELECTIVE BREEDING ON GROWTH IN PEARLSPOT

Ensuring the availability of genetically improved seeds is crucial for sustainable aquaculture production. Slow growth is one of the major hurdles faced by peralspot farmers. This study aimed to evaluate the effectiveness of selective breeding in pearlspot fishes after one generation of selection. The within-family selection was conducted using five full-sib families (F0 generation) of pearlspot. Phenotypic data on body weight for the F0 families were previously recorded over 360 days. An inter-family crossing experiment resulted in 11 crosses, with 11 pairs selected from the five full-sib families and placed in separate breeding tanks. Two pairs successfully spawned during April. The F1 families were cultured individually in 2m x 3m size meshed cages and fed with pearlspot fish feed at 5% of body weight. The estimated genetic gain for body weight over 240 days was approximately 8 to 9%. These findings indicate promising progress in selective breeding efforts for enhancing the genetic potential of pearlspot fishes. More stocks from different geographical areas will be collected (Kerala, Gujarat) to evaluate the growth performance among different stocks. During the current year, 3551 numbers of pearlspot were sold to farmers and generated a revenue of Rs 32,367/-

CLOSING THE LIFE CYCLE OF BENGAL YELLOWFIN SEABREAM (*Acanthopagrus datnia*) IN CAPTIVITY

Bengal Yellowfin seabream (*Acanthopagrus datnia*) is a tropical demersal brackishwater finfish having distribution in the eastern Indian Ocean countries. It is an important species in West Bengal coastal regions where it is sold for ₹ 300 to 400/kg. Traditional farming of this fish is being carried out in the Bheries of West Bengal by natural auto stocking. Aquaculture expansion of this species is being hindered due to the lack of availability of quality seeds. Hence, the Kakdwip Research Centre of ICAR-CIBA strengthened the broodstock (body weight 100 – 600 g) in its RAS facility and standardized the induced spawning protocols. It was observed that adult males and females with a body weight >100 g could attain gonadal maturity in water salinity of 10 – 14 ppt. However, October onwards a higher salinity is required for spawning.

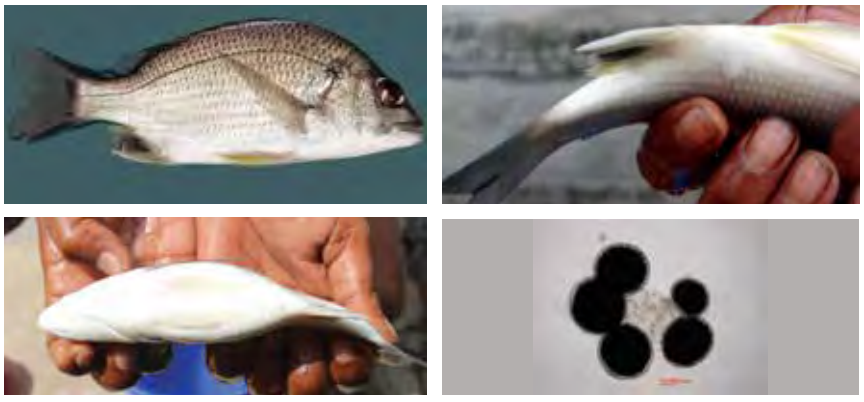


Fig. 19

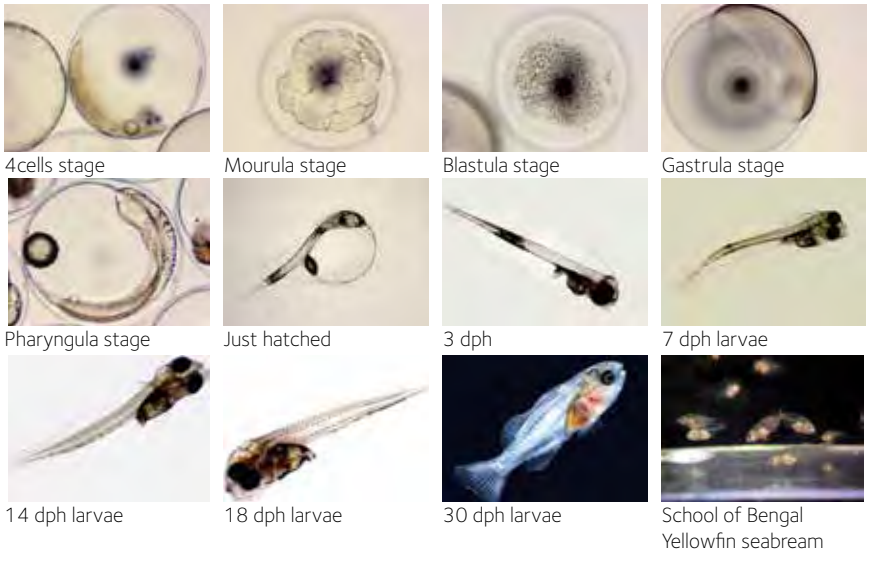
Maturity assessment in captive broodstock of *A. datnia*

The ambient water salinity in RAS was slowly increased by addition of sea water to attain a final salinity of 26 – 27 ppt. Females with oocyte diameters >450 µm were selected for hormone induction. Each spawning pair consisted of 1 female and 3 males. The dose of hCG (Human chorionic gonadotropin) was standardized to 2000 IU/ Kg body weight/female to achieve repeated spawning 3 – 5 times on consecutive days. First spawning occurs post 18 – 24 hours of hormone administration at 18 – 20 ºC. A female with a body weight of 200 – 300 g can spawn a total of 1 – 2 lakh eggs. Fertilization and hatching rate were found to be 90 and 95%, respectively in all the spawning sets. Fertilized eggs (diameter: 870 – 890 µm) were translucent and pelagic. Hatching was completed within 18 hours at 18-20 ºC. Newly born hatchlings (Fig. 20) were in the range of 1.92-1.98 mm in length. Mouth opening was observed at 50 hours post-hatching at 20 ºC. Microalgae, *Chlorella salina*, was introduced on 2nd day post-hatching (dph) in larval rearing tanks. Exogenous feeding was initiated 3 days post-hatching (dph) with rotifer (*Brachionus plicatilis*, 10 – 15 no/ml) which continued till 19 dph. *Artemia* nauplii (5 – 7 no/ml) were offered from 15 dph – 35 dph. Weaning on microparticulate formulated feed started on 30 DPH (Table 3). Outdoor nursery rearing of 30000 nos larvae in tanks and brackishwater ponds is in progress.

Days post-hatching	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Feeding regime			Microalgae (*Chlorella salina*)																																	
				Rotifer (*Brachionus plicatilis*)																																	
Water change/ day			10%														20%						30%													50%

Table. 3

Feeding and water exchange schedule during indoor larval rearing of *A. datnia*



4cells stage | Mourula stage | Blastula stage | Gastrula stage

Pharyngula stage | Just hatched | 3 dph | 7 dph larvae

14 dph larvae | 18 dph larvae | 30 dph larvae | School of Bengal Yellowfin seabream

Fig. 20

Embryonic and larval development in *A. datnia* in captivity

CAPTIVE MATURATION AND FIRST-TIME OVULATION IN GREEN PUFFERFISH (*Dichotomyctere fluviatilis*) IN CAPTIVITY

The green pufferfish (*Dichotomyctere fluviatilis*) is found in Asian countries like Sri Lanka, Bangladesh, Myanmar, and India. It occurs in Indian Sundarbans where its habitat includes rivers and estuaries. It is a euryhaline fish species having good demand in the ornamental trade where it sells for ₹ 30 – 50/ pc. Its reproductive biology in captivity is unknown. Hence, 43 adults of Green Pufferfish were maintained in RAS round the year to strengthen the broodstock and record the maturity in captivity. Milt expression in males and mature females was observed from April onwards in captivity. The diameter of mature oocytes ranged from 500 – 600 µm before spawning. Since intramuscular hormone administration is difficult due to the leathery skin and inflating behavior of fish, the dose of anaesthesia (2Phenoxy Ethanol) was standardized and optimum dose was found to be 150 ppm. Different hormones viz. hCG (1000 IU/Kg body weight), Ovaprim (0.5 ml/ Kg body weight), LHRHa (50 and 100 IUg/kg body weight) were administered to females to standardize the hormone type and dose in 0, 15 and 30 ppt. A pair was constituted with1 female and 3 males after hormonal induction with a single dose of LHRHa (female: 100 µg/kg body weight; male: 50 µg/kg body weight) spawning occurred post latency period of 24 hours in 30 ppt water salinity. Fertilized eggs were translucent, demersal, slightly adhesive, and contain numerous oil droplets (Diameter: 730 – 820 µm). Embryonic development could be observed up to (heart beating stage) i.e. till 79 hpf (3 days) (Fig 21).

Fig. 21
Captive maturation and embryo development in fertilized eggs of green puffer (*Dichotomyctere fluviatilis*)

ASSESSMENT OF MATURITY IN TADE MULLET (*Liza tade*) UNDER CAPTIVITY

Quality seed availability for stocking poses a challenge for aquaculture expansion of *Liza tade*. Its reproductive biology in captivity has not been reported earlier.Sub-adults/ adults (1, 2, and 3 years of age) of Tade mullet (*Liza tade*) were collected and stocked in earthen ponds to assess the maturity on captive broodstock (Fig 22). Maturity assessment was performed through ovarian biopsy on females with a sterilized polyethylene (PE) cannula (diameter: 0.8 mm). Males were assessed for milt production upon pressing the belly. The first occurrence of oocytes in female fish (+2-year age group) was observed in February. Oocyte diameter increased gradually with a rise in salinity and temperature. The highest size (diameter: 559.01 ± 10.19 µm) was observed during July and late atretic oocytes were observed during August month. Milting males (1 year age group) were observed during the June – July months (Fig 23).

Fig. 22
Broodstock of Tade mullet (*Liza tade*) in pond systems

Cannulation on female tade mullet

Milt expression in male tade mullet

Bulged belly and swollen vent in female

Mature testes in male

Fig. 23
Monthly maturity assessment in Tade mullet (*Liza tade*) broodstock

ARTIFICIAL BREEDING OF HILSA (*Tenualosa ilisha*)

Mature hilsa brooders were collected from Hoogly river at Godakhali, South 24 Parganas, West Bengal and artificial breeding was performed through dry stripping on boat (Fig. 24). Male (210-236g) and Female (400-1200g) ratio was 4:1. Fertilized eggs (Fig. 25) were transported in oxygenated polythene bag and incubated at 24±1.0°C temperature. The fertilization and hatching rates were 95.62±0.44% and 70.30±1.64%, respectively. Larvae were hatched out after the 18-21 hrs of fertilization.

Fig. 24
Dry stripping

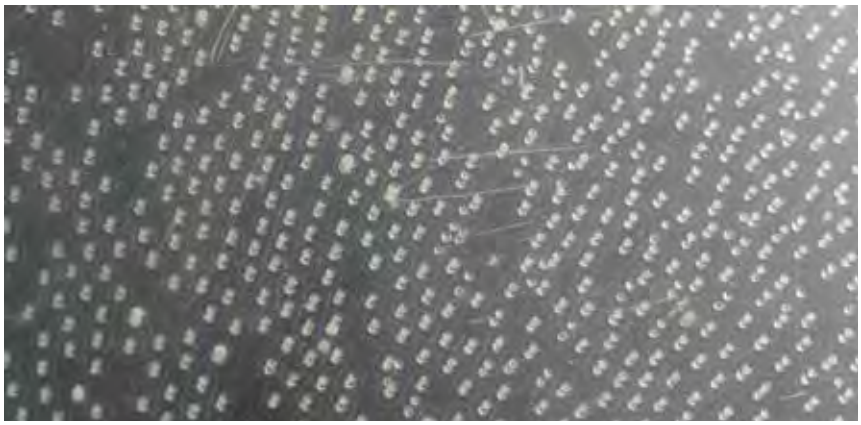


Fig. 25
Fertilized egg

INDOOR LARVAL REARING OF HILSA

Newly hatched larvae were maintained in 10L capacity plastic tub. After 3days larvae were fed with concentrated marine micro algae @ 0.5 ml/10L and rotifer (*Brachionus* sp.) @ 30 nos./ml. After 6days, survival rate was found to be 75% (Fig. 26).

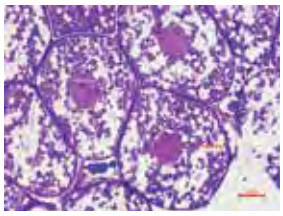
Fig. 26
Indoor larval rearing

BROODSTOCK DEVELOPMENT OF HILSA IN BRACKISHWATER POND SYSTEM

Sub adult hilsa (158.84± 12.50 g/ 22.85± 0.72 cm) were collected and stocked in brackish water pond (0.15ha). Fish were maintained with Hilsa^{Plus} feed (CP- 36.6% & EE- 13.1%) and two months prior to breeding seasons, specially designed broodstock feed (CP-42.52±0.03%, EE-14.47±0.03%) was applied. In the month of June-July female Hilsa started maturing (GSI-1.23) in pond facility (Fig. 27). During October month gonad development was observed in 80% fish. During September - October, GSI and Oocyte diameter was found to be 6.13-9.74 and 559.97-810.83 µm, respectively. GSI value was found to be highest (GSI-9.74) during October. Fecundity was found to be 2,09,085-2,67,211 (fish body weight 406-551 g) (Fig. 28 and 29).

Fig. 27
Haul of hilsa broodstock

Pond reared mature hilsa dissection



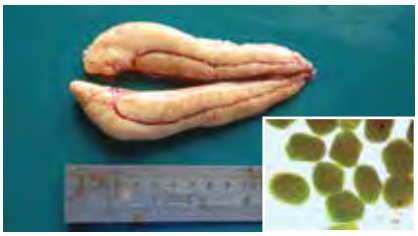
Primary yolk globule stage of hilsa

Captive hilsa egg

Immature Ovary of pond reared hilsa during July

Ovary of pond reared hilsa during August

Ovary of pond reared hilsa during September



Ovary of pond reared hilsa during October

Fig. 28

Brood stock development of hilsa in pond

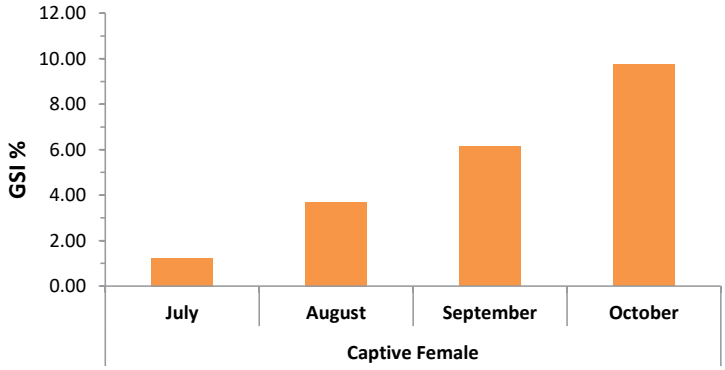


Fig. 29

GSI value of hilsa female broodstock in different months

SEED PRODUCTION AND FARMING DEMONSTRATIONS WITH INDIAN WHITE SHRIMP, *P. indicus*

Indian white shrimp, *Penaeus indicus*, has been identified as a national priority species for domestication and genetic improvement programs in India. To evaluate the reproductive and larval performance, and generate a database for the founder population, wild *P. indicus* brooders were collected across different locations in India such as Puri (Odisha), Kakinada (AP), Chennai (TN), Kanyakumari (TN), and Quilon (KR). The brooders were screened as per WOAH for all important pathogens before recruiting for hatchery production. Three million seeds were produced in the year 2023 and distributed to the farmers of different locations all across the Indian coast. The growth potential of different stocks was evaluated in the farming demonstration. Experiments conducted to evaluate the efficacy of feeding on microalgae revealed better survival during larval rearing. *P. indicus* larval production was tried with 2 different feeding strategies at nauplius and protozoea of *P. indicus* larval stages using the Conventional Larval Rearing system (CLRS) and Modified Larval Rearing system (MLRS). In the MLRS system, major intervention followed was inoculating the pure culture of microalgae in the larval rearing tanks

before stocking the nauplius VI, followed by exclusive dependence of microalgae and minimum water exchange till Mysis stages, unlike the use of outdoor microalgae and supplementary feeding followed in the conventional rearing system. The MLRS system improved 17% improvement in larval survival compared with conventional rearing units. Better control over water quality parameters, minimum chance of contamination through outdoor algal feeding, and minimum stress as water exchange followed at Mysis 3 are the major factors contributing to increased survival.

EFFECT OF HORMONAL ADMINISTRATION IN GONAD DEVELOPMENT AND SPAWNING OF CAPTIVE-REARED *P. indicus*

Although eyestalk ablation is the most common induced maturation technique used in commercial shrimp hatcheries, eye stalk ablation leads to stress, low survival, and increased moulting in captive-rearing shrimps. Against this background, a 21-day maturation trial was carried out in indoor maturation units to explore the potential of the application of sex steroids in unablated captive-reared broodstock (35-40g) for induced maturation. The treatment groups consist of eyestalk-ablated brooders (T1), unablated brooders with hormone administration (T2), and unablated control groups (T3). In hormone-treated groups, shrimp brooders were injected with 17-β-estradiol at 50 µg per brooder. The broodstocks were fed at 25% of the body weight six times per day. Among the treatments, the highest spawning, 35% was recorded in the eyestalk ablated group followed by unablated (23.5%) while none of the shrimp in the unablated group (T3) responded to spawning (Fig. 30). It was recorded that 16% of the shrimps in the unablated control group recorded 3rd or 2nd stage of gonad development suggesting the need for a trigger for final maturation in the indoor units. Although eyestalk-ablated brooders recorded the highest spawning (35.29%), there was a reduction in mating (29.42%) suggesting that eye stalk ablation can trigger moulting and thereby reduction in mating in the captive system. The study revealed hormone administration can be explored as an alternative tool for induced maturation.

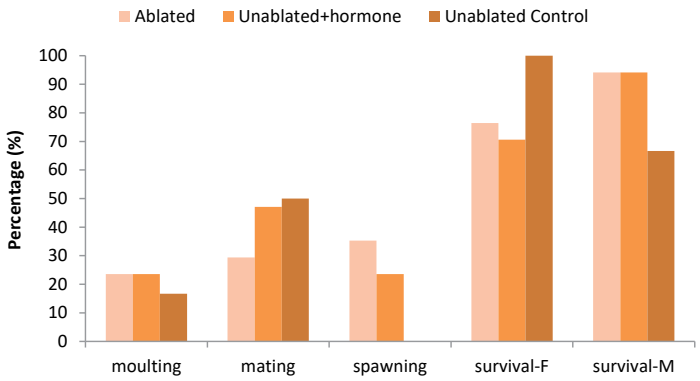


Fig. 30
The percentage of moultng, matng, spawning, and survival of *P. indicus* broodstocks subject to hormonal administration and eyestalk ablation

MIXED SEX AND MONOSEX TRIAL OF *P. indicus*

As mating in captivity is one of the great challenges in the breeding of closed thelycum shrimp such as *P. indicus*, the present study was carried out to explore the role of communal and separate rearing methods on mating and spermatophore development in shrimp. In this context, a 60 days trial was carried out using sub-adult female and male *P. indicus* to understand the effect of male gonad development and mating in monosex and mixed sex rearing of *P. indicus*. Sub adult *P. indicus* (M: 14g; F: 18g) stocked in 10 numbers per cubic meter in 5-ton outdoor tanks. The salinity and temperature varied from 26-30ppt, 29 to 31°C. The light intensity varied from 235-450 lux during dawn, 4.2-245 during dusk and 10500-72000 lux at noon. The highest survival was noticed in monosex males (81.25 ± 5.3%), followed by mono sex females (72.5±0%) while the lowest survival was noticed in mixed-sex group (65 ±14%). Among the mixed-sex groups, 58.69% contributed by males and 41.09% by females (Fig. 31). The males with whitish sperm (maturing) and milky white (mature) sperm (%) were highest in the mixed group, and 45% of females recorded mating in the mixed-sex group at the end of the trial.

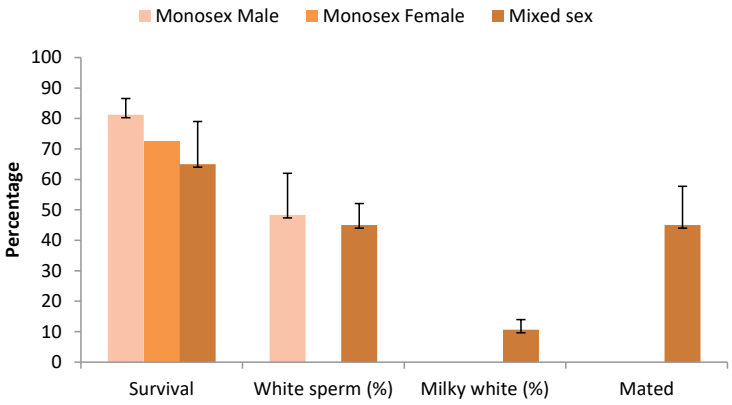


Fig. 31

The percentage of mating and spermatophore development in *P. indicus* broodstocks monosex and mixed-sex rearing

ARTIFICIAL INSEMINATION OF *P. indicus*

Artificial insemination is a tool used for controlled breeding of shrimp and is a prerequisite for genetic manipulation. In closed thelycum shrimps such as *P. indicus* eye stalk ablation of the mated females (Fig. 32) results in frequent moulting and subsequent loss of spermatophore, which remain a major constraint in captivity. To optimize the artificial insemination techniques for successful pairwise breeding and improved fertility, an experiment was conducted using intermoult *P. indicus* shrimps (20-25g; n-12). The spermatophore from each male were collected and artificially inseminated in the thelycum of females, and was observed for a period of 10 days for mating success, spermatophore rejection, thelycum blackening, etc. The study revealed that by 9th day only 20% of the female brooders successfully accepted the spermatophore (Fig. 33) while 60% of the females moulted resulting in the loss of the spermatophore. In males, 40% of the brooders recorded regeneration of the spermatophore and scanning electron microscope (SEM) analysis of sperms from the regenerated spermatophore revealed normal morphometry (Fig. 34).

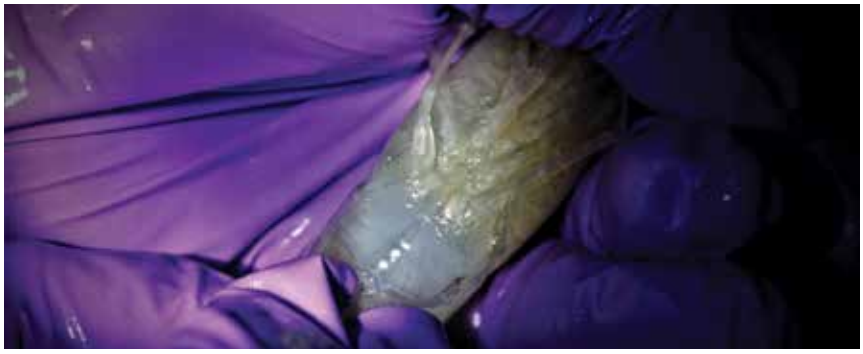


Fig. 32

Naturally mated *P. indicus*

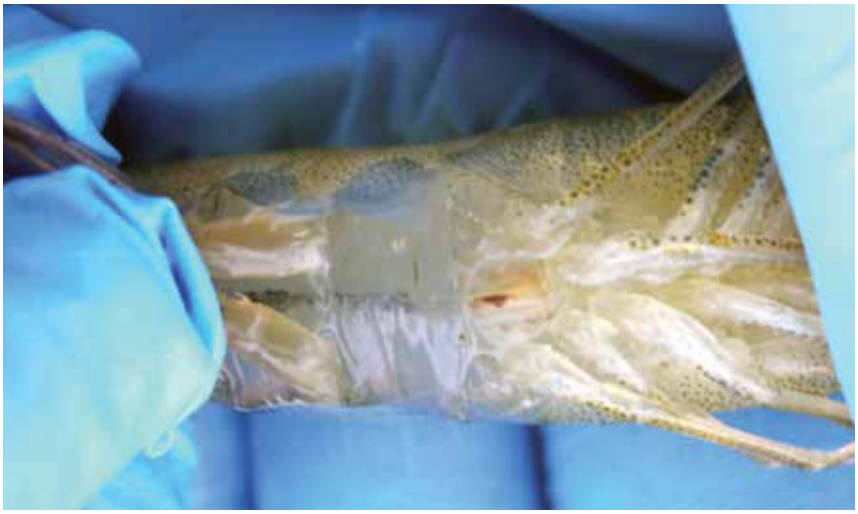


Fig. 33

Artificially inseminated *P. indicus*

Fig. 34
Sperm of *P. indicus*

MUDCRAB SEED PRODUCTION

Mud crab species of genus Scylla (*S. serrata* and *S. olivacea*) are the most economically important farmed species in India. Hatchery technology of these species has been improved using the modified seed production technology. The improved seed production technology by resolving the basic issues in larval biology of mud crabs were studied. During this period five larval cycles (Fig. 35) were carried out: Two for *S. olivacea* and the remaining for *S. serrata*. In the case of *S. olivacea* 52000 megalopa was produced with a survival of 25.3% while for S. serrata 60,000 to 1.6 lakh of megalopa were produced with an average survival of 32%. A total of 2000 healthy crablets were sent to the Kakdwip Research Centre of ICAR-CIBA for mud crab aquaculture. The successful breeding and hatchery rearing not only contribute to the conservation of natural crab populations but also offer promising opportunities for the aquaculture industry, promising higher yields and economic benefits for farmers.

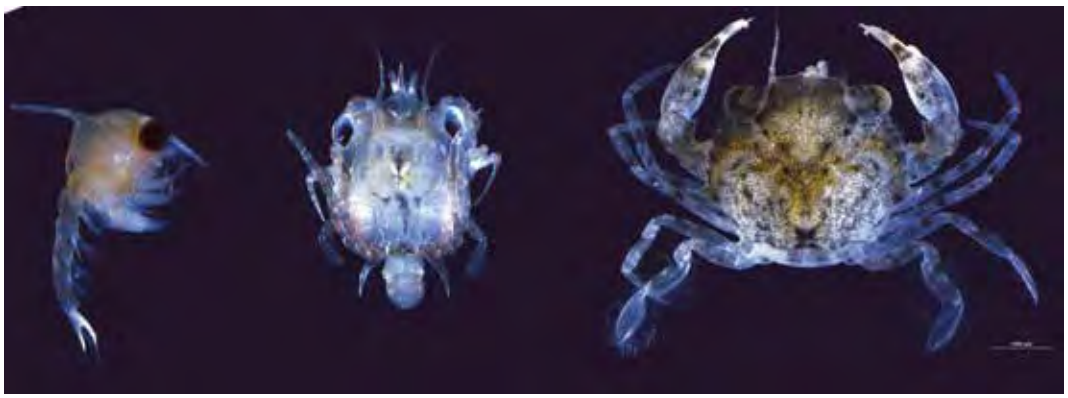


Fig. 35
Larval cycle of *S. olivacea*

SEAWEED-ASSISTED NURSERY REARING TECHNIQUES ENHANCE SURVIVAL IN MUD CRAB

Natural mud crab populatons in Indian coastal waters are declining due to wild seed collecton for culture as hatchery produced crablets still remains insufficient to meet the farmer's demand. The nursery rearing phase from megalopa to instar is challenging owing to its cannibalistic behavior. To maximize the survival during the nursery phase, experiments were conducted in in hapas using various hideouts such as seaweed bed (T1), seaweed

bed + vertical seaweed ropes (T2) and seaweed bed + black shade net (T3). The carapace width and weight of *S. serrata* were found to be significantly similar in all the treatments, however the survival was found to be significantly high in T1 (55%) and T2 (47%). There was no significant difference between the treatments in case of the weight and survival of *S. olivacea*. The carapace width was significantly higher in T1 (13.8 mm) compared to T2 (11.65 mm) and T3 (12.85). The current study (Fig. 36) provides valuable data into the improvement of survival in the nursery phase of mud crabs for the future of the mud crab hatchery industry.

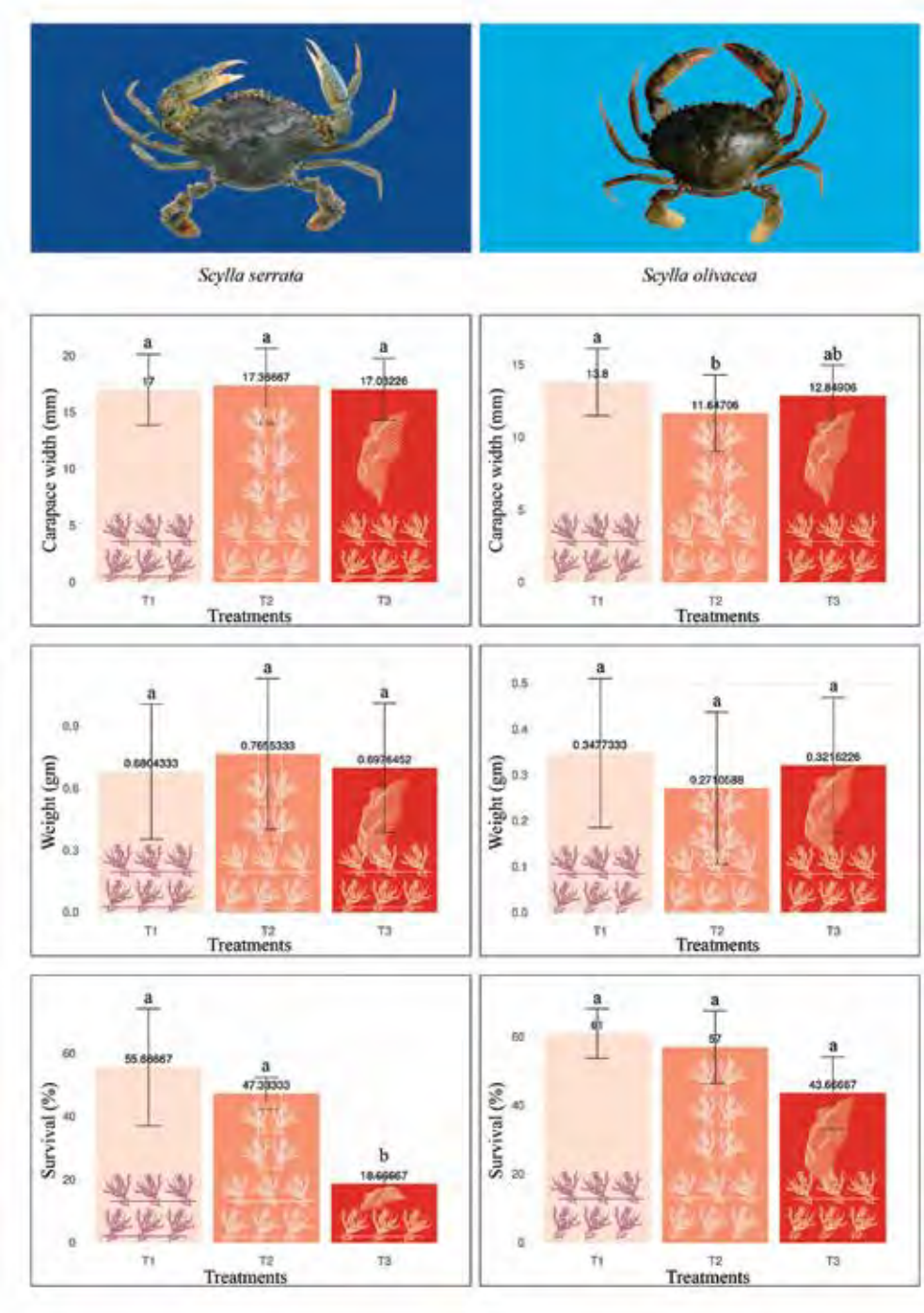


Fig. 36

Growth performance of mudcrabs, *S. serrate* and *S. olivacea* in seaweed based nursery units

ENHANCING SURVIVAL AND REDUCING COSTS: TRANSPORTATION OF MUD CRAB

Transporting crablets poses significant challenges due to their high cannibalistic behaviour and the moulting process. An experiment was conducted to evaluate the feasibility of transporting *S. olivacea* instar stage crabs (1cm in carapace width) in a thermocoal box containing seaweed (*Gracillaria salicornia*) and mangrove leaves (*Avicennia marina*). The objective was to assess survival rates and lower transportation costs. To prevent crablets from escaping, a dampened cotton cloth was tightly secured inside the thermocoal box, which was provided with minor holes for ventilation. Results indicated the highest survival rate (100%) after 16 hours of travel when mangrove leaves were exclusively used, compared to a combination of seaweed and mangrove leaves (90%). This packing method (Fig. 37) holds the potential to decrease production costs for farmers while concurrently improving survival rates, thereby offering notable advantages for mud crab aquaculture.

seaweed + mangrove leaves Mangrove leaves alone

Fig. 37
Mangrove leaves as packing material for mudcrab transportation

NUTRITION AND FEED TECHNOLOGY

BLACK SOLDIER FLY LARVAL MEAL AS A REPLACER OF FISH MEAL IN SHRIMP DIETS:

Black Soldier Fly larvae, commonly known as BSF larvae, possess a high protein content, essential amino acids, and beneficial fatty acids, making them an ideal candidate for aquaculture diets. The larvae's ability to efficiently convert organic waste into valuable biomass further underscores their potential in contributing to a circular economy within the aquaculture sector. To evaluate the effect of BSF larval meal as a replacer of fish meal in the diet of shrimp *P. vannamei*, four experimental diets were prepared to contain 0,5,7.5 and 10% BSF larval meal and a 60 days feeding experiment was conducted using juveniles of *P. vannamei* (1.15±0.06g). The results indicated the beneficial effect of BSF larval meal inclusion at 7.5% and it can be considered as the safe level of inclusion for better weight gain and FCR. It is interesting to note that the taste of shrimp fed with BSF meal was better than the control. Lactic acid bacterial count was significantly high $p(<0.05)$ in the BSF supplemented at the level of 50%. Serum prophenol oxidase activity, total heterotrophic bacterial count and vibrio load in the gut of *P. vannamei* showed no significant differences between treatment and control. Total haemocyte was significantly low ($p<0.05$) in BSF 10% supplementation. This finding suggests the potential BSF meal for improving the health of shrimp at7.5%.

EFFECTS OF BLACK SOLDIER FLY MEAL IN THE DIET OF BLACK TIGER SHRIMP (*Penaeus monodon*)

Fish meal is the major ingredient in shrimp feed, its overconsumption, and limited availability, compelled the aquaculture feed industry to search for alternative protein sources to replace fish meal. In recent times, insect meal (IM) has emerged as a sustainable protein source showing promising results. It not only has a high protein content but is also rich in lipids, vitamins, and minerals. The composition of IM closely matches the dietary requirements of shrimp and fish, making it a potential resource as an alternate ingredient to fish meal in aqua feeds. Against this backdrop, a 45-day feeding trial was conducted to investigate the effects of black soldier fly (BSF) larval meal as fish meal replacer in the diet of tiger shrimp (*P. monodon*). Five experimental diets were prepared (isoproteic 380 g kg^{-1} and isolipidic 100 g kg^{-1}) with varying levels of BSF meal that included 0% (BSF0), 3% (BSF3), 6% (BSF6), 9% (BSF9), and 12% (BSF12). Shrimp post larvae (with an initial body weight of 0.4 ± 0.02 g) were stocked at 30 animals each, in fiberglass reinforced plastic (FRP) tank of capacity 100 L which were arranged in completely randomized design (CRD) where, each diet was fed to triplicate groups. At the end of the feeding trial, there were no significant differences in the growth performance between the groups fed with BSF3 and the control (BSF0). The BSF3 group showed the highest weight gain percentage (320.12%). Both the control and BSF3 diet-fed groups exhibited similar average weight gain (AWG), specific growth rate (SGR), and daily weight gain (DWG), with no significant differences ($p > 0.05$). However, the BSF12 group recorded the lowest final body weight (FBW), weight gain% (WG%), AWG, SGR, DWG, and feed intake (FI). Up to an inclusion level of 9%, the survival was found to be non significant (95.57%) ($p > 0.05$). The activity of chymotrypsin and alkaline phosphatase was found to be significantly higher at BSF9 (716.71 ± 15.23) compared to control (39.50 ± 0.42) ($p < 0.05$). While, the activity of trypsin and leucine amino peptidase increased up to an inclusion level of 6% (BSF6) in the diet. The BSF6 group exhibited the highest serum protein (1.092 ± 0.029), while the highest glucose (76.71 ± 0.67) and triglycerides (141.90 ± 3.21) were found in the BSF3 group. Serum triglycerides and cholesterol levels were lowest in the BSF12 group. In conclusion, this study suggests that BSF larval meal is having the potential to replace fish meal in *P. monodon* diets up to an inclusion level of 6% without negatively influencing growth and survival. The optimal inclusion level of BSF meal for *P. monodon* diets ranges from 3.73 to 5.13%, as indicated by broken line regression analysis of various growth parameters. Histology of hepatopancreas has not shown any structural variations in all the treatments (fig 1).

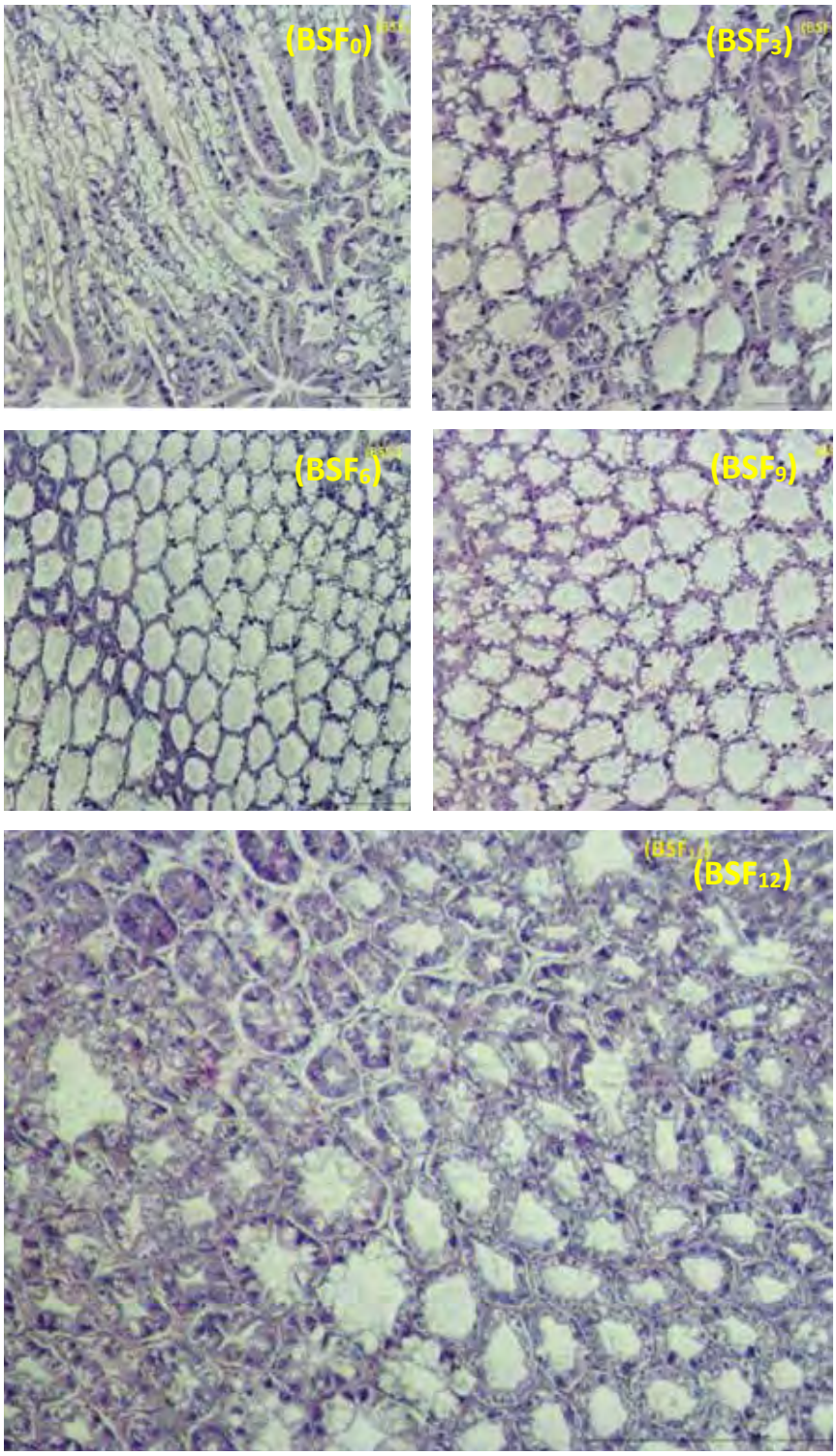


Fig. 1

Histological sections showing cross-sections of hepatopancreas of *P. monodon* fed with BSF0, BSF3, BSF6, BSF9, and BSF12, diets.

POND TESTING OF NEXT GENERATION FEED CONTAINING BSF MEAL

Based on the laboratory findings a field testing was carried out to ascertain the beneficial effect of BSF meal. A standard diet (control 0% BSF meal) was tested against the next generation diet containing 6.0% BSF meal. The experiment was curtailed and emergency harvest was made on 40th day and the average body weight was 5.14 and 5.20 g (Fig 2)in control and treatment group with the survival of 70.1 and 72.1% respectively. Due to continuous rain, mortality started at 40th day in the control while it delayed by three days in the treatment group indicating a lead in the improved health of shrimp fed with BSF meal and further studies are needed to explore the functional aspect of improving the health of shrimp through BSF meal.

Fig. 2

A haul of shrimp and harvested shrimp fed with BSF meal containing next generation feed

BSF FRASS NUTRITIONAL QUALITY

Nutritional potency of BSF frass as an ingredient

In search of novel ingredients, hitherto unexplored, BSF frass has been identified as one of the circular ingredients. BSF frass, is a residual biomass remaining after bioconversion of organic .materials by *Hermetia illucens* larvae consisting of the excreta and molt reamings and residual wastes. To ascertain the nutritional value, frass sample was collected and subjected for chemical analysis. The results indicated that it contains 23.44% crude protein, 0.56% ether extract 17.64% crude fibre and 12.34% total ash. The results indicated that frass is having a potential to be included as one of the circular and cost-effective ingredients. Considering its higher ash content, the sample was subjected for mineral analysis and the results indicated that frass contains 683.4, 235.2, 212.5 mg/kg of iron, zinc and manganese, respectively. Heavy metals like lead and mercury are below detectable level indicating its safety to use as feed ingredient.

EFFECT OF BSF FRASS ON MICROALGAE GROWTH

The BSF (Black soldier fly) Frass was tested for the efficiency of enhancing the microalgae growth in controlled conditions. The product was fine powdered in a small mixer grinder and soaked in water for 10 minutes with stirring. Then it was filtered using a sieve (500-micron mesh). The experiment was conducted in two species, *Nannochloropsis oculata* and *Chaetoceros gracilis*. The dose of BSF used was 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1 g/L of seawater. At 0 g/L chemical media was added and kept as a control. The results of the 6-day growth experiment showed that 0.7g/L gave better growth of *N. occulata* and 0.6g/L gave better growth of *C. gracilis* as compared to other treatments, except control (Fig 3-4). It is inferred from the trials that; the nutrients present in the BSF frass support the microalgae growth to an extent without any chemical media.

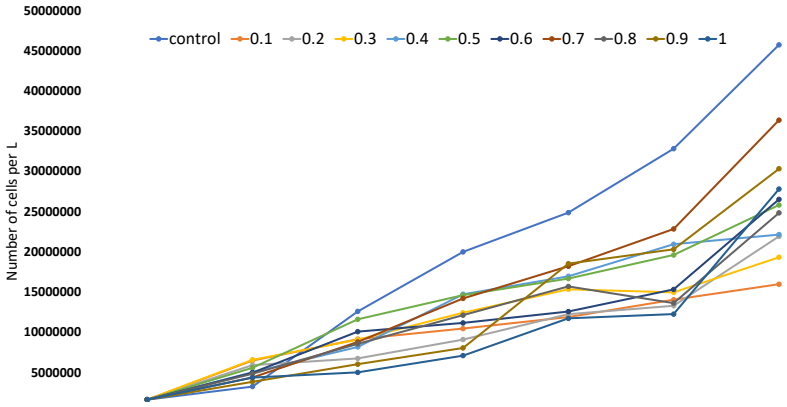


Fig. 3
Growth of *N. oculata* in BSF frass-supplemented seawater.

Fig. 4
Evaluation of microalgae growth in BSF frass supplemented media.

Subsequently, we attempted an experiment in outdoor tank systems where the pond environment was simulated. The dose of BSF used was 0, 0.2, 0.4, 0.6, 0.8, and 1 g/L of seawater. The data from the 15 days showed that the microalgae abundance was significantly higher in BSF frass-supplemented tanks as compared to the control. The abundance of microalgae was increased with increasing BSF dose. The beneficial microalgae species like *Isochrysis galbana, Tetraselmis* sp and *Chlorella* sp were dominant in BSF-supplemented tanks (Fig 5).

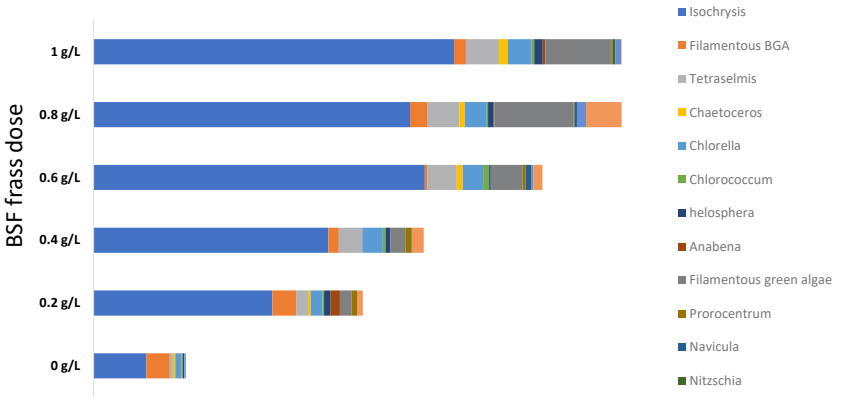


Fig. 5
Abundance of phytoplankton in BSF frass supplemented tanks.

BSF FRASS AS AN INGREDIENT IN SHRIMP FEED

To study the possibility of inclusion of BSF frass meal in the diet of shrimp, *P. vannamei,* five experimental diets were prepared to contain 0,2.5,5.0,7.5 and 10.0% frass meal. A 60 days feeding experiment in juvenile shrimp with an initial body weight of 0.6g was conducted and the results inferred that the frass can be incorporated upto 5.0% with out affecting growth and FCR. There was no problem in feed intake among the dietary treatments. However, when frass was included more than 5.0% there was a tendency for a decreased weight gain and poor FCR. Hence it is inferred that there is a scope to include the frass at 5.0% in the diet of *P.vannamei.*

Prophenol oxidase was significantly p(<0.05) in BSF supplementation of 2.5% and control. However, PO significantly reduced with increase in supplementation in *P. vannamei.* No significant difference in the total heterotrophic and total vibrio count between treatment and control.

EFFECT OF FRASS INCORPORATION IN THE DIET OF MILKFISH *Chanos chanos*

Frass is the by-product of the larval meal industry and it includes larval excrement, exoskeleton sheds and residual feed ingredients. It had a protein and fat content of 18.82% and 3.65%, respectively. A 60 day feeding trial was conducted to evaluate the effect of dietary levels of frass on growth, nutrient utilization of Milkfish, *Chanos chanos.* Five diets containing 0, 5, 7.5, 10 and 12.5% of frass in diet were fed to Milkfish (6.77 ± 0.16 g). Weight gain (%) is significantly highest (Fig 6) in fish fed with 5% Frass diet (238.82 ±7.87) whereas lowest weight gain (%) was observed in fish fed on 12.5% Frass diet (177.51 ± 5.21).

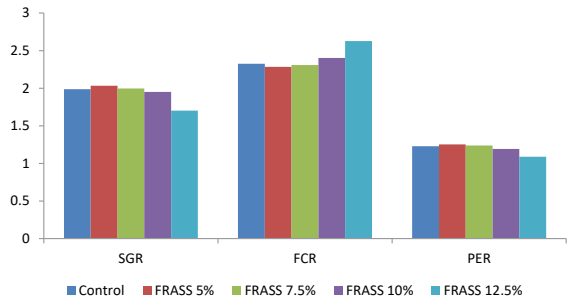


Fig. 6
Effect of frass feeding on SGR, FCR and PER in Milkfish

CHINESE POTATO AS AN ALTERNATE ENERGY SOURCE

Chinese potato is abundantly available in certain season and if its nutritional utility in shrimp and fish diets has not been explored (Fig 7). Hence this study was planned in association with CTCRI. The samples were received from CTCRI and subjected for analysis and the results indicated that this potato contains 84.5% moisture and crude protein and ether extract are 11.95% and 1.56% respectively on dry matter basis.

Fig. 7
Fresh Chinese potato samples ready for drying

EFFECT OF DIETARY SUPPLEMENTATION OF *Lactiplantibacillus plantarum* PROBIOTICS AS FUNCTIONAL ADDITIVES IN PACIFIC WHITE SHRIMP (*Penaeus vannamei*)

The present study was to investigate *Lactiplantibacillus plantarum* as functional feed additives in *Penaeus vannamei*. The experiment comprised of three treatment group, Group I fed with *L. plantarum* probiotic 10^{11} CFU/kg of the feed (LLP), Group II fed with *L. plantarum* paraprobiotic (DLP) and Group III Control (CON) fed with basal diet without feed additive, in *P. vannamei* for the period of 45 days. Whiteleg shrimp with initial body weights of 4.43±0.045 g was fed with these diets. Growth of the shrimp fed with LLP (17.03±0.42 g) was higher. The final weight, weight gain, survival was higher numerically in the probiotic supplemented group LLP. Proximate composition of post fed experimental shrimps showed crude lipid was significantly p(<0.05) high in LLP. Total haemocyte count (THC), small non-granular haemocyte (SNGH), large non-granular haemocytes (LNGH), small granular haemocyte (SGH), large granular haemocyte (LGH) was significantly p(<0.05) high in the LLP. Percentage occurrence of haemocytes SNGH, LNGH, SGH and LGH of *P. vannamei* were significantly high p(<0.05) in LLP. The hepatopancreatic digestive enzymes specific activity of leucine aminopeptidase and amylase was significantly p(<0.05) high in LLP. Further, LLP supplemented diet showed significantly high p(<0.05) total heterotrophic bacterial count and low total vibrio count. Regardless of diet, *Proteobacteria* have been demonstrated to be the most prevalent phylum in the gut microbiome of shrimp. Tenericutes, Bacteroidetes, Planctomycetes, and *Verrucomicrobia* were also found but were not influenced by the diet. *Rhodobacteraceae* and *Flavobacteriaceae* were beneficial core microbiome bacterial signatures observed predominantly in the LLP supplemented diet. The intestinal histology depicts the villi height, crypt depth and muscular layer thickness was significantly p(<0.05) high in LLP (Fig. 8). After 45 days feeding trial, shrimp were challenged with *Vibrio campbellii* 5 x 10^4 CFU/shrimp intramuscularly. At the end of the five days of the challenge experiment, LLP recorded significantly p(<0.05) low cumulative mortality (30%) (Fig 9). In addition, LLP dietary supplementation significantly p(<0.05) upregulated the expression of immune genes viz., *Prophenol oxidase, Super Oxide Dismutase* and *Heat shock protein*. Therefore, the results demonstrated that the *L. plantarum* could be used as functional feed for *P. vannamei*.

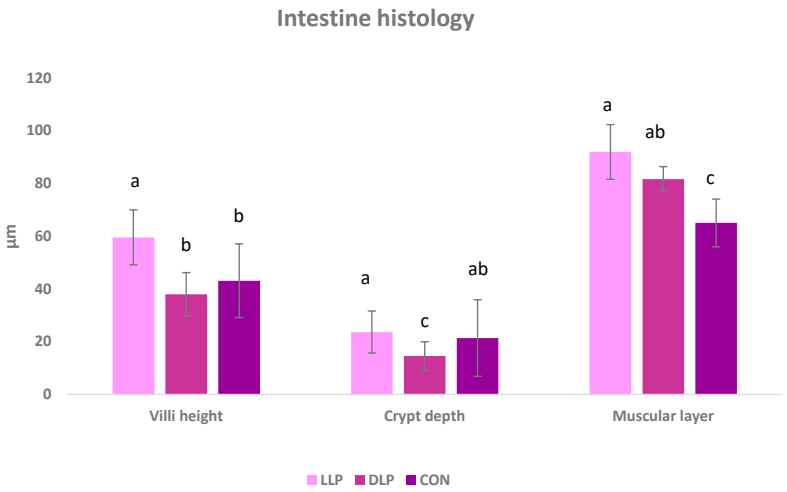


Fig. 8

Intestinal histology of *P. vannamei* fed with functional feed additive (VH villi height; CD – crypt depth; ML - muscular layer thickness; LLP – Live *L. plantarum*; DLP – Dead *L. plantarum*; CON – Control)

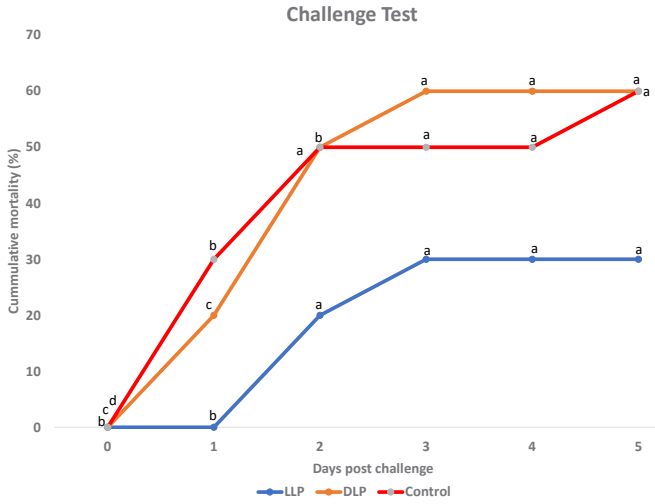


Fig. 9

Challenge test against *V. campbellii* (LLP – Live *L. plantarum*; DLP – Dead *L. plantarum*; CON – Control)

ENRICHMENT OF COPEPODS FOR BETTERMENT OF ITS NUTRITIONAL VALUE AS LIVE FEED

A specialized facility for copepod and ciliate culture was established to improve larval survival in finfish larval rearing. Five copepod species were isolated from brackishwater and marine ecosystems using different techniques (3 cyclopoids - Cyc1, Cyc2, Cyc3; 1 harpacticoid; 1 calanoid). Cyc2, exhibiting the shortest generation time and fastest growth rate, was chosen for further experiments. A 12-day growth study on Cyc2 in different enrichment media was conducted (T1: *Tetraselmis* culture on alternate days, T2: 40 ppm fish waste hydrolysate (FWH) on alternate days, T3: Both *Tetraselmis* and FWH (40 ppm) on alternate days). Results indicated the highest growth (copepods per ml) in the treatment with *Tetraselmis* and FWH together, followed by the treatment with only *Tetraselmis* (Fig 11). The lowest growth occurred in the FWH-only treatment, highlighting the potential to enhance copepod growth with a combination of microalgae and FWH.

Fig. 11

Copepod with enrichment

MARINE POLYCHAETE CULTURE

The marine Polychaete worms, Perineris spp were collected from the seashore area of Maraikayar pattinam at Mandapam. The worms were packed in earthen pots with sand substrate and transported to the CIBA. Perineris spp was extracted for DNA, and around 700 bp of cytochrome c oxidase subunit I (COI) genes were amplified with the help of primers polyLCO and then sequenced and identified as *Perineris nuntia* (Fig 12). The sexes are separate in Perineris nuntia, On attaining maturity, the head region of a female turns green and that of the male white. The matured male and female worms (60 nos.) were collected and stocked in a 1:2 ratio (male and female) in a 50-litre FRP tank containing filtered seawater for spawning with continuous aeration. The free-swimming metatrochophore larvae hatched out, but their survival was very low, and their further development as nectosaeta did not happen.

Fig. 12
Marine Polychaete worms, *Perineris* spp were collected from the seashore area of Maraikayar pattinam at Mandapam

DEVELOPMENT OF GROW-OUT TECHNOLOGY FOR MASS CULTURE OF SANDY AND MUDDY POLYCHAETE WORMS AND ASSESSMENT OF THEIR SEASONAL NUTRITIONAL PROFILING FOR USE IN SHELL FISH AND FIN-FISH HATCHERIES

Forty adults of *Onuphis* sp. (14±0.3cm) when reared in 100 L tanks, produced 2,500 juveniles (6 ± 0.2cm & 0.2g) in 4 months with 90% survival. Each adult produced around 55 juveniles within 4 months. The juveniles (6.1±0.1cm, n=50 (0.20g) were reared in 25L plastic tubs by feeding a mixture of CIBA shrimp larval feed no:1, soybean meal, and fish meal in a 1:1:1 ratio. The survival rate showed 95%, with the SGR for a juvenile *Onuphis* sp. being 0.41. The size reached a length of 18.0 cm with increased biomass to 33.25g after 4 months. Around 500 juveniles were mass-reared in 1000L FRP tanks by feeding with a diatom, *Chaetoceros calciferons* (10^6CFU/ml) with a mixture of CIBA shrimp larval feed as detailed above, which produced 400 adults (biomass 240g) with 80% survival in 4 months (18±0.2cm) with SGR was 0.33. The net weight gained was 0.50g for juveniles.

CAPTIVELY REARED RABBIT FISH (*Siganus* sp) ON FUNCTIONAL BROODSTOCK FEED SUCCESSFULLY RESPONDED WITH INDUCED MATURATION AND SPAWNING

Rabbit fishes present a potential for brackishwater farming, but obtaining hatchery-produced seeds remains a challenge. To address this, we focused on developing functional feed to support maturation and seed production in captivity, considering the seaweed-eating behaviour of the species. Our goal was to optimize amino acid and total lipid content in the feed, incorporating plant-based ingredients like seaweeds, spirulina, and common oil meals. Fish oil and soy lecithin provided dietary lipids. Specialized diets were administered to adult *Siganus javus* (n=120) and *Siganus lineatus* (n=23) for a year. In October, both species exhibited maturation in ovaries (Fig 13) and testes. Hormonal induction was attempted in CIBA FCD hatchery, leading to successful spawning and hatching of *Siganus lineatus* in late October 2023. Feeding continues with the same formulation, supplemented with fresh seaweeds to meet functional micronutrient requirements. It is expected that *S. javus* also will respond in the coming season.

Fig. 13
Effect of feeding functional broodstock diet on ovarian development in rabbit fish

FISH PROCESSING BYPRODUCTS FROM SURIMI PLANT

Fish processing byproducts from Surimi Plant located near Udipi are collected and analysed for their nutrient composition. In final Surimi product protein is concentrated and fat and ash are reduced. Mainly two by products from the surmi are a protein rich and the second one being fat rich products which are useful for aqua feed. Presently both these byproducts are shifted to conventional fishmeal producing factory. Crude protein content is 71.46, 90.46, 51.32 and 10.56% on dry matter basis in raw fish, final (Surimi), fish byproducts 1 and 2, respectively (Fig 14). Fat is a very valuable product but it contains 40% moisture due to which its keeping quality is deteriorating. Chemical treatment protocols are in progress to improve their quality.

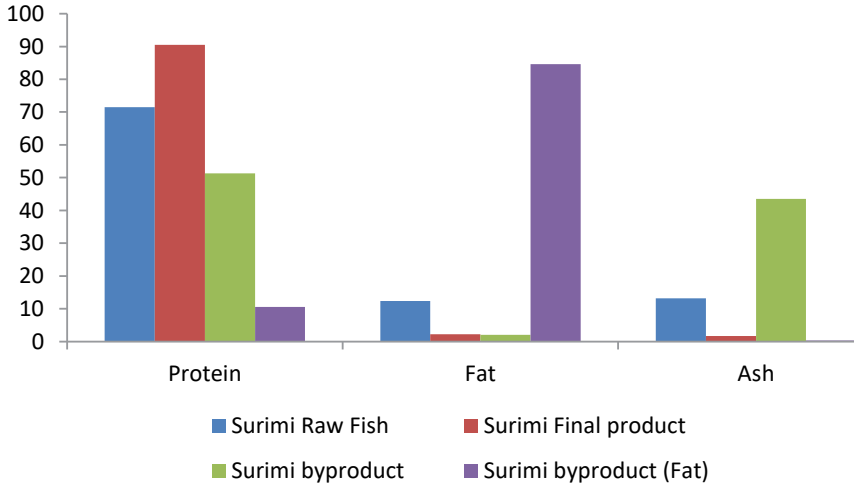


Fig. 14
Nutrient composition of Surimi and its byproducts

EFFECT OF SOLID STATE FERMENTATION OF SOYBEAN MEAL WITH BACILLUS SUBTLIS OR SACCHAROMYCES CEREVISIAE ON GROWTH AND NUTRIENT UTILIZATION IN *P. vannamei*

In order to increase its inclusion level, soybean meal was fermented with *Bacillus subtlis* or *Saccharomyces cerevisiae* in the pilot scale fermentor. Experimental diets were prepared by incorporating different levels of raw and fermented soybean meal. Growth trial results indicated that fermented soybean meal can be included up to 35% in the grow-out feeds of *P. vannamei* and fermentation has improved the growth by 9.5 and 8.7% with Bacillus (Fig 15) and yeast, respectively.

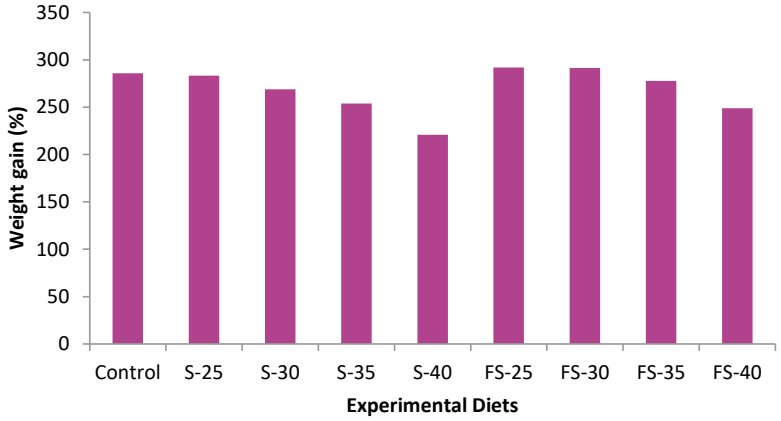


Fig. 15
Effect of Solid State Fermentation of Soybean meal with *Bacillus subtlis* on weight gain (%) in *P. vannamei*

EFFECT OF DIETARY CRUDE PROTEIN LEVEL ON GROWTH, NUTRIENT UTILIZATION AND METABOLIC PATHWAYS IN SHRIMP

Shrimp feeds containing five crude protein levels, viz., 21.8% (LCP1), 27.0% (LCP2), 37.2% (CCP), 41.9% (HCP1), and 46.8% (HCP2), were used in this study, among which 37.2% was the control group. At the end of the experiment, shrimp samples were collected for RNA sequencing. On average, 58 million reads of RNAseq data have been generated for each sample. To find the optimum crude protein level of the feed for obtaining maximum weight gain, broken-line regression analysis was done with the data on protein levels in the feed and measured weight gain (Fig 16). It was observed that 38.51% crude protein level in the feed resulted maximum weight gain in the animals. Venn diagram was plotted to see shared DEGs among the individual comparisons made between control group (CCP) and treatment groups (Fig 17). There are around 114 DEGs common to low crude protein groups and 31 DEGs common to high crude protein groups. Overall, there are 23 DEGs differentially altered due to changes in the crude protein levels compared to control group. Enriched KEGG terms were identified using pathway enrichment analysis. One of the notable observations in enriched KEGG pathways for low protein groups was down-regulation of the citrate cycle and pyruvate cycle (Fig 18). This suggests impairment of mitochondrial functions of generating energy when the animal is fed with low protein feed. The other metabolism related down-regulated pathways in LCP groups indicate disturbed cellular processes due to insufficient amount of crude protein in feed.

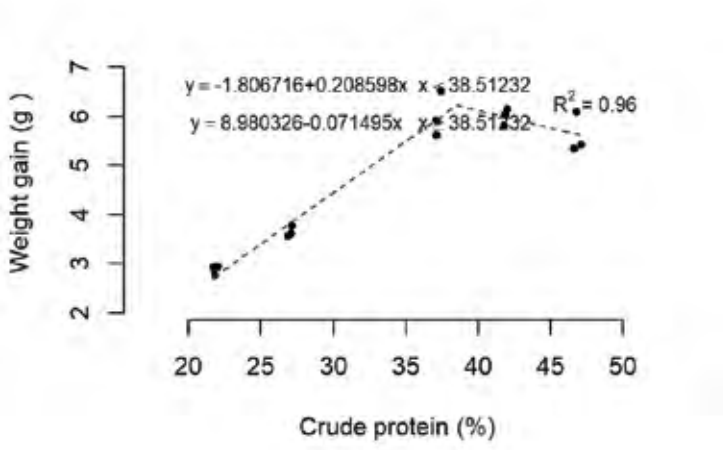


Fig. 16
Broken-line regression for crude protein and weight gain in *P. vannamei* under varying crude protein levels in feed.

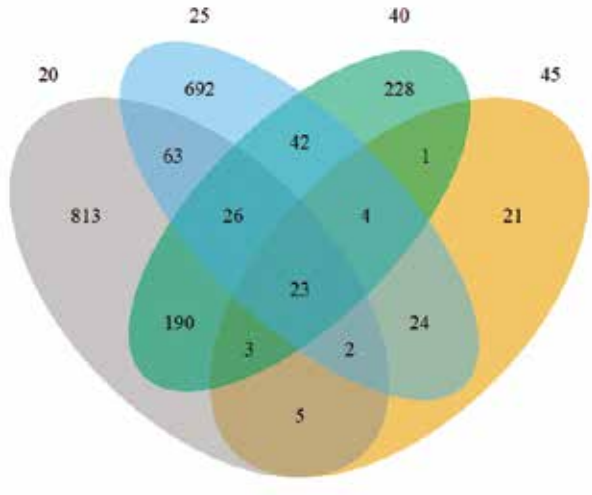


Fig. 17
Venn diagram showing shared DEGs between treatment groups of different crude protein levels.

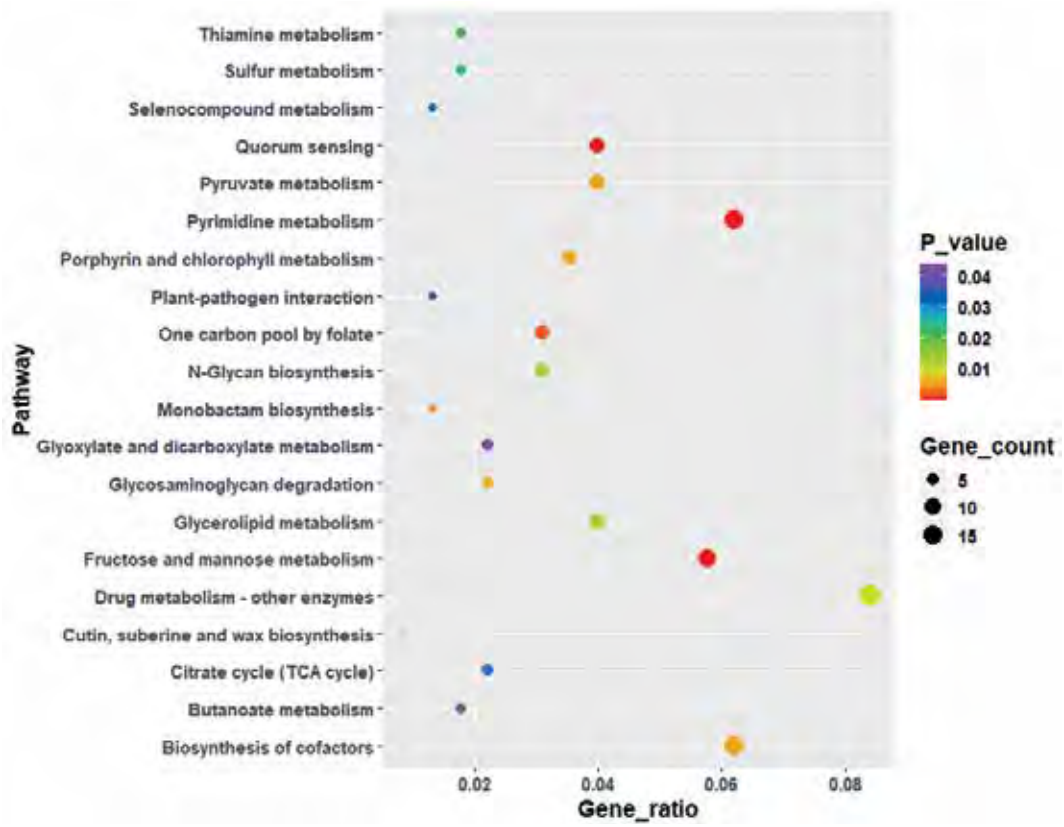


Fig. 18

Enriched KEGG pathways for down-regulated genes in LCP1 feed group

DIVERSITY OF FUNGI IN THE GUT OF *Penaeus vannamei* CULTURED WITH HIGH PROTEIN, LOW PROTEIN AND AZOLA BASED DIETS IN BRACKISHWATER PONDS

Study on fungal diversity in the gut of *Penaeus vannamei* fed on high protein, low protein and azola-based diets was carried out. Shrimp samples were collected from brackish water ponds supplemented with high protein, low protein and azola based diets at 120th day of culture before harvest of the ponds. The shrimps were dissected and the gut was aseptically removed, macerated in Normal saline solution, serially diluted and plated on YPD agar and incubated for 5 days. The colonies were isolated and identified. The total viable plate count (TPC) of fungi revealed that the low-protein feed administered group showed higher TPC of 1X10^4 CFU/ml (Fig 19). A total of 43 fungi isolates were identified based on molecular tools. *Parasarocladium breve* and *Penicillium oxsalicum* were the most abundant species found in the high protein feed administered groups. *Sakaguchia oryzae* was most abundant in the low protein feed groups (Fig 20& 21).

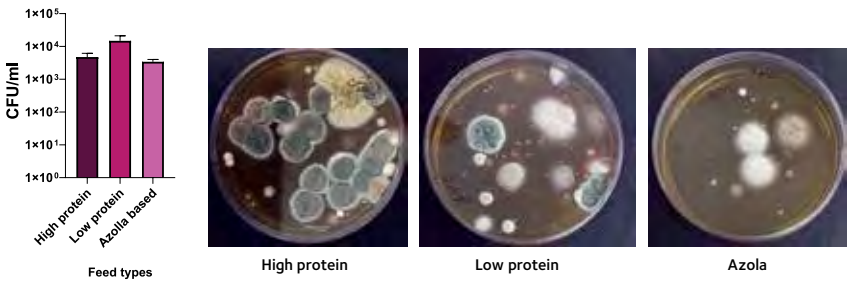


Fig. 19

Total viable fungal count in the gut of *P. vannamei* fed with various feed type

Fig. 20

Phylogenic tree of different species found in brackishwater ponds supplemented with different diets.

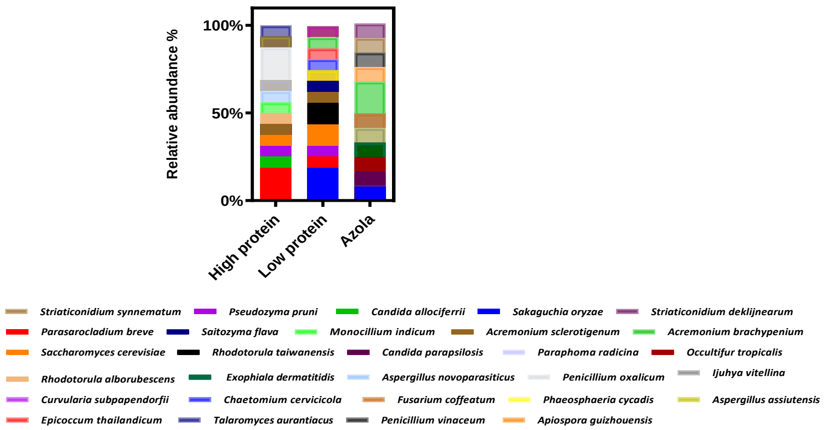


Fig. 21

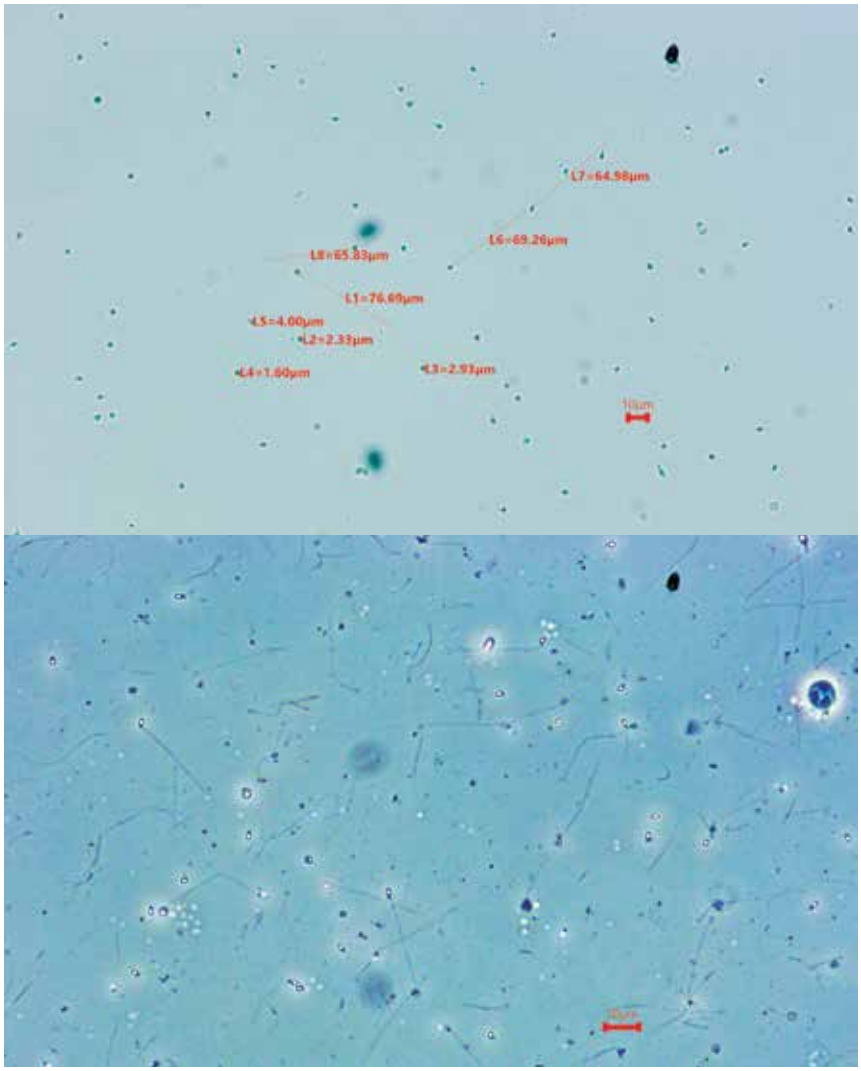
Relative abundance fungi in brackishwater ponds supplemented with different diets

BROODSTOCK FEED DEVELOPMENT FOR HILSA

Previously developed broodstock feed of hilsa was fine-tuned considering the biochemical composition of captive hilsa ovary and fully matured (running phase) wild hilsa ovary. Nutritionally balanced formulated feed (CP-42.52±0.03% & EE-14.47±0.03%) was supplemented for brood stock rearing of hilsa during September - October. After feeding of fine-tuned broodstock feed, it was found that 90-95% female and 95-100% male were at different stage of maturity in brood stock pond. Amino acid profile of gonad in captive hilsa was found to be superior compared to gonad of wild hilsa. In RAS tank facility also broodstock feed was offered to one and half year old hilsa @ 10% body weight. In the month of September, male brood fish (BW-75g /BL- 17.5 cm) with mature gonad attained GSI value of 0.52 and motile sperm count was 4.6x108/ml (Fig 22).

Broodstock feed

Matured testis in RAS reared hilsa



Matured hilsa sperm

Fig. 22
Broodstock feed development and maturation of hilsa in captivity

NURSERY FEED DEVELOPMENT FOR HILSA

Six days old hatchlings were stocked @ 80 nos./m^2 in earthen pond (30 sq m). Ponds were fertilized with mustard oil cake (100 kg/ha), Plankton^{Plus} (160 L/ha/week) and fermented rice bran juice (100L/ha/week) prior to stocking. Two types of larval feed i.e., Feed-I (CP- 51.57±0.05%, EE-13.37±0.05%): prepared with ingredients of animal origin and Feed-II(CP- 49.35±0.17%, EE-11.14±0.02%): prepared with ingredients of both animal & plant origin, were formulated and feed (200-900 µm) were prepared for feeding larvae (Fig 23). Feeds were evaluated and performance was compared with commercially available zooplankton (*Calanus finmarchicus*) powder (CP-37.51±0.25%, EE-24.71±0.48%). After 90 days growth performance of fry was 18.07% and 99.71% higher in pond supplemented with Feed-I (T1)and Feed-II (T2), respectively, compared to zooplankton powder supplemented pond (T3).

Fig. 23

Nursery feed preparation

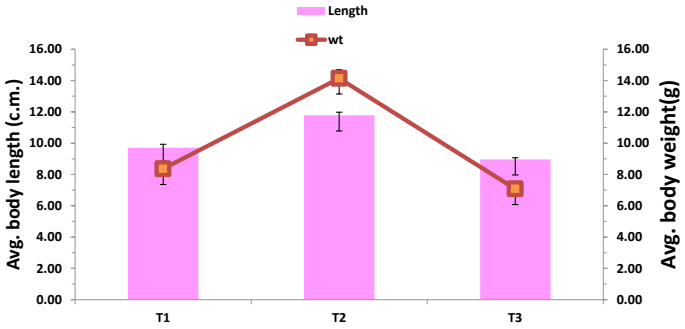


Fig. 24

Growth performance of hilsa larvae supplemented with different feed in pond system

In tank system, after 77 days of rearing, fish attained higher growth in T2 supplemented with Feed-II in comparison with T1 and T3 (Fig 24 & Table 10).

UPGRADATION OF VALUE ADDED PRODUCT FROM FISH WASTE

Experiment was conducted for reduction of moisture content of Plankton^{Plus} at different temperature i.e., at 70 and 80 ° C. It was found that after 24, 48 and 72 hours of drying at 70 and 80 °C, moisture (%) reduction of Plankton^{Plus} were 20.73±2.97, 56.83±1.41, 70.80±0.46; and 25.20±2.39, 63.67±1.67, 72.17±0.92, respectively. To dry the Plankton^{Plus} completely, it takes 168 h and 120 h, respectively at 70 and 80° C temperature (Fig 25). There were no significant changes in the proximate composition (CP, EE, CF, Ash%) of the product dried at different temperature (Fig 26).

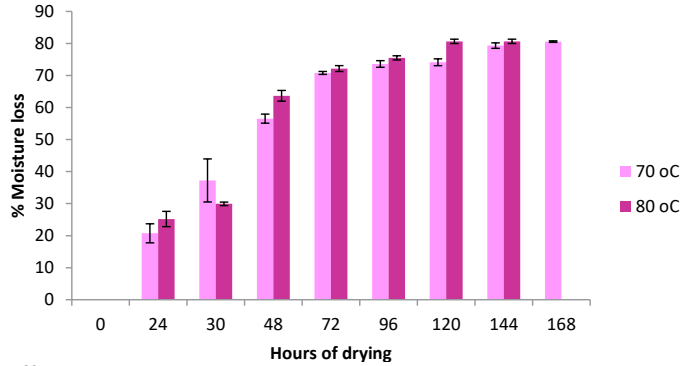


Fig. 25

Moisture reduction at different temperatures at different hours

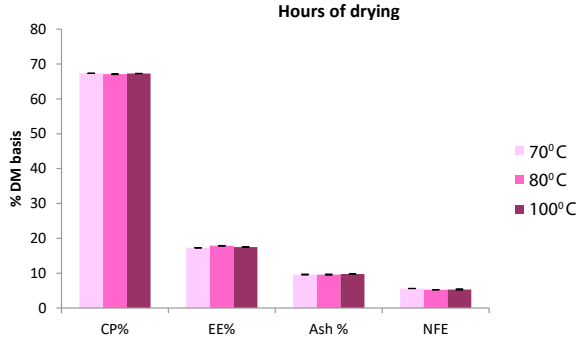


Fig. 26

Effect of temperature on proximate composition of Plankton ^{Plus}

EVALUATION OF FISHWASTE VALUE ADDED PRODUCT (HORTI ^{PLUS}) IN VEGETABLE PRODUCTION POTENTIAL BENEFIT OF HORTI PLUS IN POTATO PRODUCTION AND NUTRIENT FORTIFICATION

An experiment was conducted to evaluate the effect of Horti^{Plus} in yield and quality of potato (Fig 27). Nine plots, each of 15 sq m area, were taken for cultivation of potato. Plots were treated with three different treatments, T1-FYM (1t/ha) along with Mustard cake (1 t/ha) and diammonium phosphate(400 kg/ha); T2- FYM (1t/ha) along with Mustard cake (0.5 t/ha), diammonium phosphate(200 kg/ha) and Horti^{Plus} (1 t/ha); and T3- FYM (1t/ha) along with Mustard cake (1 t/ha) and Horti^{Plus}(1.2 t/ha), during land preparation. Potatoes were planted @2333 kg/ha. All standard agronomic practices required for potato cultivation were followed. After 60 days of planting, potatoes were harvested. It was found that potato yield was better when Horti^{Plus} was applied in soil, though differences were not statistically significant (P>0.05). From nutrient analysis of potato it was found that EE and Ash content of potatoes were higher in plots received Horti Plus . Minerals analysis data revealed that when Horti^{Plus} was supplemented potatoes were enriched with Ca, Mn, Fe, Cu and Zn element. It can be concluded that Horti^{Plus} can be applied for fortification of mineral in potato (Fig 28).

Fig. 27
Potato production with Horti^{Plus} at KRC farm

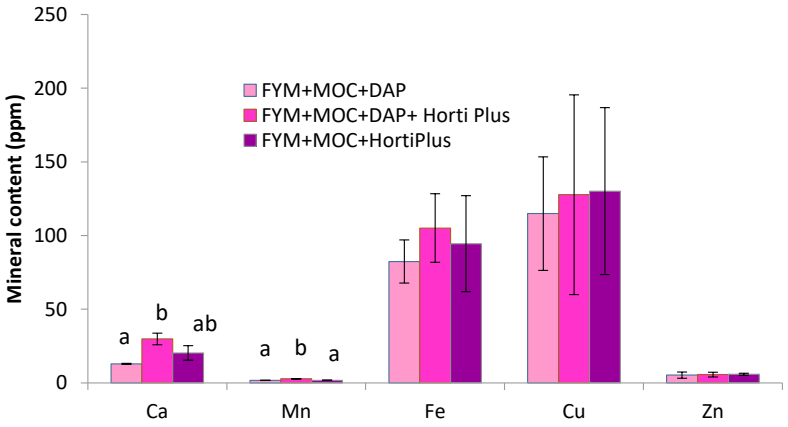


Fig. 28
Effect of horti^{Plus} in mineral enrichment of potato

EXPLORING POTENTIAL BENEFIT OF HORTI^{PLUS} IN VEGETABLE PRODUCTION

Experiment was conducted to evaluate the effect of Horti^{Plus} in yield and quality of different winter vegetables. Fourteen plots, each of 20 sq m area, were taken for cultivation of seven types of vegetables. Plots were treated with two treatments, T1-Urea (250 kg/ha)+ SSP (250 kg/ha)+ DAP(500 kg/ha); T2- Urea (250 kg/ha)+ SSP (250 kg/ha)+ Horti^{Plus} (1.5 t/ha) during land preparation. All standard agronomic practices required for vegetable cultivation were followed. After 60 days of cultivation, vegetables were harvested. It was found that yield of every vegetable was better when Horti^{Plus} was applied in soil, however, nutrient content did not differ significantly (Fig 29).

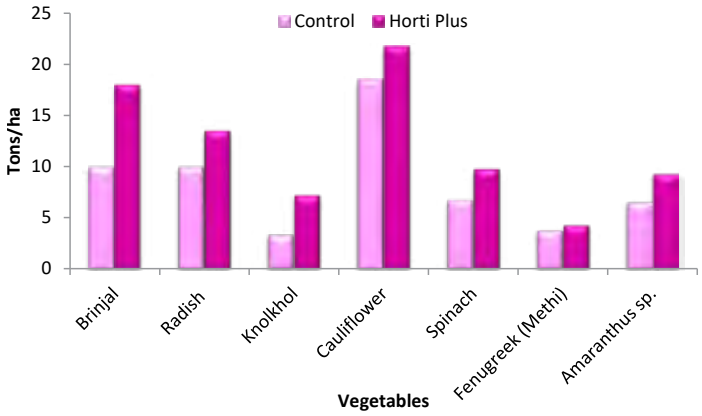


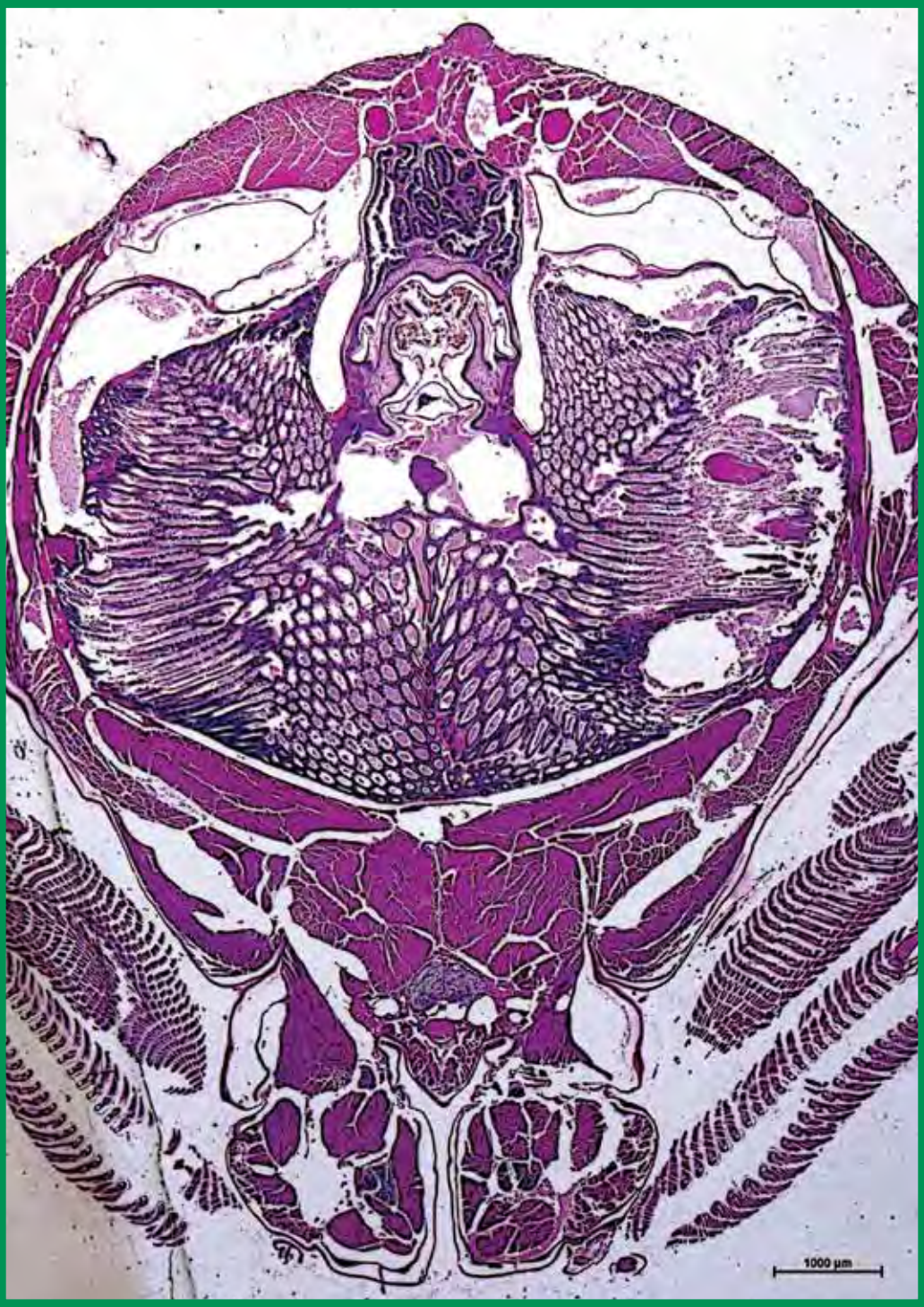
Fig. 29
Effect of Horti^{Plus} on yield of vegetables

EFFECT OF DIETARY VITAMIN E ON GROWTH AND MATURITY IN SILVER MOONY, *Monodactylus argenteus*

Insufficient vitamin E in fish feed can negatively impact gonadal development, fecundity, and egg hatching. Vitamin E has been shown to expedite gonadal development and enhance egg production. Thus, our study aimed to determine the optimal vitamin E levels necessary to accelerate gonadal maturation and growth in silver moony fish. The effects of different levels of dietary vitamin E (0, 100, 200, and 300 mg/kg diet) on growth and maturity were studied in silver moony for 120 days. Fish fed the diet containing 200 mg of vitamin E/kg had the best weight gain and maturity. Fish fed the control diet lacking vitamin E began to exhibit gonad development on day 90, while those fed diets containing vitamin E began to exhibit milting males and eggs from day 45 onwards. Females fed with 200 and 300 mg of vitamin E/kg diet had a significantly higher number of milting males and maturing females compared to other treatments, and there was no significant difference between these two treatments. Thus, 200 mg of vitamin E/kg diet is the optimum level for improving maturation in silver moony.

CIBA MATURATION FEED VS. FROZEN FEED FOR INDIAN WHITE SHRIMP TO ENHANCE THE GONADAL DEVELOPMENT

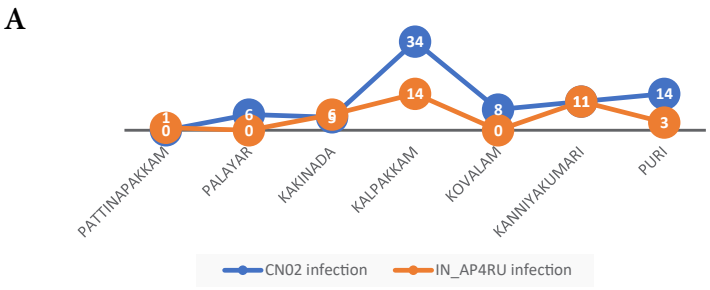
To enhance the gonadal development of female broodstock *P. indicus* (n-36), the experiment was conducted using eyestalk ablated and unablated females with maturation feed. The experiment consists of four groups: Eyestalk ablation + Frozen feed (E. A+F.F), Eyestalk ablation + CIBA maturation feed (E. A+CIBA), Non-Eyestalk ablation (F.F) + Frozen feed and non-Eyestalk ablation + CIBA maturation feed. Feeding was at 20% of body weight. Following two days after eyestalk ablation, males were introduced. In a 12-day trial, it was observed that 25% of shrimp without eyestalk ablation achieved stage 3 and 16.67% reached stage 2 when fed with CIBA feed.



AQUATIC ANIMAL HEALTH MANAGEMENT

GENOTYPING AND VIRULENCE ANALYSIS OF WHITE SPOT SYNDROME VIRUS

With increasing number of White Spot Syndrome Virus (WSSV) sequences reported, WSSV shows high genetic variability with variable genome size. The primers based on Missing Regions Finder (MRF), have been designed for genotyping WSSV infected samples of *Penaeus indicus*. *P. indicus* WSSV-infected samples were collected from various locations. WSSV infected shrimp samples were further used for identification of WSSV genotypes. Preliminary findings revealed presence of CN02 type (Chinese) samples collected from Palayar (6), Kakinada (5), Kalpakkam (34), Kovalam (8), Kanyakumari (11), Puri (14) and the samples collected from Pattinapakkam (1), Kakinada (6), Kalpakkam (14), Kanyakumari (11), Puri (3) locations showed presence of IN_AP4RU (Indian) isolate (Fig. 1). Further work is in progress to genotype WSSV for presence of other geographical isolates of WSSV in Indian waters, which would help to study the molecular epidemiology of WSSV and to carry out precise diagnosis and control of WSSV.



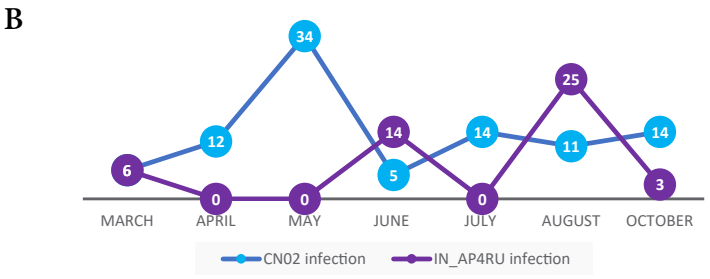


Fig. 1

WSSV genotyping based on MRF markers - CN02 and IN_AP4RU isolates detection in *P. indicus* samples collected from (A) different locations and (B) months

ESTIMATING THE DOSE (COPY NUMBER) OF WSSV IN SHRIMP FOR DISEASE REVERSAL

An experiment was conducted in *Penaeus vannamei* shrimp to study the virulence pattern of WSSV. Shrimp samples were screened for WOAH listed shrimp pathogens like WSSV, IHHNV, TSV, YHV, IMNV, AHPND and EHP. About 315 *P. vannamei* shrimp were divided into seven different groups of each comprising 45 shrimps. Of these, six groups were injected with 10^1, 10^2, 10^3, 10^4, 10^5, 10^6 copy number of WSSV virus and one group was injected with PBS. The experiment was done in triplicate. The shrimps were sacrificed at 6, 24, 48 and 72 h interval and tissue samples such as haemolymph, gill, and pleopod were collected. The total haemocyte count did not show any change during 6 h intervals, however significant change was observed in all the groups at 24 h. From 48 h onwards the haemocyte count decreased. The viral copy number in gill and pleopod was estimated, the gill from 106 group gave positive signal from 24 h onwards indicating that the gill tissue is most appropriate for WSSV diagnosis. The experimental groups inoculated with 10^1, 10^2 and 10^3 did not had mortality, however, 10^6 group had mortality from 6 h onwards which might be due to the stress in the animal due to the injection. The histopathological changes were observed in gill, pleopod and eye.

FLOW CYTOMETRY ANALYSIS OF THE IMMUNOLOGICAL RESPONSE OF WSSV-INFECTED *P. indicus* SHRIMP

Flow cytometry was used to analyse the immunological response of WSSV-infected *P. indicus* shrimp, exposed to different temperatures. The shrimps were acclimatized to three temperature conditions of 27°C, 30°C and 33°C and WSSV challenge experiment was carried out. The shrimp samples were collected at different time points *viz*., 12 hpi, 24 hpi, and 48 hpi and used for flow cytometry analysis for cytoplasmic free Ca^{2+} concentration, respiratory burst activity, cell cycle analysis, apoptosis (Fig. 2), and phagocytosis. Cytoplasmic free Ca^{2+} concentration was observed at increased levels at 48 h across the three temperature range. An increased respiratory burst activity was observed at 24 hpi and 48 hpi at all temperature points. The infected shrimp at 33°C showed highest apoptotic activity at 48 hpi. The cell cycle experiment using a flow cytometer revealed all WSSV-infected samples with a reduced amount of G1 phase cells at all time points at 3 temperature points. G2 and S phase cell percentage increased in all WSSV-infected samples in all time points. The WSSV infected samples showed higher percentage of apoptotic cells when compared to un-infected samples. The infected shrimp at 33°C showed highest apoptotic activity at 48 hpi. Granulocyte percentage was higher in all control groups when compared to infected groups. Further work is in progress and the present study indicates variations in the immunological response during course of WSSV infection in shrimps exposed to different temperature conditions.

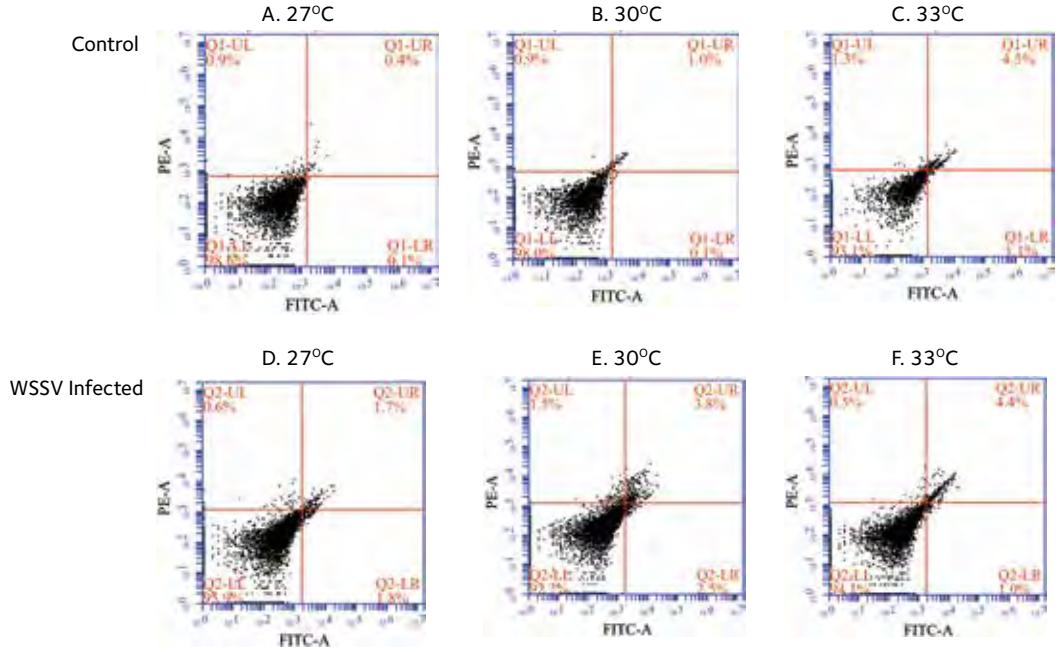


Fig. 2

Apoptosis analysis by flow cytometry of *P. indicus* exposed to different temperatures. Control shrimps (A) 27°C, (B) 30°C and (C) 33°C and WSSV infected shrimps (D) 27°C, (E) 30°C and (F) 33°C

PREVALENCE OF *Enterocytozoon hepatopenaei* (EHP) IN *Penaeus monodon* FARMS AND ITS INFECTIVITY

A survey was conducted in 62 farms to understand the prevalence of EHP in *P. monodon* across Andhra Pradesh, Tamil Nadu, West Bengal, Gujarat and Kerala. The analysis revealed the prevalence of 30.6% (19/62 farms) with 94.7% of positive farms tested only in nested level (Table 1). The pathogen was confirmed by sequence analyses of spore wall protein (SWP) gene and submitted to NCBI (Acc. No. PP216218). State-wise, farms from West Bengal had the highest prevalence of EHP (53.85%;

7/13 farms). Challenge experiments were conducted in *P. monodon* and *P. vannamei* by oral infections to study the host response at different time intervals (7th, 15th, 30th, 60th, and 90th day post-challenge [dpc]) using light microscopy, histopathology, in situ hybridisation, PCR, qPCR, transcriptomic and metagenomic analyses. In comparison to *P. vannamei* (1.5-5.3x10^5 per ng of DNA), the EHP load was comparatively low (5.6-10x10^3 per ng of DNA) in *P. monodon* at all the time points. Challenged *P. monodon* tested positive only in the nested level till the end of experiment, whereas *P. vannamei* detected with EHP in the first step PCR from 7th dpc. Transcriptomic sequencing analysis at 30th and 60th dpc revealed the higher level of differentially expressed genes (DEGs) in challenged group at 60th dpc (1169 DEGs: 660 up & 509 down-regulated) than 30th dpc (565 DEGs: 209 up & 356 down-regulated) on comparing with the control group. Gene ontology and KEGG (Kyoto Encyclopedia of Genes and Genomes) pathway analysis showed pathways involved in metabolism (lipid, nucleotide, carbohydrate), cellular processes, membrane transport, and lysozyme activity, were enriched. Further analyses of the samples are in progress.

State	No. of farms Tested	PCR results (No.)			Prevalence (%)
		Ist step positive	Nested positive	Negative	
Andhra Pradesh	18	1	4	13	27.8
Tamil Nadu	9	0	2	7	22.2
West Bengal	13	0	7	6	53.8
Gujarat	13	0	2	11	15.4
Kerala	9	0	3	6	33.3
Total	**62**	**1**	**18**	**43**	**30.6**

Table. 1

P. monodon farms in five states screened for EHP and the PCR results

SUSCEPTIBILITY OF CRAB SPECIES TO *Enterocytozoon hepatopenaei* (EHP)

Hepatopancreatic microsporidiosis (HPM) and vibriosis caused by the microsporidian parasite EHP and *Vibrio* spp., respectively with slow growth, size variation, white feces syndrome (WFS) and mortality are considered to be important pathogens in shrimp aquaculture. It is pertinent to study the multiple interactions of hosts and pathogens with therapeutic approaches. Hence, Multiple-dose challenge and susceptibility study experiment was conducted in crab species. The juveniles of Green crab, *Scylla serrata* (Average body weight [ABW] – 63.2±3.42g; Internal carapace width [ICW] – 83.3±2.3mm) and Red crab, *Scylla olivacea* (ABW – 62.07±3.78g; ICW – 81.3±1.8mm), and crablet of *S. olivacea* (ABW – 11.97±0.43g; ICW – 46.0±0.1mm) were acclimatised for 14 days, feeding with commercial pellet feed @ 10% body weight (BW), PCR screened and found negative for all World Organisation for Animal Health (WOAH, formerly OIE) listed pathogens. Crabs were grouped in triplicates with respective controls and each replicate with 25 animals. EHP infected Pacific white shrimp, *P. vannamei* (ABW - 10.84±0.88g) was brought from the farmer's pond, confirmed against EHP SWP gene by PCR and quantified by qPCR as 22.31x10^6 copies g^{-1} of hepatopancreas (HP). The infected HP with gut was fed to each group for five days while the control group received only commercial feed. Samples such as haemolymph for haematology and bacteriology, whole animal in Davidson's fixative for histopathology, HP for PCR and qPCR were collected in triplicate at weekly intervals. The water quality parameters and total *Vibrio* count were recorded throughout the experiment. PCR analysis of HP of crab species revealed positive on 7th dpc (Fig. 3). qPCR analysis of HP revealed that there was very low level of EHP load with consistent decrease in load up to 42nd dpc. EHP copies in HP of crablet S, olivacea was highest (24.22±9.12x10^3 copies g^{-1} of HP tissue) on 14th dpc followed by 3.35±3.35x10^3 and 2.88±1.39x10^3 copies g^{-1} of HP on 28th and 14th dpc in juvenile *S. olivacea* and *S. serrata*, respectively (Fig. 4). EHP load reaching zero after 42nd dpc is suggestive of no establishment and/or no proliferation of EHP spores in HP tissues in crab species.

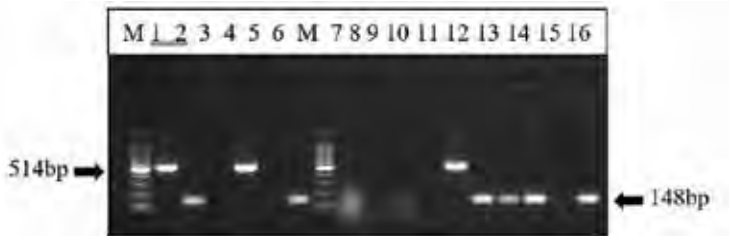


Fig. 3

Crab species susceptibility to EHP by PCR assay. M–100bp marker; 1–Shrimp HP EHP I step positive; 2–Shrimp HP EHP nested positive; 3 & 10–EHP I step negative control; 4 & 11–EHP I step positive control; 5 & 15–EHP nested negative control; 6 & 16–EHP nested positive control; 7 to 9-HP of juvenile *S. serrata* and *S. olivacea*, and crablet *S, serrata* negative for EHP; 12 to 14-HP of juvenile *S. serrata* and *S. olivacea*, and crablet *S, serrata* positive for EHP.

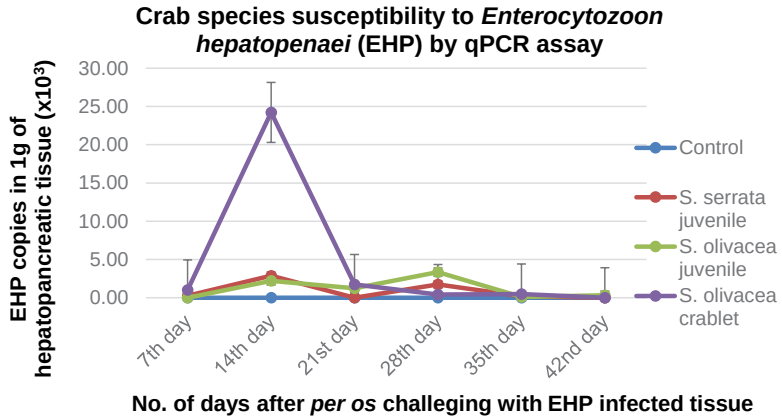


Fig. 4

Crab species susceptibility to EHP by qPCR assay

STUDY ON THE SHRIMP SPECIES VARIATION IN SUSCEPTIBILITY AND RESISTANCE AGAINST *E. hepatopenaei* (EHP)

Experience during the field grow out demonstrations of Indian white shrimp, *P. indicus* and shrimp aquaculture farmers' feedback on the resistance of this species to *E. hepatopenaei* (EHP) drives us to conduct an experiment under the controlled environment to understand the hypothesis. For this purpose, the juveniles of three economically important species of shrimps such as *P. indicus* (Average body weight [ABW] - 1.94±0.21g; Average body length [ABL] – 59.6±0.20mm), *P. monodon* (ABW - 2.67±0.29g; ABL – 65.2±0.26mm) and *P. vannamei* (ABW - 1.48±0.11g; ABL - 5.81±0.17mm) were procured from hatcheries. The animals were acclimatised for one week feeding with commercial pellet feed @ 6% body weight (BW) and PCR screened for all WOAH listed pathogens. Multiple-dose challenge and susceptibility study experiment was conducted with three treatments using respective species and a control in triplicate, each replicate with 25 animals. EHP infected hepatopancreas (HP) with gut ($22.31x10^6$ copies g^{-1} of tissue) was fed to each group for seven days while the control group received only commercial feed. Samples such as haemolymph for haematology and bacteriology, whole animal in Davidson's fixative for histopathology, and HP for PCR and qPCR were collected in triplicate at weekly interval. The experimental animals were found to be negative for all WOAH listed pathogens. Quantitative PCR analysis of HP collected from different species of shrimp revealed that there was significant difference in EHP load. EHP copies in HP of *P. vannamei* was highest ($64.35x10^6$ copies g^{-1} of HP tissue) on 42nd day of experiment followed by $1.61x10^6$ copies g^{-1} of HP in *P. monodon* on 35th day and the least EHP load in HP of *P. indicus* was $0.02x10^6$ copies g^{-1} of HP tissue (Fig. 5) during entire 42 days of experiment.

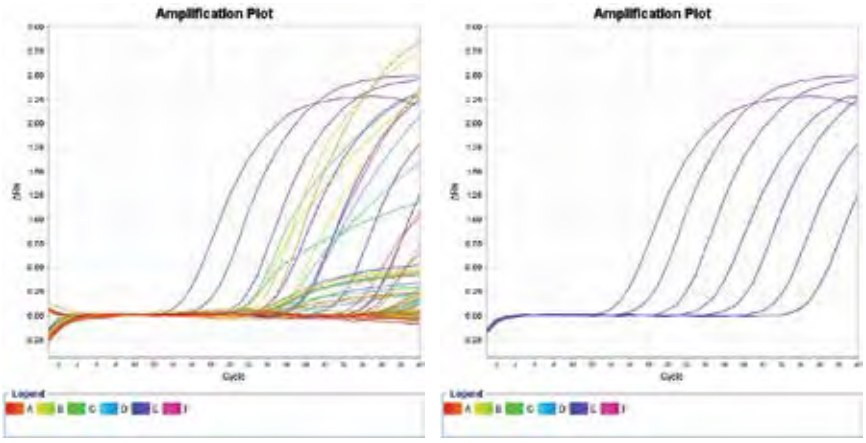


Fig. 5

qPCR amplification plot for EHP plasmid control and positive shrimp samples

PATHOGENICITY OF *Vibrio parahaemolyticus* FROM WHITE FECES SYNDROME (WFS) AFFECTED SHRIMP

White feces syndrome (WFS) has emerged as major problem in shrimp culture worldwide. Compared to earlier reports of association of EHP with WFS, recent reports associated vibrios and other bacterial species along with EHP. Therefore, to understand the role of bacteria, a series of eight challenge trials were conducted with bacterial isolates originated from WFS ponds and isolates before the reports of WFS. The analysis suggests that bacterial isolates especially *V. parahaemolyticus* originated from the WFS affected ponds results in consistent mortality up to 15 to 25% by bath immersion in shrimp juveniles. However, other isolates despite showing symptoms of pathogenesis such as black spots etc. failed to produce mortality by immersion challenge at similar dose. Overall, the data suggests a higher level of pathogenicity by the isolates originated from WFS ponds.

PROPHYLACTICS AND THERAPEUTICS AGAINST EHP AND *Vibrio* spp.

EHP in association with other opportunistic bacteria causes severe growth retardation, WFS and mortality leading to severe economic losses in shrimp farming nations. The studies on safe and eco-friendly anti-microbial therapeutics are very limited. Hence, an attempt was made to develop plant based therapeutics against EHP and *Vibrio* spp. Five herbal extracts were *in vitro* tested for their anti-*Vibrio* activity and three were found to be effective. The three extracts were green synthesised in to nanoparticles with tissue recognition ligands to increase their water solubility, absorption, bioavailability and longer half-life. The coupling efficiency was found to be between 96.36 and 99.64% by multimode microplate reading. The study is in progress for nanoparticles characterisation and *in vivo* experiments. In another study, different potential natural therapeutics were evaluated for the treatment and control of EHP. Different plant based essential oils and compounds were evaluated for anti-microsporidian activity *in vitro* by inducing the EHP spore germination. Among eight essential oils and four active components, one essential oil and one active component were found to completely inhibit the EHP spore germination (Fig. 6).

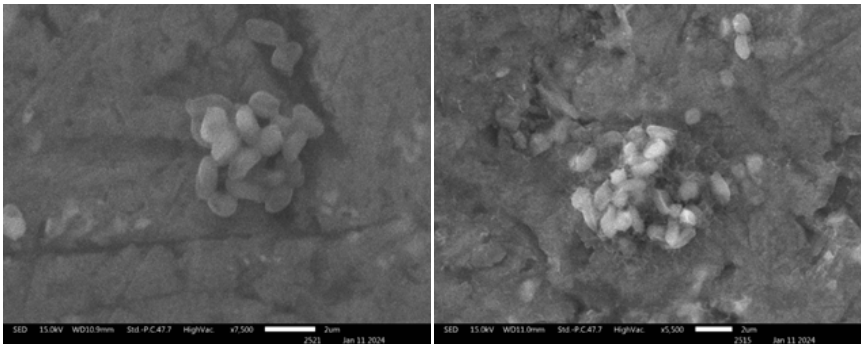


Fig. 6

Showing the complete inhibition of EHP spore germination by the two compounds

ASSESSMENT OF THE EFFICACY OF SILYMARIN COMPOUNDS AS HEPATOPROTECTANT IN SHRIMP AGAINST EHP AND COINFECTION WITH *Vibrio* spp.

EHP damages the HP resulting in impaired nutrient metabolism leading to clinical signs such as size variation, growth retardation, secondary bacterial infections and mortality. Hepatoprotectant such as silymarin compounds with cellular regeneration capacity was proved to prevent or reverse the hepatotoxicity in animals and fishes. Hence the study was aimed to assess the efficacy of silymarin as feed supplementation in prevention and/or treatment of EHP infection in shrimp. The ABW of 1.49g shrimps, *P. vannamei* were obtained from Muttukadu Experimental Station. Shrimps free of WOAH listed pathogens and *E. hepatopenaei* were acclimatized to the experimental conditions for two weeks. They were distributed in ten FRP tanks (200 L) of fifteen each and fed four times daily @ 6% BW with commercial basal diet. The water quality parameters of salinity of 25±1 ppt and water temperature ranging from 28 to 30 °C were monitored with continuous aeration and maintained with 70% water exchange in three days. Silymarin derivative was supplemented in commercial shrimp feed at required dosages and coated with soya based binder and stored in 4 °C. Four treatment groups I, II, III, IV and a control group in duplicates were fed with the experimental feed supplemented with silymarin at 0.01%, 0.02%, 0.05%, 0.10% and 0.00% respectively for 20 days. There was no significant difference in the weight gain in the treatment and control group (Fig. 7). The shrimp in all groups were challenged per os with *E. hepatopenaei* and the experiment is in progress.

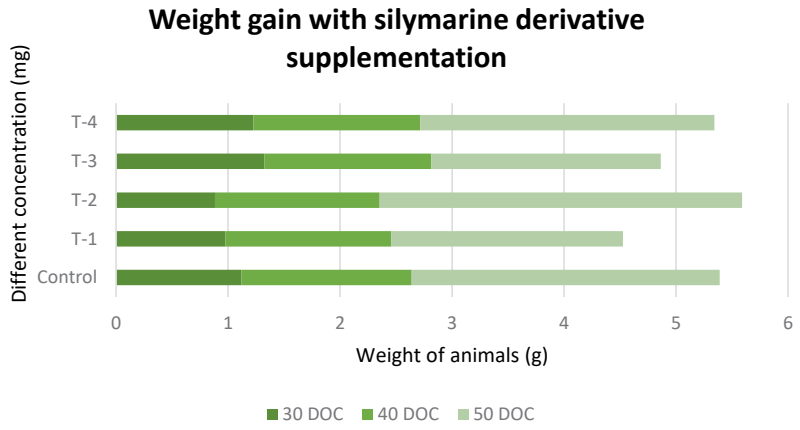


Fig. 7
Average body weight (g) of *P. vannamei* with silymarin derivative supplementation

PROPHENOLOXIDASE ACTIVATING PEPTIDASE INTERACT WITH SPORE WALL PROTEINS OF EHP

Spore wall proteins (SWPs) of microsporidians interact directly with host cells during infection and play important roles in host cell adhesion, ion channels, energy transfer, signal transduction, and enzymatic reactions. The present study aimed to identify bio-enzymes (peptidases) against EHP SWPs to reduce the infection and spread in the target organ HP. An *in silico* protein-peptidase interaction study was carried out using SWPs reported from EHP and the proteins up-regulated in EHP- infected *P. vannamei* from a previously published study. An up-regulated protein prophenoloxidase-activating peptidase (Accession no.: AFW98991.1; UniProt entry: K7WDM8) was identified. An Alpha Fold structure of the peptidase, comprising 462 amino acids, was obtained from the UniProt database. Three SWPs and the peptidase were processed using Protein Preparation Wizard for protein-protein docking studies and optimized by assigning hydrogen bonds through the PROPKA package at pH 7.0. The SWPs were defined as receptors, while the *P. vannamei* prophenoloxidase-activating peptidase was defined as the ligand. Six sets of protein-protein docking, involving three SWPs each against the prophenoloxidase-activating peptidase of *P. vannamei* and the SWP was performed in Schrödinger's Maestro interface using Protein-Protein Docking panel. The selected

poses exhibiting high potential energy were used to generate protein-protein interactions using PDBSum. The final protein-peptide complexes were selected based on high potential energy, representing the interaction energy between the proteins. Notably, the highest potential energy scores of 16188.68, 13869.33, and 13548.08 were observed for the docking of three SWPs to *P. vannamei* prophenoloxidase-activating peptidase. To study the interaction of selected poses showing high potential energy resulting from the protein-protein docking, the PDBSum tool was used. The residues of SWP (Accession no.: QIQ08173.1), such as THR26, ILE27, TYR72, PHE20, PHE68, ILE16, VAL48, TRP23, TYR42, ILE75, TYR10, and GLY6; SWP 1 (Accession no.: AQW38599.1), including ILE17, HIS20, TRP24, PHE21, TYR73, LEU18, THR46, ILE76, TYR43, GLU12, TYR11, ASN84, MET83, and HIS23; and SWP 1 (Accession no.: UAO74359.1), such as THR5, HIS9, TRP13, PHE58, LEU51, PHE2, GLY3, LEU7, PHE10, ILE6, ILE31, THR35, TYR62, TYR32, and ILE65, all exhibited interactions with *L. vannamei* prophenoloxidase-activating peptidase. Figure 8 (D, E, F) provides details on the number of interacting residues, hydrogen bonds, salt bridges, and non-bonded contacts, along with the amino acid residues involved in hydrogen bond interactions for the selected poses of three SWPs docked to *L. vannamei* prophenoloxidase-activating peptidase. The interaction of ProPO-activating peptidase and EHP proteins will be validated in vivo in shrimp post-challenge with EHP.

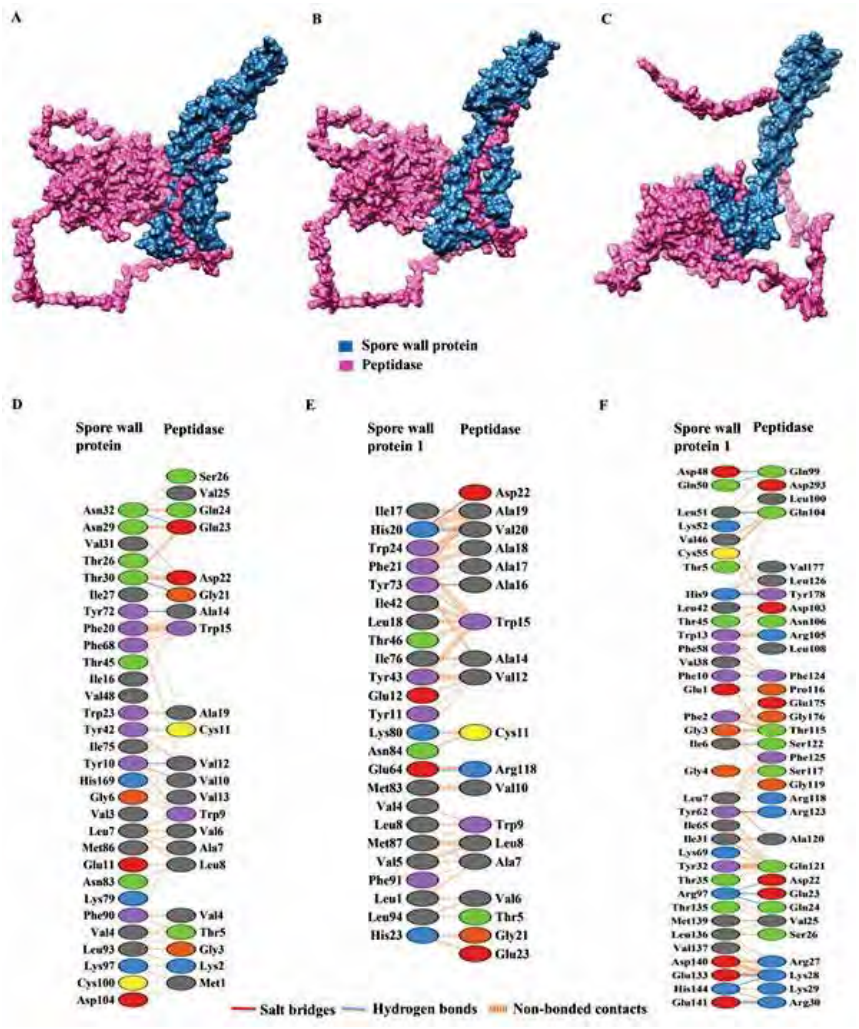


Fig. 8

Protein-protein docking and interaction of three spore wall proteins to the *L. vannamei* prophenoloxidase-activating peptidase. The docking poses of *L. vannamei* prophenoloxidase-activating peptidase with (A) Spore wall protein (Accession no.: QIQ08173.1), (B) Spore wall protein 1 (Accession no.: AQW38599.1), and (C) Spore wall protein 1 (Accession no.: UAO74359.1). SWP and peptidase are depicted in blue and pink, respectively. The interactions of *P. vannamei* prophenoloxidase-activating peptidase with (D) SWP (Accession no.: QIQ08173.1), (E) SWP 1 (Accession no.: AQW38599.1), and (F) SWP 1 (Accession no.: UAO74359.1). The lines between any two residues indicate salt bridges (red), hydrogen bonds (blue), and non-bonded contacts (orange)

FIELD EVALUATION OF *E. hepatopenaei* (EHP) THERAPEUTIC CIBA EHP CURA I

E. hepatopenaei (EHP), the shrimp microsporidian, has been a serious threat to the shrimp aquaculture industry in recent years. EHP infection does not cause mass mortality but inflicts severe economic losses by causing reduced feed conversion and stunted growth. The annual economic loss due to EHP in Indian shrimp farms was estimated to be about RS 3977 crores. The studies on the therapeutics of EHP are very limited. ICAR-CIBA developed 'CIBA EHP cura I' for the treatment and control of EHP. 'CIBA EHP cura I' is a combination of natural product and nutritional supplements which significantly reduced the EHP load and improved the shrimp immunity and growth in both the lab and initial field studies. Field evaluation of CIBA EHP cura I has been initiated in shrimp farms of Nagapattinam, Thiruvallur districts of Tamil Nadu, Bapatla and Bhimavaram districts of Andhra Pradesh and Navsari district of Gujarat. Around 1500 liters of CIBA EHP cura I have been used for the field evaluation and a revenue of Rs 7,47,450 has been generated. Also, two MoUs has been signed with Meenam aqua needs, Chennai and Sai Aqua, Bapatla for large scale field validation of 'CIBA EHP cura I' in Andhra Pradesh (Fig. 9). The data collection is in progress and need to be analysed.

Fig. 9

Field evaluation of CIBA EHP cura I and MoUs signed with Meenam aqua needs, Chennai and Sai Aqua, Bapatla for large scale field validation of 'CIBA EHP cura I' in Andhra Pradesh

APPLICATION OF GENE EDITING TECHNOLOGIES (CRISPR/CAS) FOR DISEASE DIAGNOSIS

The White Spot Syndrome Virus (WSSV) TATA box binding protein gene was targeted for primer design in order to conduct the recombinase polymerase amplification (RPA) assay. The RPA-based isothermal amplification method was standardized. The WSSV TATA box targeting gene was successfully cloned and the copy number was normalized, serving as a template for the CRISPR/Cas12 assay. The clones were verified through sequencing, and a standard curve of WSSV was established using quantitative reverse transcription polymerase chain reaction (qRT-PCR). Subsequently, in vitro transcription was conducted, and the amplified region of interest was detected using CRISPR/Cas12a. Further, specificity check was performed to ensure that there was no cross-reactivity with other pathogens such as *E. hepatopenaei* and Infectious Myonecrosis Virus (IMNV). The Trans-cleavage activity of CRISPR/Cas12a was standardized using a FAM-BHQ1-labeled reporter assay (Fig. 10). Currently, ongoing work involves further standardization of sensitivity of the assay and development of field-applicable point-of-care diagnostics.

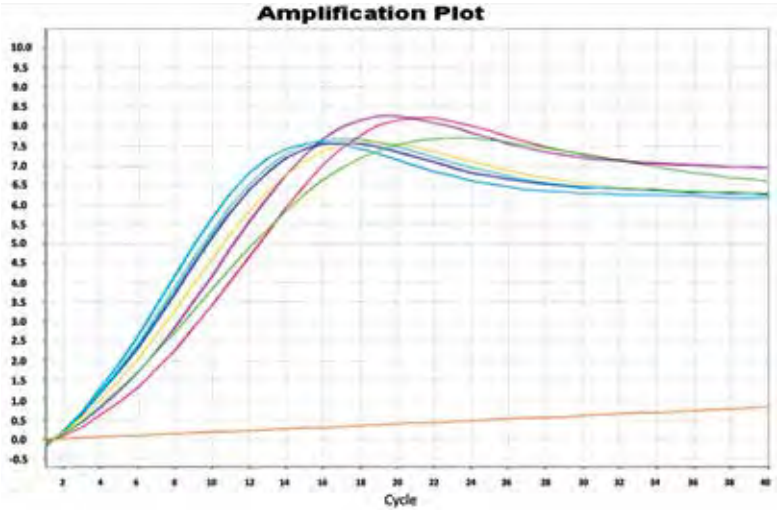


Fig. 10
Amplification plot of FAM-BHQ1-labeled reporter assay

DEVELOPMENT OF POINT OF CARE DIAGNOSTICS FOR THE DETECTION OF MAJOR SHRIMP PATHOGENS WSSV AND EHP

For the development of EHP lateral flow immune assay, EHP Spores were purified from EHP infected shrimp HP. The complete sequence of EHP SWP gene has been amplified. The spore wall protein has been cloned into pGEX-6P-1 by infusion cloning method. The SWP was expressed in BL21 bacterial strain. The expressed protein was extracted and purified. The purified recombinant SWP was concentrated and used for the polyclonal antibody production. Around 750 mg of purified recombinant SWP mixed with Freund's complete adjuvant had been injected into the rabbit (2.5 Kg) for raising polyclonal antibody against EHP.

DEVELOPMENT OF MULTIPLEX LAMP ASSAY FOR WSSV AND EHP

WSSV and EHP, are the most important cause of severe economic loss to the present global aquaculture sector. Early and rapid detection of pathogens is very much necessary to mitigate the impact of disease outbreak. In this context ICAR-CIBA developed a multiplex LAMP for the simultaneous detection of EHP and WSSV. LAMP primers had been designed using VP28 region for WSSV detection and spore wall protein region for EHP detection. This multiplex LAMP is a closed tube LAMP and did not cause cross contamination. This multiplex LAMP has been performed in a simple dry bath and did not need any expensive equipment. This multiplex LAMP can detect both WSSV and EHP up to 10 copies in 45 minutes (Fig 11). Further clinical validation and lateral flow strip based detection need to be developed.

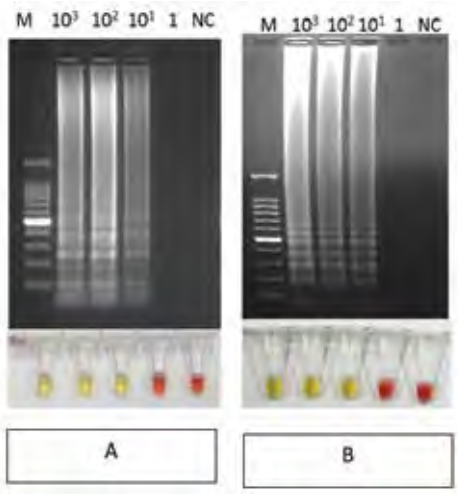


Fig. 11

Gel electrophoresis and visual detection of serially diluted WSSV DNA (A), EHP DNA (B), LAMP amplicons. M- Marker, NC- Negative control

DEVELOPMENT OF RECOMBINANT MICROALGAE EXPRESSING NERVOUS NECROSIS VIRUS CAPSID PROTEIN FOR VACCINATING FINFISH AGAINST VIRAL NERVOUS NECROSIS

Chlamydomonas reinhardtii, strain TN72, plasmids pSRSapI and pASapI were procured from the University of Minnesota, USA. pChlamy_4 plasmid and codon-optimized NNV were procured commercially. Primers with restriction sites were designed to amplify the codon-optimized NNV capsid protein gene. The PCR product and the vectors were double digested with restriction enzymes SapI and SphI-HF (Fig. 12). The double-digested plasmids and the PCR products were ligated and transformed into E. coli DH5α competent cells by heat shock method. Positive colonies were screened by colony PCR. The recombinant plasmid was isolated from PCR-positive colonies and sequenced using primers designed on the plasmid. The sequence results revealed that the full-length capsid protein gene has been cloned in the vectors. Upon digestion with KpnI (Fig. 13) the recombinant plasmid containing the insert gave bands of the expected size indicating the presence of the insert in the recombinant plasmid.

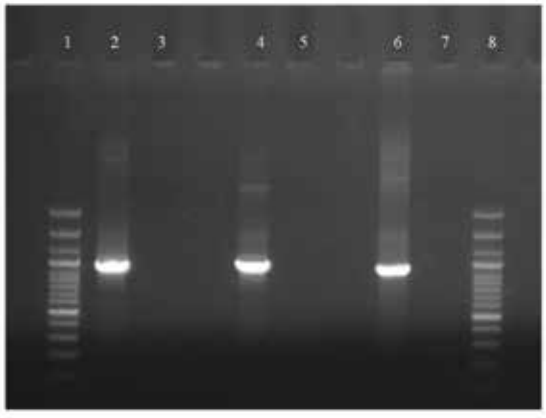


Fig. 12

Colony PCR for transformed DH5a cells.

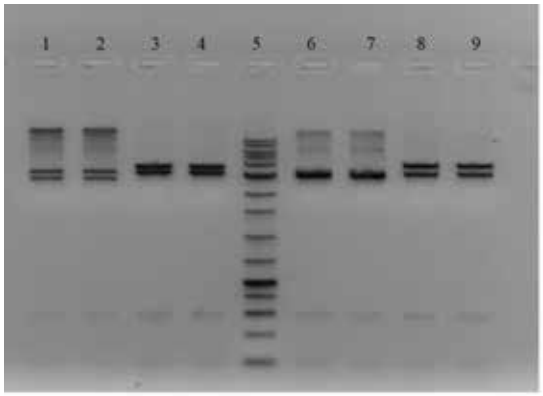


Fig. 13

Agarose gel electrophoresis of recombinant plasmids with and without insert digested with the restriction enzyme KpnI

CHARACTERIZING AND DEVELOPING THE INDIGENOUS FISH CELL LINES TO PROVE STEMNESS AND PROLIFERATION IN SEAFOOD CELL CULTURE

Asian seabass fingerlings of size 20 g were procured from fish hatchery at MES, Muttukadu. Muscle tissue was collected aseptically and minced with a sterile scalpel. The cells and tissues were washed with an L-15 medium containing antibiotics. The primary explant culture of muscle was grown in L-15 medium supplemented with 20% FBS in 25 cm2 flasks. The explant culture of muscle tissues could be established into a fibroblastic monolayer in three weeks with 100% confluency. The muscle cells were sub-cultured 10 times at regular intervals with a split ratio of 1:3 during the log phase with uniform culture conditions. Two flasks of cells were handed over to Neatmeatt Biotech Pvt. Ltd. as part of the MoU signed with them after signing the material transfer agreement. The cell growth slowed down subsequently and fresh primary culture from muscle tissue from Asian seabass has been initiated (Fig. 14).

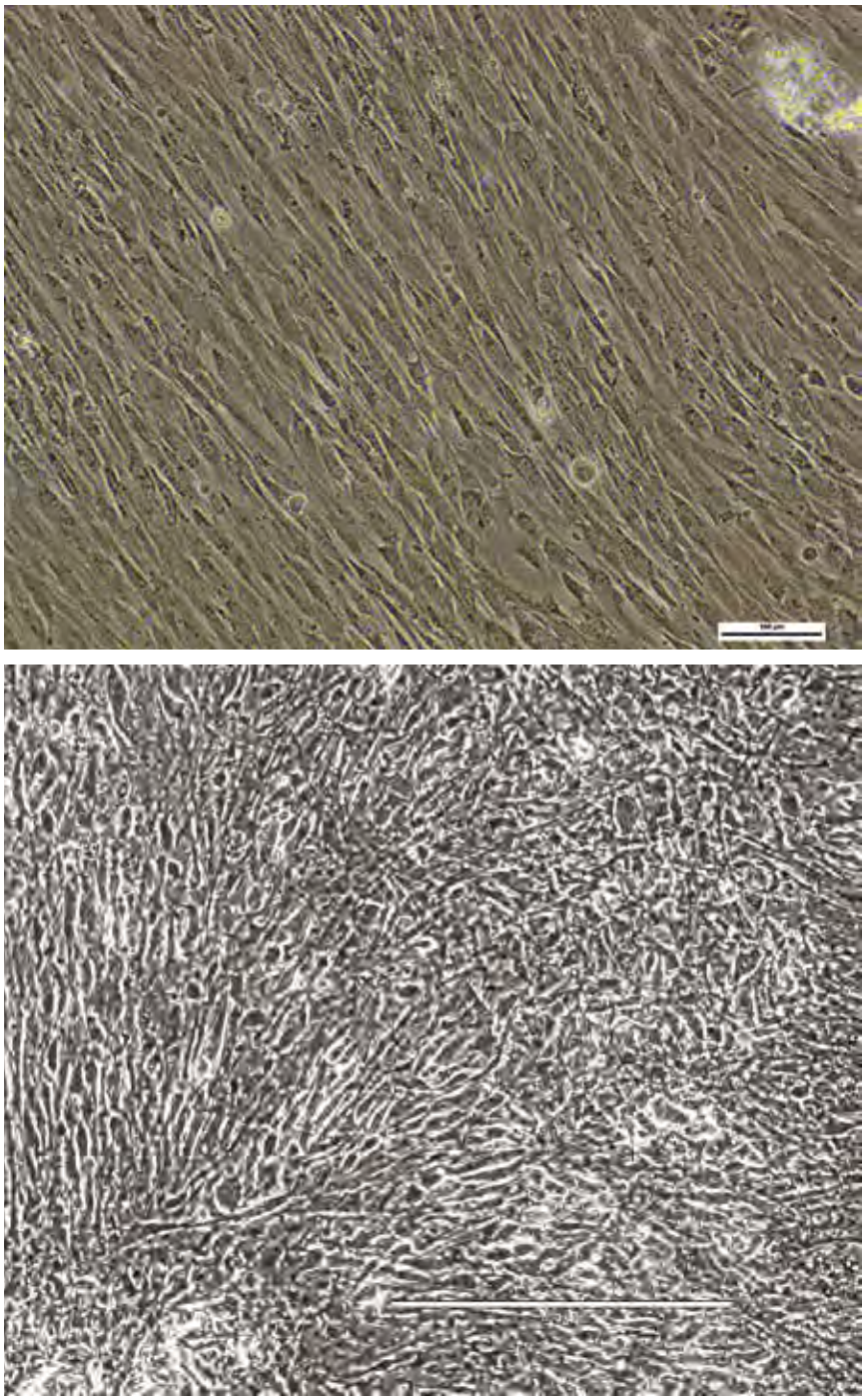


Fig. 14

Asian seabass muscle explant culture at 10 days (A) and muscle cells at 7th passage (B)

DEVELOPMENT OF PROBIOTICS AND IMMUNOSTIMULANTS FOR SHRIMP

Microbial strains were isolated from natural environment and culture systems and screened for potential bioremediation properties. Initially the isolates were screened for their ability to produce extracellular enzymes which helps in improvement of food assimilation and immunity in addition to fight against the pathogenic microbes. Fifteen of the 34 isolates demonstrated amylase (starch), protease (gelatin and skim milk) and lipase (tributyrin and tween 80) activities.

Further to evaluate the bioremediation potential the growth performance of the bacterial strains were assessed in sulphur oxidising bacteria (SOB) medium (*Thiobacillus* agar medium). Time kinetics of the bacterial growth was analysed to understand growth potential and toxic metabolite utilisation capability of the selected bacterial strains. The strains PB1, PB3, PB20, PB23, PB5, PB8, PB10-PB13, PB17, PB19-27, LPB1-LPB3 were resulted positive growth in Thiobacillus agar medium. Studies to evaluate the efficiency in utilisation of ammonia and nitrite were assessed using media containing 10 ppm of ammonia and nitrite. The ammonia and nitrite tolerating isolates were tested for utilisation kinetics for 24h period. PB 6 and PB 7 probiotic strains were efficient in ammonia utilisation while PB4, PB6, PB7, PB16, and PB20 were efficient in utilising nitrite.

EVALUATION OF *Streptomyces griseorubens* AND *Bacillus pumilus* FOR PROBIOTIC POTENTIAL

To develop a suitable probiotic bacterium for shrimp culture, bacterial isolates were screened for antagonistic activity against pathogens. The two bacterial isolates *Streptomyces griseorubens* and Bacillus pumilus were found to have antagonistic effect against *Vibrio campbellii* and *Bacillus pumilus* also have antagonistic effect against *Vibrio. mimicus* & *Edwardsiella tarda*. A bioassay experiment was conducted to evaluate the immunomodulatory properties of the isolated bacteria in *P. vannamei*. The shrimps were fed with formulated feed supplemented with probiotic bacteria along with a control feed without probiotics for 20 days. Gene expression study of hepatopancreas tissues collected on 20th day showed that the Prophenol oxidase gene (PoPO), Beta-glucan binding protein (BGBP) gene, and hemocyanin (Hc) genes were upregulated in shrimps administered with Bacillus pumilus (Fig. 15). The results indicated immunostimulatory and antagonistic activity of *Bacillus pumilus* and can be used as promising candidate probiotic bacteria.

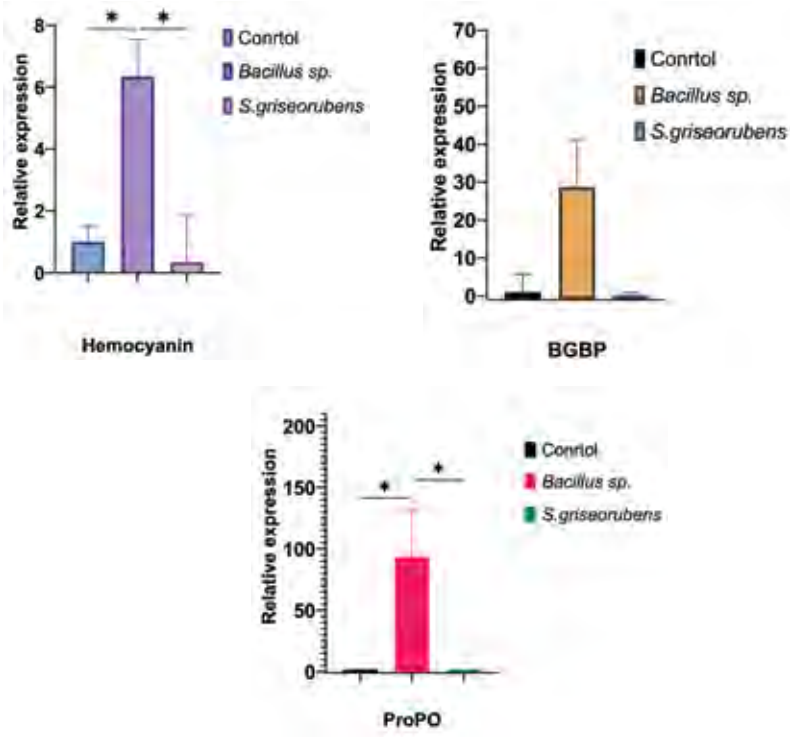


Fig. 15

Relative expression of immune genes after administration of *Streptomyces griseorubens* and *Bacillus pumilus*

EVALUATION OF *Bacillus* sp. AS A PROBIOTIC CONTROLLING BACTERIAL LOAD UNDER POND CONDITIONS

An experiment was conducted to evaluate the probiotic potential of *Bacillus* sp. under pond conditions. *Bacillus* sp. was mass cultured in the laboratory and then brewing was conducted outdoors using pond water (30 L), Rice bran (30 g), left over shrimp feed (210 g) and wheat flour(30g). Around 4x10^9 cfu/ml cells were brewed for 48 hours and after brewing the cell count was 3x10^9 cfu/ml cells. The brewed probiotic was added at a rate of 100 L/ha at an interval of 15 days. Every 15 days samples were collected and microbial analysis was carried out. The results showed that in sediment, on 45 DOC onwards total *Vibrio* count increased in control and it was below that of control in probiotice treated ponds. There was an increase in *Bacillus* count in test ponds when compared to control. The total plate count was showing a similar trend in both test and control with a slight increase in test from 60 DOC onwards. Similarly, in water total *Vibrio* count was higher in control than test during the culture period. The total *Bacillus* count was higher in test than control through out the culture period (Fig. 16).

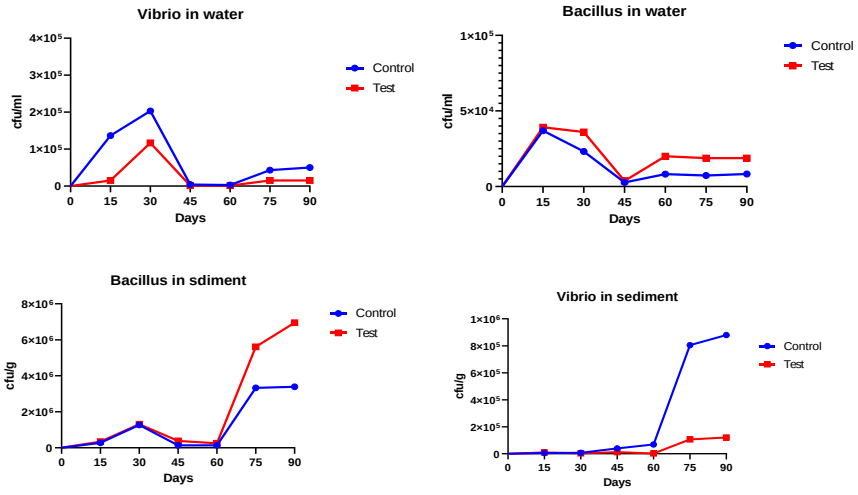


Fig. 16

Total bacterial count of various beneficial *Bacillus* and *Vibrio* in the pond water and sediment

DEVELOPMENT OF SPECIES-SPECIFIC QUANTITATIVE REAL TIME PCR FOR IMPORTANT *Vibrio* SPECIES

Harveyi clade constitute a group of thirteen closely related species of Vibrios namely *V. harveyi, V. campbellii, V. parahaemolyticus, V. alginolyticus, V. owensii, V. rotiferianus, V. natriegens, V. jasicida, V. diabolicus, V. aquamarius, V. sagamiensis, V. azureus* and *V. mytili.* Many of these species are pathogen of great importance in shrimp and finfishes. However, due to close genetic makeup and similar phenotypic characteristics, mis-identification is very common. Therefore, to understand their pathogenesis and develop diagnostic markers whole genome sequences of these thirteen species comprising 2244 isolates were analysed. The analysis suggests that *V. harveyi* often get misidentified with *V. campbelii, V. owensii* and *V. jasicida*; and *V. alginolyticus* from *V. diabolicus* and *V. aquamarius*; *V. parahaemolyticus* from *V. alginolyticus*. Keeping these in mind, all these genomes were differentially analysed and novel diagnostic markers were identified (Fig. 17). Earlier, real time PCR for four species viz, *V. harveyi, V. campbellii, V. owensii,* and *V. rotiferianus* were developed. Their analytical sensitivity and specificity were 100%. To examine their diagnostic specificity, more than 100 field samples including samples from hatcheries and white fecal syndrome affected HP and fecal samples were examined. Sanger sequencing were carried out for amplicon using these real time PCR primers for 20 random field samples and indicated 100% diagnostic specificity. To further boost the diagnostic capability, quantitative real time PCR for *V. parahaemolyticus* has been developed and is being evaluated for quantification of pathogen from white fecal syndrome affected shrimp samples.

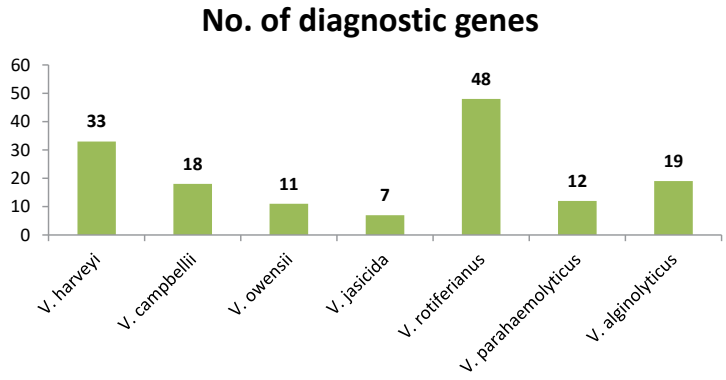


Fig. 17

Species wise number of diagnostic markers identified among Vibrio spp

MAPPING OF VIRULENCE FACTORS AMONG VIBRIOS OF AQUACULTURE IMPORTANCE

Harveyi clade constitute a group of thirteen closely related species of Vibrios namely *V. harveyi, V. campbellii, V. parahaemolyticus, V. alginolyticus, V. owensii, V. rotiferianus, V. natriegens, V. jasicida, V. diabolicus, V. aquamarius, V. sagamiensis, V. azureus* and *V. mytili*. Very little understanding exists about virulence of these pathogens. Therefore, under the present study virulence factors with respect to secretion systems, conjugative plasmids and prophage elements were mapped in these species (Fig. 18). The analysis revealed that T1SS, T2SS, T3SS, T4SS, T5SS and T6SS are present among different species. As a rule type I and type II secretion system is present in most of the isolates. However, type III secretion system (T3SS) and T5SS has species wise variation with restricted presence in few species. The T6SS was present in all the species except in V. natrigens. Conjugative plasmid is one of the key factors which influence the emgergence of new pathogens and transfer of virulence factors and antimicrobial resistance as it can be easily transferred between the isolates. Though, it was present in most of the species, *V. harveyi, V. owensii* and *V. rotiferianus* had the maximum% isolates with conjugative plasmid (Fig. 19). All most 1/3rd of the isolates within *V. harveyi* possessed conjugative plasmids which is quite sizeable as 56 isolates were under analysis. In comparison, less than 10% isolates within *V. campbellii, V. parahaemolyticus* and *V. alginolyticus* possessed conjugative plasmids.

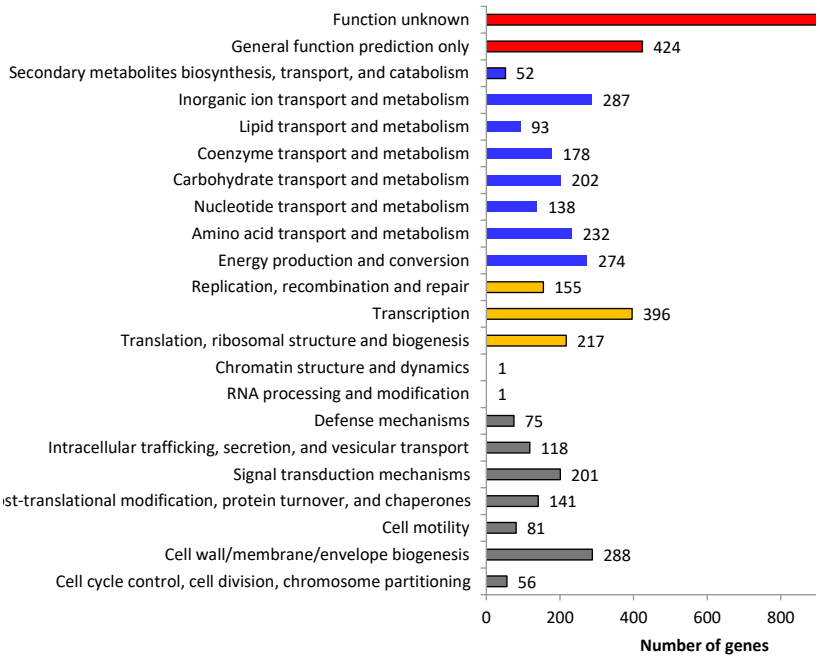


Fig. 18

Characterisation of genes within *Vibrio harveyi* SB1

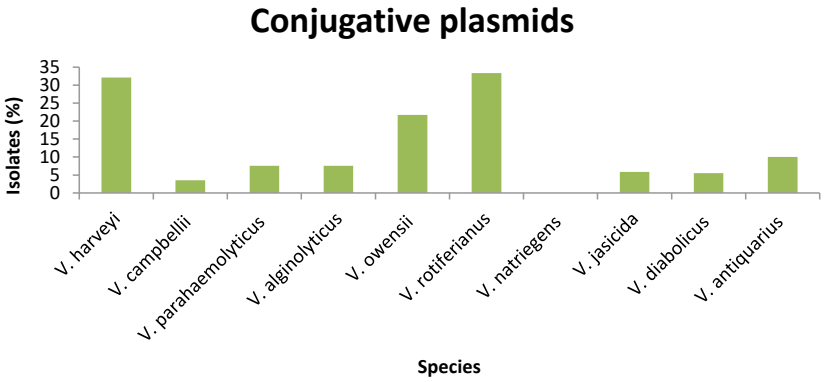


Fig. 19

Distribution of conjugative plasmids among different *Vibrio* species

A FIRST REPORT ON MORTALITIES ASSOCIATED WITH POLYOPISTHOCOTYLEAN MONOGENEAN, *Polylabris* sp. (FAMILY: MICROCOTYLIDAE) IN CAPTIVE STOCK OF *Siganus javus*

Monogeneans are parasitic flukes in aquatic animals with high host specificity. Recurrent mortalities in wild collected Java rabbit fishes (600 g) were investigated. Infested fish appeared with eroded skin and pale gills (Fig. 20). The examination revealed the presence of white thread like flukes, approximately 100-200 worms per fish affecting gills and are oviparous. Worms were microscopically examined, length and width were recorded. Total length of the adult worms vary from 2.1 mm to 2.9 mm and width ranged from 0.30 mm to 0.49 mm, the length of polyopisthohaptor ranged from 0.17 mm to 0.83 mm with a 16 -24 pairs of clamps (~50 µm) varied with maturity of the worms, the size of the pre-oral suckers were 0.08 mm×0.05 mm. Eggs were appeared spindle shaped, entangled in thread like extensions from the ends. Infested fishes were given freshwater bath treatment for 30 min to 1 h under aeration consecutively for 4-5 days, fish were recovered and no mortalities recorded post-treatment. Morphological identification (Fig. 21) has shown their close morphological similarity to polyopisthocotyledon of F. Microcotylidae, *Polylabris* sp. reported from *Siganus javus* from Visakhapatanam coast of India and the molecular characterisation of 28S rRNA gene of the monogenean revealed its 99.67% identity to *P. mamaevi* from Gulf of Oman, Arabian sea (Fig. 22).

Fig. 20

Polylabris sp. infested Rabbit fish, *Siganus javus*

Fig. 21

A. B. *Polylabris* sp., C. Egg mass of the *Polylabris* sp.

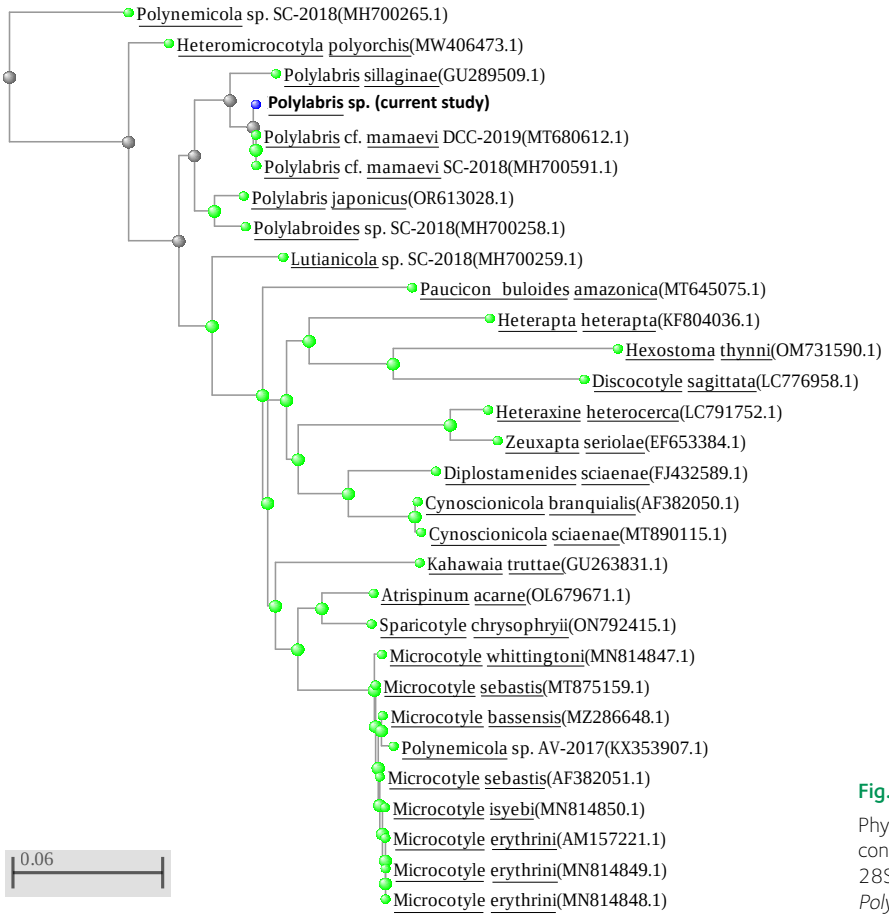


Fig. 22

Phylogenetic tree constructed using 28SrRNA gene of *Polyopisthocotyleans* reported from *F. Microcotylidae* available in NCBI

DISEASE SURVEILLANCE IN *P. vannamei* SHRIMP FARMS AT THIRUVALLUR DISTRICT OF TAMIL NADU

During this period 71 samples were collected from 30 in *Penaeus vannamei* farms in the Thiruvallur district of Tamil Nadu. These farms were screened for OIE listed shrimp pathogens and other pathogens. Fifty-one percent farms were infected with WZ8 and 36 percent farms were infected with EHP, eight percent with IMNV and five per cent with WSSV. The overall disease prevalence was found to be more during the month of June. Forty six percent of the farms had coinfection and out of which thirty five percent farms were found to be co-infected with EHP and WZ8, while the combination of other pathogens was found to be less than 10% (Fig. 23).

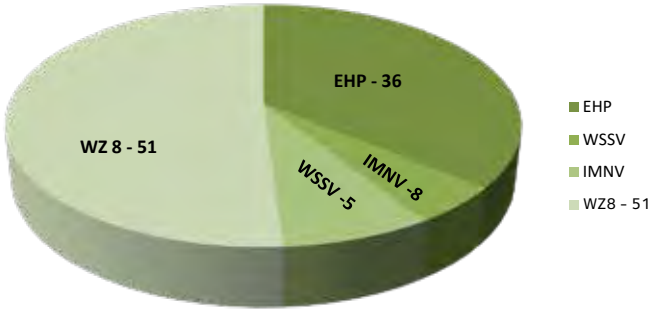


Fig. 23

Overall disease prevalence in *P. vannamei* shrimp farms at Thiruvallur district of Tamil Nadu

DEVELOPMENT OF MULTIPLEX REAL TIME PCR TESTING OF WSSV AND EHP

Presently, in shrimp aquaculture WSSV and HPM were found to be the major diseases causing havoc to farmers. Diagnosing it at an early stage can enable the farmers to deter the loss arising by this disease. Therefore, we have standardized a multiplex real time PCR for diagnosis of both pathogens (Fig. 24, 25). For WSSV diagnosis, VP 28 gene and for EHP tubulin gene were considered for primer designing.

Fig. 24

Amplification for both WSSV and EHP first step in conventional PCR

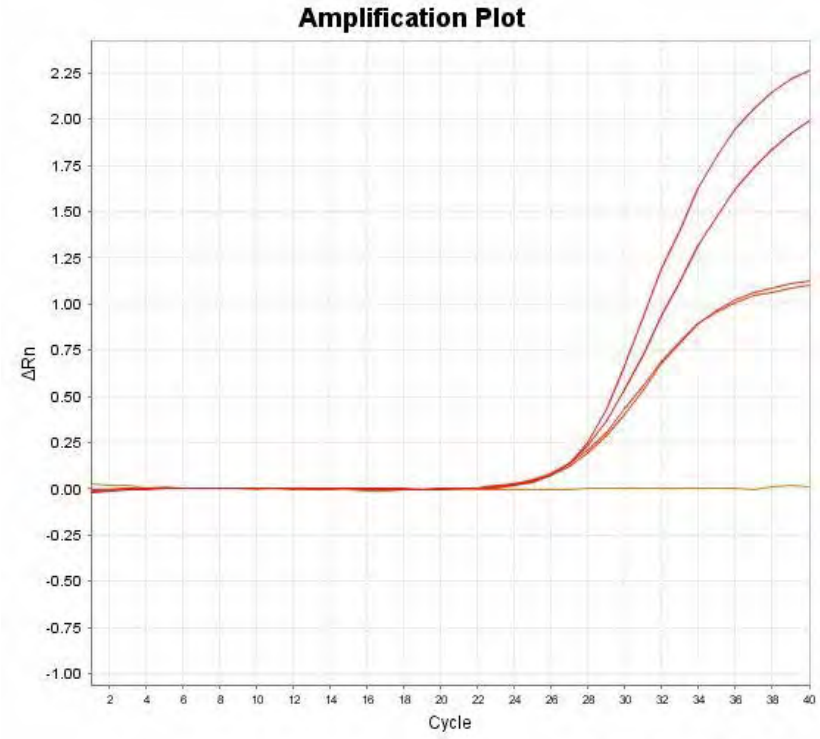


Fig. 25

Amplification for both the WSSV and EHP primers in Real time PCR (with probe)

NATIONAL REFERRAL LABORATORY FOR BRACKISHWATER AQUATIC ANIMAL DISEASES (NRLBAAD) OF ICAR-CIBA GETS NABL ACCREDITATION AS PER THE STANDARD ISO/IEC 17025:2017

A state-of-the-art referral laboratory of ICAR-CIBA was successful in getting National Accreditation Board for Testing and Calibration Laboratories (NABL) accreditation as per the standard ISO/IEC 17025:2017 (Fig. 26), solidifying the position as one among the few select ICAR institutes recognized for its state-of-the-art facility and ability in the field of biological testing. The National Referral Laboratory for Brackishwater Aquatic Animal Diseases (NRLBAAD) established in this institute got NABL accreditation for the detection of WSSV, IHHNV, IMNV and EHP pathogens. The NABL accreditation stands as a

testament to the unwavering commitment in maintaining the highest standards of quality, research, provides formal recognition of competence of the laboratory to enable the customers, our collaborators, clients and stakeholders to find reliable testing, precise results and calibration services to meet their requirement within the realm of fisheries science. It reflects the dedication and ongoing pursuit of excellence in all aspects of its operation. Farmers, stake holders, central government organizations and various other research institutes avail the facility of NRLBAAD regularly to get their samples tested for the presence of various fish and shrimp pathogens.

National Accreditation Board for Testing and Calibration Laboratories

NABL

CERTIFICATE OF ACCREDITATION

NATIONAL REFERRAL LABORATORY FOR BRACKISHWATER AQUATIC ANIMAL DISEASES

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE, 75, SANTHOME HIGH ROAD, M R C NAGAR, R A PURAM, CHENNAI, TAMIL NADU, INDIA

in the field of

TESTING

Certificate Number: TC-12486

Issue Date: 27/10/2023 Valid Until: 26/10/2025

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Entity: ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer

Fig. 26
NABL certificate obtained by NRLBAAD of ICAR-CIBA

ANTIBIOTIC RESISTANCE WAS DETECTED IN SHRIMP AND WATER SAMPLES FROM SHRIMP CULTURE PONDS

Aim of this study was to screen antimicrobial resistance in *E. coli, S. aureus*, and *Vibrio* species, including *V. parahaemolyticus* in farmed shrimp. A total 112 cultured shrimp samples and 80 source water samples form Nellore and Guntur district of Andhra Pradesh and Cuddalure and Nagapattinam district of Tamil Nadu were analysed. A total of 82 *V. parahaemolyticus,* 21 *S. aureus* and 58 *E. coli* were isolated and identified by biochemical test and molecular technique. Highest of 65% and 2% isolates of *V. parahaemolyticus* and *E.coli* were resistance to Ampicillin respectively. While 85% of *E.coli* was resistance to Amikacin, 100% of *S. aureus* were resistance to Penicillin. Highest 80% and 70% of S. aureus were resistance to Tetracycline and Erythromycin respectively whereas nearly about 4% of *V. parahaemolyticus* and *E.coli* were resistance to Tetracycline. Total of 8% *V. parahaemolyticus* isolates were resistance to Cefotaxime (Fig. 27, 28, 29).

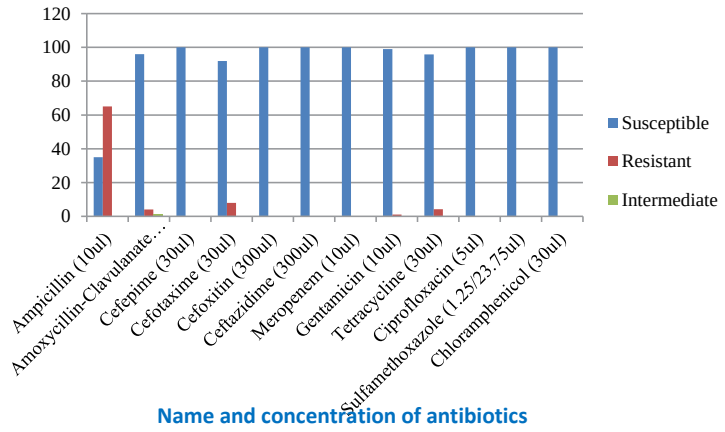


Fig. 27
Drug resistant patterns of *V. parahemolyticus*

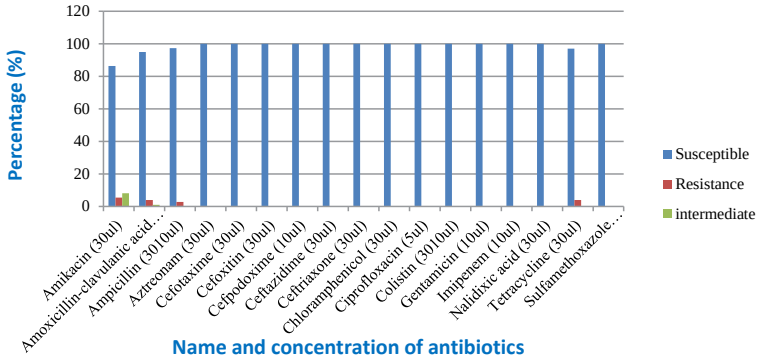


Fig. 28
Drug resistant patterns of *E. coli*

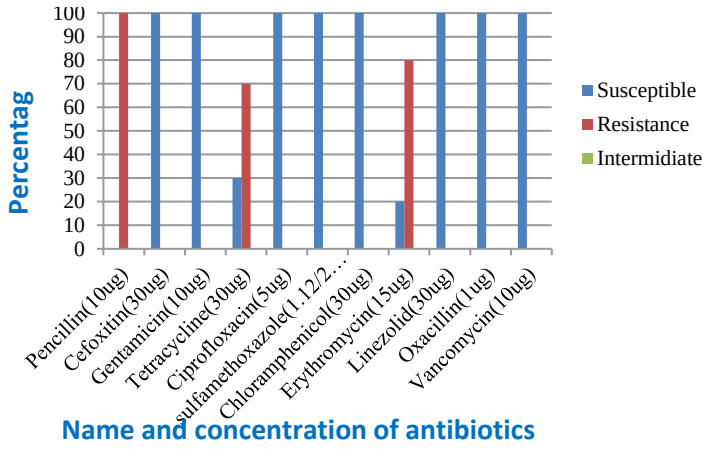


Fig. 29
Drug resistant patterns of *Staphylococcus* sp.

ALL INDIA NETWORK PROJECT ON FISH HEALTH

Administration of antimicrobial agents, oxytetracycline (80 mg/kg bw) and florfenicol (15 mg/kg bw) in Asian seabass showed a withdrawal period of 12 h for OTC whereas there was no need for a withdrawal period for florfenicol. In-feed administration of anti-parasitic agent lufenuron was found to be 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, morbidity, clinical signs, gross and histopathological lesions, gene expression and mortality. Environmental degradation of VMPs (emamectin benzoate, florfenicol and potassium permanganate) showed major role of photodegradation, along with initial concentration, temperature, pH, salinity and intensity of sunlight. The study suggests that, India, being in the tropical zone has the advantage of bright sun light throughout the year and thus facilitates swift degradation of aquaculture drugs as photolysis is the primary factor influencing

degradation. Similarly, the effect on environmental indicator organisms (ex. Spirulina, *Arthrospira platensis*) suggest the little adverse impact of studied VMPs at the therapeutically relevant concentrations.

Further, the data collected based on a questionnaire from the major farming systems IMC (n=1246), IMC+ (n=1045), pangasius pond (n=79), pangasius cage (n=26 batteries), tilapia (n=28), marine fish cages (n=83 batteries) and shrimp (n=216) and analysis using a model framework ELDA estimated the economic burden of diseases to Indian aquaculture sector at Rs. 18304.15 crores, which is 14.95% of the total value of annual aquaculture produce.

IMMUNOMODULATORS WERE EFFECTIVE IN PROVIDING HIGHER GROWTH AND DISEASE RESISTANCE TO *P. vannamei*

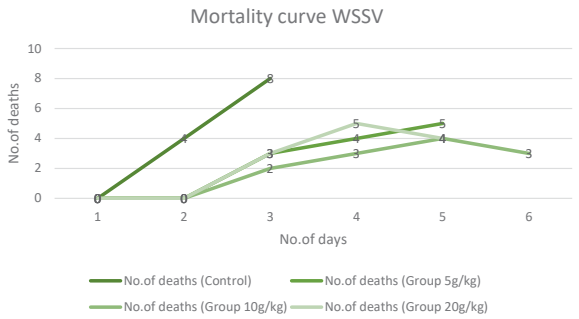
The aim of the project was to determine effective dosage of immunomodulators (prebiotics, probiotics and immunostimulants) for providing better growth and disease resistance. *Bacillus subtilis* was used as candidate probiotic. The optimum concentration at which the maximum growth (20 to 40% higher growth) and better disease resistance (both viral and bacterial) was observed at 10^7 CFU/ml. As in the same manner, the prebiotic, inulin at 20g/kg coated feed gave higher growth and better disease resistance i.e, showed about 22-32% higher growth in experiment group (highest in 20g/kg). Along with this metagenome study and gene expression studies were done to ensure the validity of the results obtained. The gene expression studies for immune and growth genes revealed that higher level of expression in all experimental group as compared with control (Fig. 30). The metagenome results clarified the abundance of more bacterial family in the gut of experimental animal than in control.

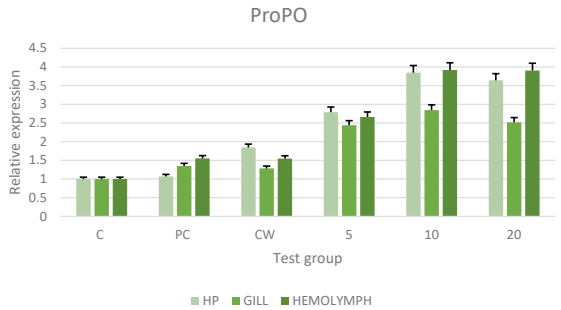
Fig. 30

With Probiotic (*Bacillus subtilis*) – Higher growth (A), Extended mortality (B) and higher immune gene expression (C) was observed

DEVELOPMENT OF MICROALGAE BASED IMPROVED DELIVERY METHOD FOR CONTROL OF SHRIMP WSSV IN CULTURE PONDS

The aim of the project was to develop an algal based field delivery method for the treatment of shrimp white spot syndrome virus. VP28 gene of WSSV as such was taken as wild and the same was codon optimised based on the sequence of microalgae was used as experimental type. For wild type VP28, PCR was carried out with added restriction sites on both sides of the primer. The amplified product was restriction digested and ligated to algal vector. VP28 sequence was subjected to codon optimization based on microalgae sequence and restriction site insertion. The optimised sequence was synthesised custom made for further use. After PCR amplification, the same was restriction digested and ligated to the algal vector. Further transformation to the microalgae is in process (Fig. 31).





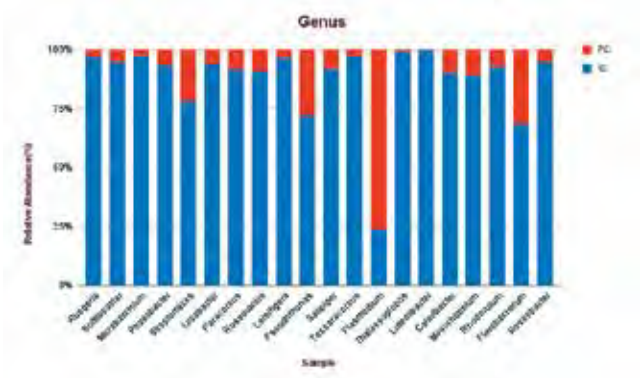


Fig. 31

With Prebiotic (Inulin) - Higher growth (A), Extended mortality (B), higher immune gene expression (C) and better gut bacterial diversity (D) were observed

AQUATIC ENVIRONMENT

AQUACULTURE POND AGEING ON SOIL, WATER QUALITY AND CROP PRODUCTIVITY IN SHRIMP CULTURE PONDS

Influence of ageing on aquaculture pond soil fertility

To study the effect of aquaculture pond ageing on soil fertility, soil samples were collected from ponds of varying age (<5, 5-10, 11-15, 16-20 and > 20 years) in Nagapattinam, Pattukkottai and Nellore clusters. The results indicate with the ageing, the fertility status of aquaculture ponds deteriorated. Organic carbon content of the virgin ponds falls under medium to high category (0.75 to 1%) and ponds above 10-year-old falls under low levels (<0.5%). Available nitrogen content varied from 6 to 8, 4 to 4.8, 3.2 to 3.9, 2 to 2.4 and 1 to 1.7 percent in pond soils of <5, 5-10, 11-15, 16-20 and > 20 years, respectively. Similar results were observed in the phosphorus and potassium content of the soils of varying age (Fig. 1). The microbial activity of the aquaculture pond soils decreases with the ageing as indicated by the soil respiration. Fresh ponds are highly fertile with the nutrient index (Fig. 2) of more than 1.75.

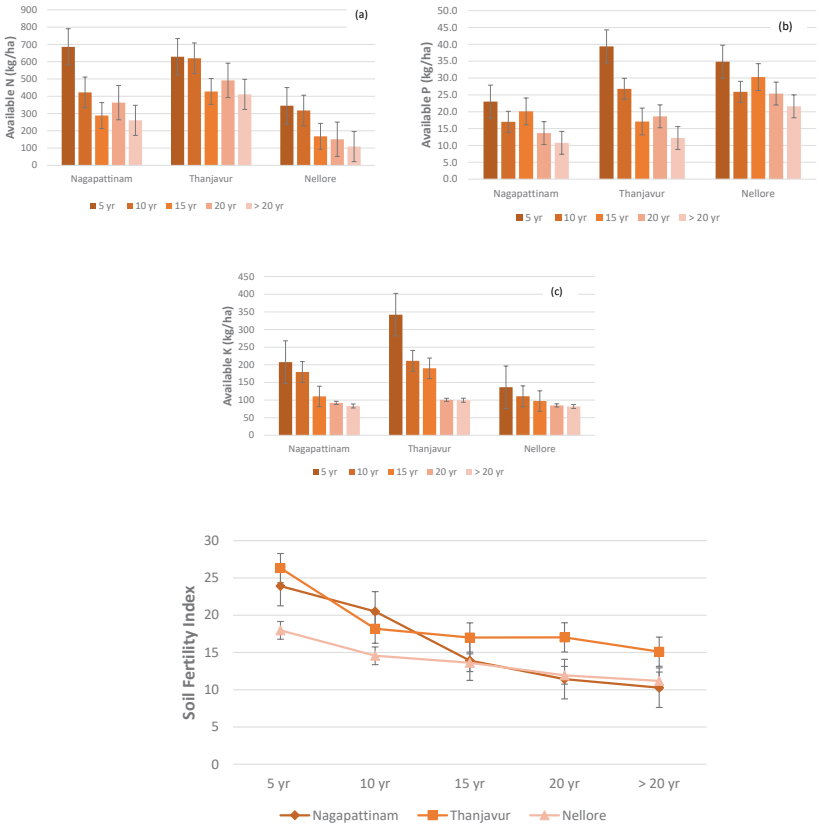


Fig. 1
Fertility status (Available Nitrogen, Phosphorus and Potassium) of aquaculture pond soils varying in age

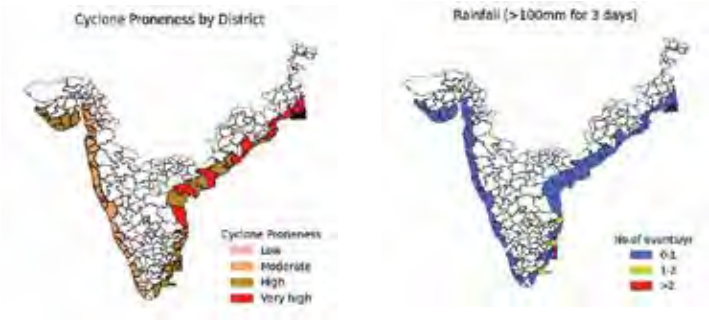
Fig. 2
Soil Fertility Index of aquaculture pond soils varying in age

NATIONAL INNOVATIONS IN CLIMATE RESILIENT AGRICULTURE (NICRA) – DEVELOPING SUSTAINABLE ADAPTIVE AND MITIGATION STRATEGIES FOR CLIMATE SMART BRACKISHWATER AQUACULTURE

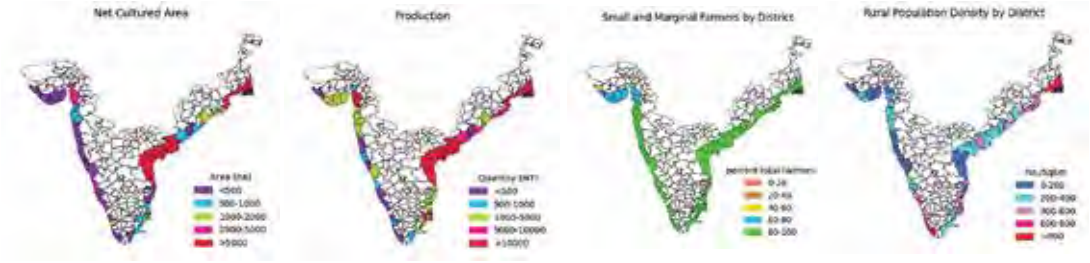
INDICATORS FOR RISK AND VULNERABILITY ASSESSMENT OF BRACKISHWATER AQUACULTURE TO CLIMATE CHANGE

Risk and vulnerability assessment of brackishwater aquaculture to climate change was assessed as per AR5 of IPCC methodology, considering three pivotal factors viz., hazard, exposure, and vulnerability. Climatic gridded data from RCP 4.5 form the basis, supplemented by secondary data. The identified risk indicators by expert group discussions are changes in maximum and minimum temperature, incidence of unusually hot and cold days, number of events with rainfall >100 mm in 3-days, average highest rainfall in a single day as a percent of annual normal, and diurnal variation in temperature for future hazards; flood proneness, cyclone proneness, extremely

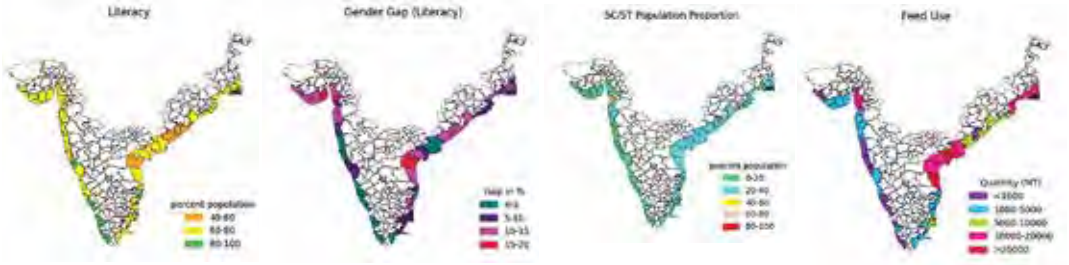
heavy rainfall and heat waves for historical hazards; net cultured area, number of small and marginal farmers and rural population density for exposure; and mangrove area, groundwater availability, literacy, gender gap, self-help groups, road connectivity, rural electrification, feed use and per capita income for vulnerability. District-wise maps were created for all the indicators (Fig. 3).



Historical hazard indicators



Exposure Indicators



Vulnerability indicators

Fig. 3

District wise maps for indicators for risk and vulnerability assessment

EFFECT OF TEMPERATURE ON REPRODUCTIVE PERFORMANCE OF PEARLSPOT DURING WINTER MONTHS

Pearlspot (*Etroplus suratensis*) shows peak breeding season during March to September (open water temperature, 29-30ºC) in the Chennai region. To understand the effect of continuous exposure of elevated temperature (32ºC) on the reproductive performance of pearlspot during November to January (26-27ºC) when they do not exhibit breeding behavior, an experiment was conducted with female (150-220 g, 17- 22 cm tl.) and male (78-140 g, 14.5-18 cm tl.) fishes in four 520 L aquarium tanks with RAS set up and flow through, and fitted with 300 w thermostat heater to maintain continuous water temperature of 32ºC for 30 days. Spawning was observed inside earthen pots of tanks (32ºC), and no spawning in control (27ºC) (Fig. 4). Attached eggs were placed in separate larval rearing tanks in green water with the same rearing temperature (Fig. 5). This preliminary result gives the lead to develop a protocol for off-season breeding of pearlspot.

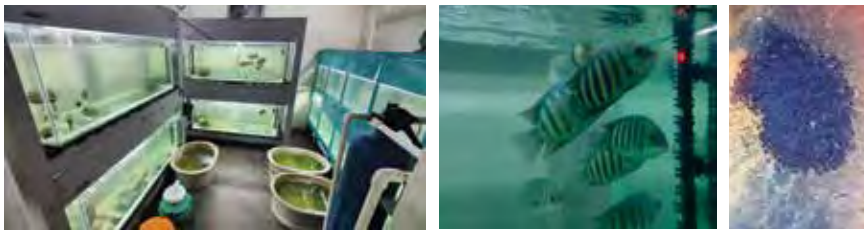


Fig. 4
Pearlspot maintained in 32ºC deposited eggs on earthen pot

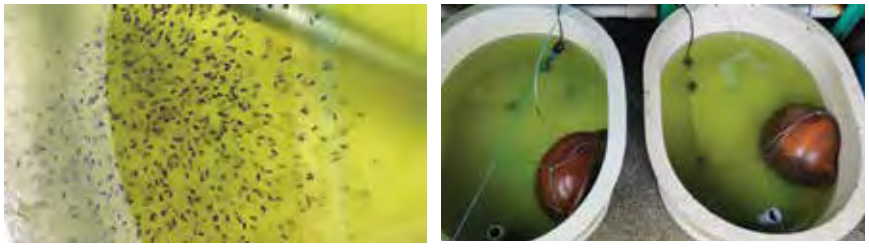


Fig. 5
Wriggler stage larvae in green water

EFFECT OF DIFFERENT SALINITIES ON MILKFISH HATCHING, LARVAL SURVIVAL & DEFORMITIES

Milkfish is known for its euryhaline nature, but there are no studies on salinity resilience during early life hours. An experimental trial was conducted to study the embryogenesis/early larval development of milkfish under different salinities (20, 25, 30, 35, 40 & 45 ppt). A maximum hatching rate of 81% was observed in 40 & 45 ppt salinity with deformities (36% of hatchlings). The lowest hatching rate of 26% was found in 20 ppt salinity along with maximum noticeable deformities (54% of hatchlings). Major deformity found to be curved spinal cord. The preferred salinity was 30-35 ppt with an average hatching rate of 75% without any noticeable deformities (Fig. 6). This baseline data on salinity tolerance during hatching will help to select the preferred salinity regime to be maintained for milkfish hatching to increase larval productivity in the hatchery.

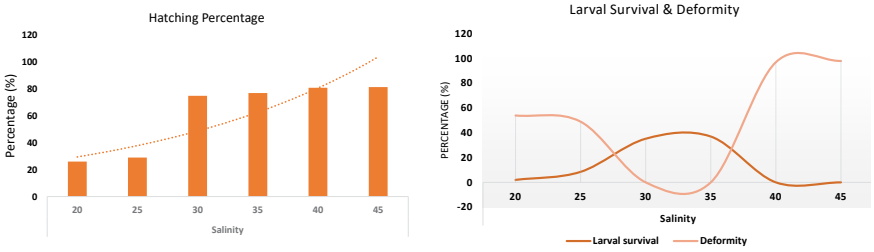


Fig. 6
Effect of salinities on hatching, larval survival and deformities

IMPACT OF RAINFALL PATTERN VARIABILITY ON CHANGES IN WATER QUALITY, IMMUNE PARAMETERS AND INCIDENCE OF WHITE SPOT SYNDROME VIRUS IN SHRIMP GROWING ENVIRONMENT

Three experiments were conducted by simulating the rainfall patterns variation using artificial rainwater, showers and water flow gauges, a) 50, 100, 150, 200 and 250 mm in 1-day; b) 50, 100, 200, 300 and 400 mm in 3-days; c) 50, 100, 200, 300 and 400 mm in 7-days (1-week). *P. vannamei* (6±0.2 g; n=12) were exposed to each rainfall variation to study the changes in water quality and immune parameters. After one day of each experiment, the animals were challenged with WSSV by oral administration. Water parameters (pH, salinity, nutrients, metabolites and minerals) showed a decreasing trend, animals were under stress as evidenced by changes in immune parameters (phenol oxidase and superoxide dismutase), and a gradual mortality was observed between 4 to 7 days in various treatments compared to 9-days in control (Fig. 7). This indicates the need for the implementation of BMPs immediately after heavy rains to reduce stress to shrimp.

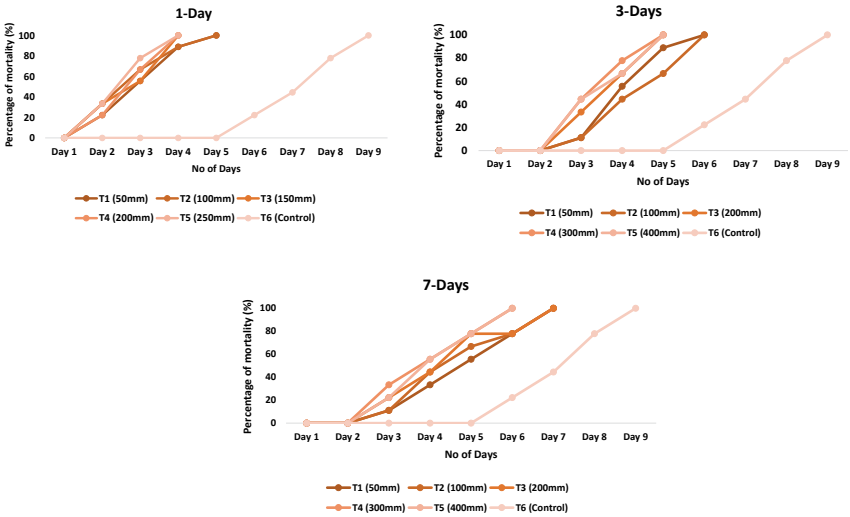


Fig. 7

Mortality of shrimp after exposure to heavy rainfall variations and challenge with WSSV

GROWTH CHARACTERISTICS OF *Penaeus vannamei* AND PENAEUS MONODON IN COMMERCIAL SHRIMP FARMS DURING HEAT WAVE PERIOD

Average daily growth rate (AGD-g/day), weekly weight gain, average body weight and feed consumption pattern of *Penaeus vannamei* and *P. monodon* were evaluated for 3 months (April-June) in commercial shrimp farms (n=10 each) located within the same region at Navsari, South Gujarat during the notified (IMD) heat wave conditions and normal temperature periods. The mean maximum air and pond water temperatures during heat wave and normal periods were 40.65±0.21°C and 34.62±0.3 °C, and 35.32±0.14°C and 32.20±0.15°C, respectively. The ADG of *P. vannamei* and *P. monodon* were significantly lower ($p<0.05$) during heatwave (0.189±0.01 and 0.24±0.02 g/day) as compared to normal temperature (0.247±0.02 and 0.35±0.03 g/day) periods (Fig. 8). The observations indicate that though high water temperature significantly influenced the growth of both species, could recover and demonstrate normal growth as conditions improved resulting in normal production. Prolonged heat wave conditions can however make shrimp susceptible to diseases.

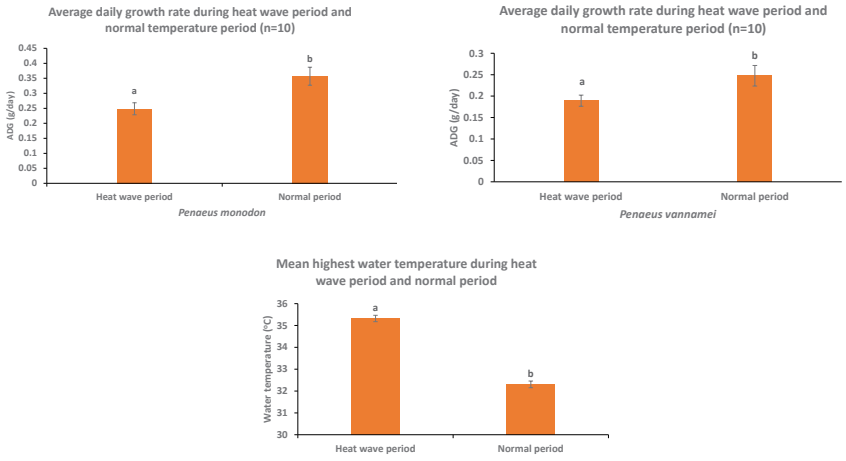


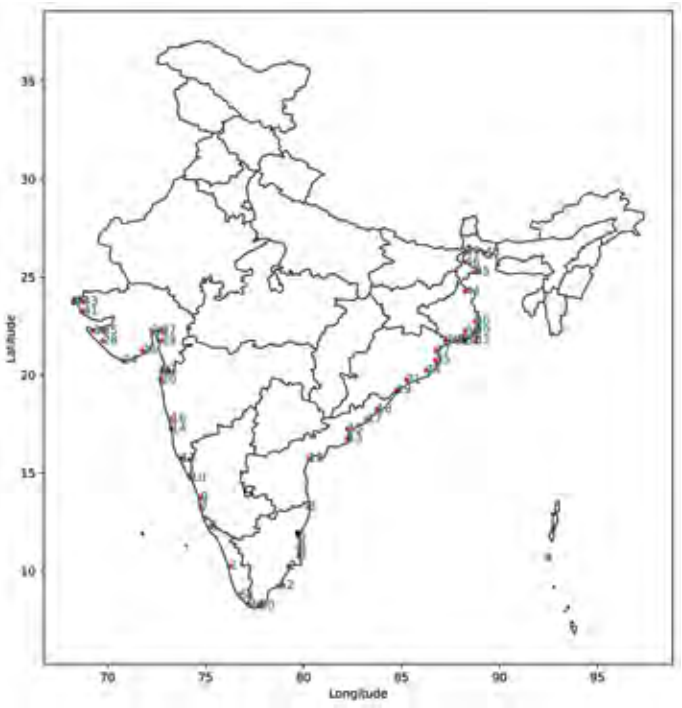
Fig. 8

Effect of heat wave on growth charateristics of *P. vannamei* and *P. monodon*

TRENDS IN SURFACE WEATHER PARAMETERS OF COASTAL INDIA AND IMPLICATIONS FOR BRACKISHWATER AQUACULTURE

A comprehensive analysis of weather data spanning 41 years (1969 to 2009) and covering 52 grid points across eight coastal states examined the trends in three key climatic variables: maximum temperature, minimum temperature, and rainfall by employing the Mann-Kendall trend test and Sen's slope estimator. The study identified significant rainfall trends at 20 locations, including 11 positive and 9 negative trends that were limited to Gujarat, Andhra Pradesh and West Bengal. Regarding maximum

temperature, significant trends were observed with 38 trends being positive and one trend being negative in West Bengal. Similarly, for minimum temperature, significant positive trends were observed for a total of 47 locations (Fig. 9). A generated heat map illustrated the spatial distribution of coastal grid mean values, complemented by future scenarios for 2020, 2050, and 2080 under RCP 4.5. These projections are useful in planning crop calendar activities such as pond preparation, species stocking and harvest.



Selected data points of fifty-two locations

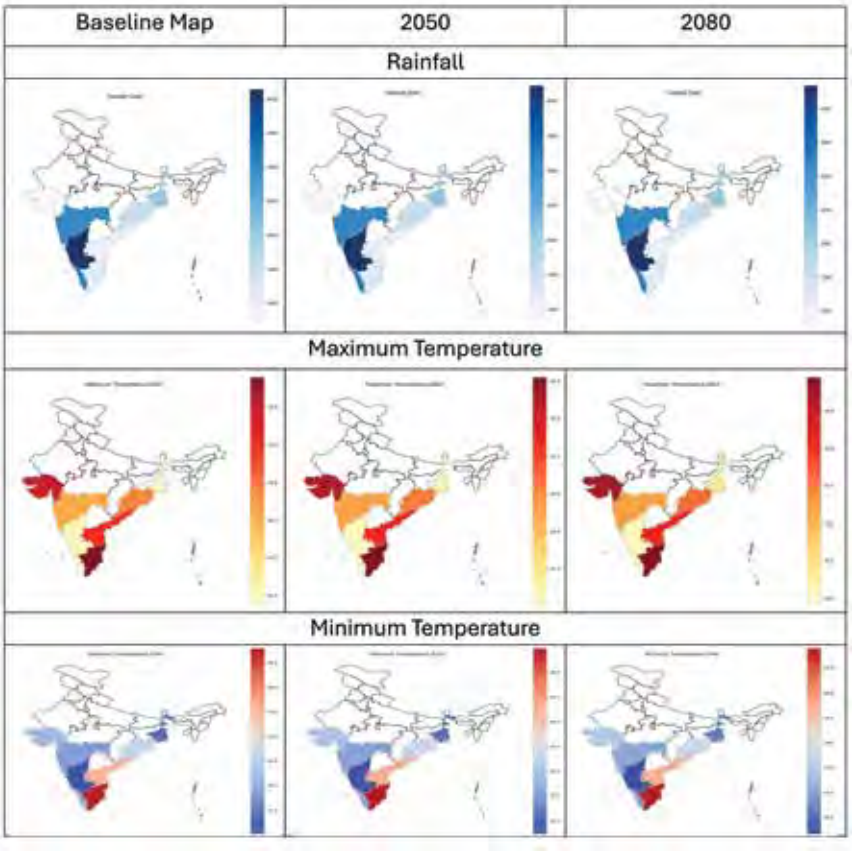


Fig. 9

Rainfall, Maximum and Minimum temperature spread for the baseline and predicted data points for the years 2050 and 2080

EVALUATING THE ENVIRONMENTAL FOOTPRINT OF SHRIMP PROCESSING THROUGH LIFE CYCLE ASSESSMENT APPROACH

Environmental hotspots in farmed shrimp processing were identified using the life cycle assessment (LCA) method, a valuable tool for assessing the environmental performance of any process/sector. The primary data on electricity consumption, machinery usage, lighting, air compression, cold storage facilities, and plastic and packaging materials was collected from a shrimp processing facility located at Damavaram, Nellore, Andhra Pradesh in South India (Fig. 10). The environmental impact categories assessed in this study are the standard LCA categories based on the Life Cycle Impact Assessment (LCIA). ReCiPe 2016 Midpoint (H) V.1.02, the latest and most advanced LCA techniques were used. The calculated emissions per ton of shrimp were 433 kg CO_2eq (global warming potential), 9.25e-5 kg CFC11eq (ozone depletion potential), 0.78 kg SO_2eq (terrestrial acidification potential), and 0.0705 kg PO4eq (freshwater eutrophication potential). Notably, energy use through electricity emerged as the primary contributor to global warming potential (Fig. 11).

Fig. 10

Flow chart of shrimp processing, system boundary for LCA analysis

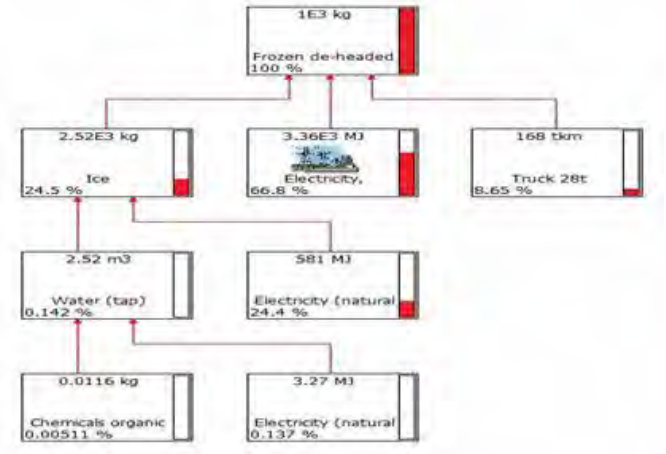


Fig. 11

Percentage contribution of each component during shrimp processing to the characterized impact value

ALTERNATE SCENARIOS TO DECREASE GLOBAL WARMING POTENTIAL (GWP) FROM SHRIMP PROCESSING PLANT

The conventional shrimp processing operations consume significant amounts of energy and resources. Various scenarios were explored to propose environmentally friendly improvements in shrimp processing, particularly concerning the energy mix. The study analyzed the potential benefits of installing photovoltaic panels in shrimp processing plants. The impact of shrimp processing with grid electricity was compared with the scenarios modeled with 50% and 100% photovoltaic coverage by LCA (Fig.12).

Results showed that the use of photovoltaic panels can significantly reduce shrimp processing impact on the analyzed environmental impact categories. The GWP was 339 kg CO_2eq with 50% PV and 222 kg CO_2eq with 100% PV compared to 433 kg CO_2eq under the typical conditions of complete grid electricity per ton of shrimp.

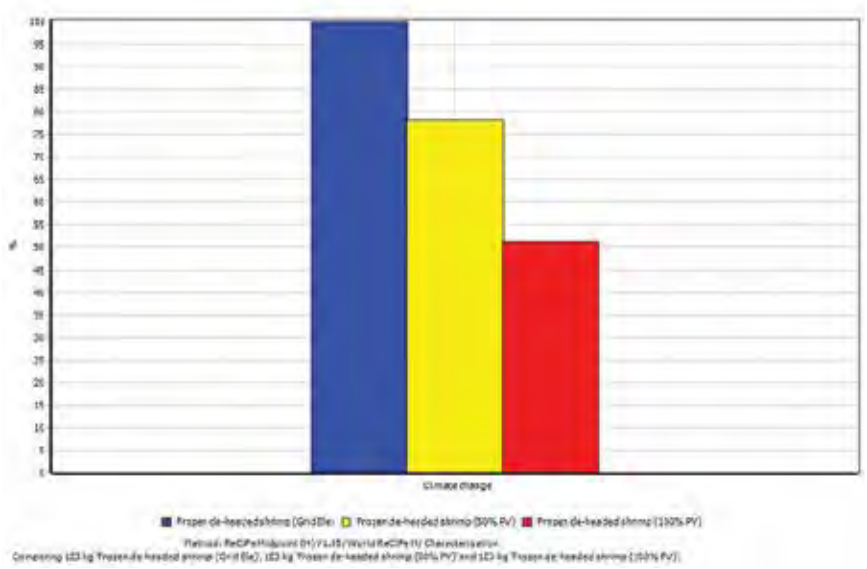


Fig. 12
Graphical representation of comparison of different scenarios of energy use for climate change during shrimp processing

ACTIVITY OF METHANE OXIDISING BACTERIA ISOLATED FROM DIFFERENT ENVIRONMENTS

Sediment samples were collected from open water sources such as barmouth, lagoon and estuary, and aquaculture ponds (shrimp/fish/crab) with salinity ranging between 0 to 38 ppt from Tamil Nadu, Andhra Pradesh, and West Bengal for the isolation of the methane oxidizing bacteria (MOB). Twenty-six bacterial strains have been isolated from the enrichments. The MOB count ranged between 4.301 to 6.333 log_{10} CFU/ml (Fig. 13). Further, the isolates were screened for the soluble methane monooxygenase activity which ranged from 0.05 to 0.70 nmol min^{-1} mg of $protein^{-1}$ (Fig. 14).

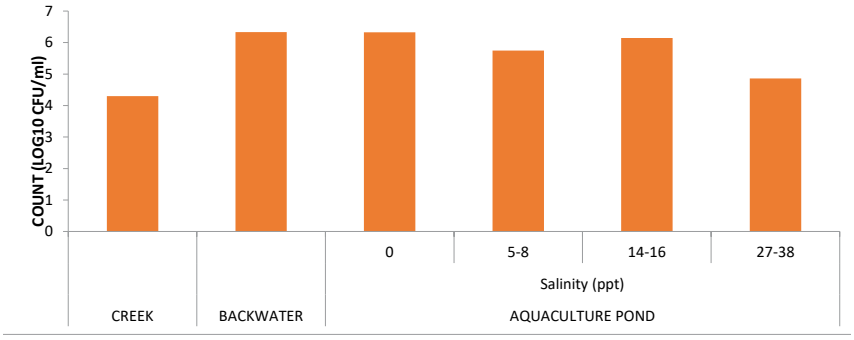


Fig. 13
Count of MOB isolated from varying environments

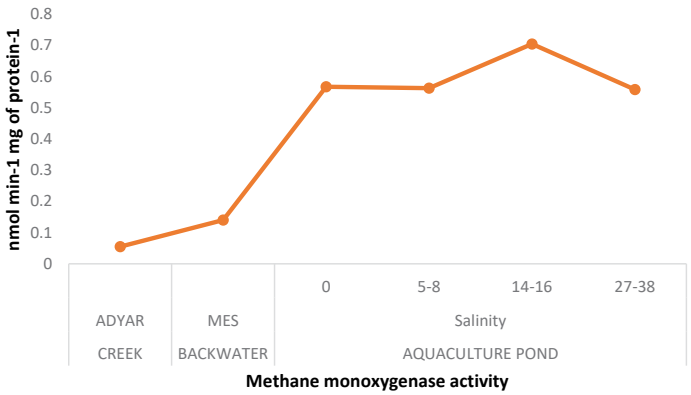


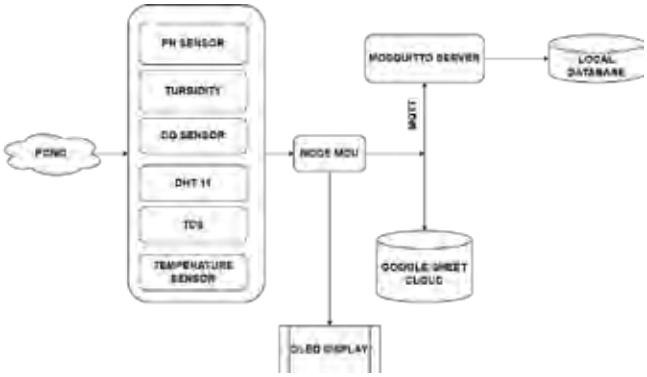
Fig. 14
Methane monooxygenase activity of MOB isolates

PRECISION BRACKISHWATER AQUACULTURE USING MACHINE INTELLIGENCE

CALIBRATION OF SENSORS AND DEPLOYMENT OF WATER BUOY WITH SENSOR MODULES TO TEST ITS EFFICIENCY

The commercially available pH, temperature, turbidity and TDS sensors were procured and calibrated with standards at different temperature and salinity levels with the help of machine learning algorithms. The turbidity sensors are infrared-based, which provides inaccurate results in real-time, hence reconfigured with the visible white light. The sensors were integrated and mounted with the PCB board specifically designed and interfaced with the battery and solar in an aqua buoy. The prototype aqua buoy was deployed in hatchery and culture systems to test the buoyancy and accuracy of sensors. The data collected from the aqua buoys is stored in a public IP server through the MQTT approach and compared with the manual measurement data. Deep learning support system methodology, architecture for water health classification (Fig. 15) and android-based application were developed which can alert the shrimp farmers on the water quality and provide specific advisories to the farmers in vernacular languages.

Aqua Buoys embedded with sensors



Water buoy working module and PCB board

Fig. 15

Test the efficiency of water buoy with sensor modules for water quality classification

Sphingobacterium sp. SDKRC- 13, A POTENTIAL ISOLATE FOR REDUCTION OF TAN AND NITRITE IN FISH AND SHRIMP REARING TANK SYSTEM

Experimental trials were conducted to study potential of *Sphingobacterium* sp. SDKRC-13, isolated from the root of the French bean (*Phaseolus vulgaris*), in reduction of total ammonia nitrogen (TAN) and nitrite nitrogen in *P. indicus* and *M. gulio* rearing tanks (100 L). *Sphingobacterium* sp. SDKRC-13 inoculam was added @ 8 × 10^7 CFU at 7 days interval in the shrimp and fish rearing tanks containing 80 L brackishwater (salinity around 6 ppt). In the case of *P. indicus*, each experimental tank housed 12 shrimps (ABW 4.4.g), whereas, during the experiment with *M. gulio*, each tank contained 10 fishes (ABW 11.6 g). Results indicated that addition of *Sphingobacterium* spp. reduced TAN level significantly ($p < 0.05$) in *P. indicus* rearing tanks after 35 days of rearing. The level of nitrite- nitrogen was also reduced with addition of this organism, although the reduction was not statistically significant ($p > 0.05$). On the other hand, the significant reduction was noticed for both TAN and nitrite nitrogen ($p < 0.05$) in rearing tanks of *M. gulio*. Results indicated that *Sphingobacterium* sp. SDKRC-13 can function as a good candidate in the formulation of water probiotics, which can lower the level of harmful gases like ammonia and nitrite.

PREPARATION AND CHARACTERIZATION OF NANOMINERALS

Low saline and inland saline water have mineral deficiency that affects the sustainability of shrimp culture. This problem can be effectively solved by applying minerals in nanoscale size, which enhances their assimilation by the shrimp.

To study the efficiency of nano minerals in shrimp culture, nano forms of calcium and phosphorus were prepared and characterized. Calcium was prepared in the form of calcium chloride (C_aCl_2) nanoparticle by ball milling method and Mono calcium phosphate (MCP) nanoparticles were synthesized by sol-gel method. The prepared nanoparticles were characterized using UV, XRD FTIR, Raman spectroscopy and SEM analysis. The XRD pattern of C_aCl_2 and MCP matched well with a standard pattern of JCPDS No. 01-072-2432 and 00-009-0347 confirming the tetragonal and triclinic crystal structure respectively (Fig. 16). UV-visible absorption spectrum showed peak at 205 nm and 211 nm, confirming the presence of calcium and MCP nanoparticle. The size of C_aCl_2 and MCP nano particles were 125 and 93 nm respectively. FTIR peaks at a specific range indicated the presence of functional groups in both the prepared nanominerals (Fig.17).

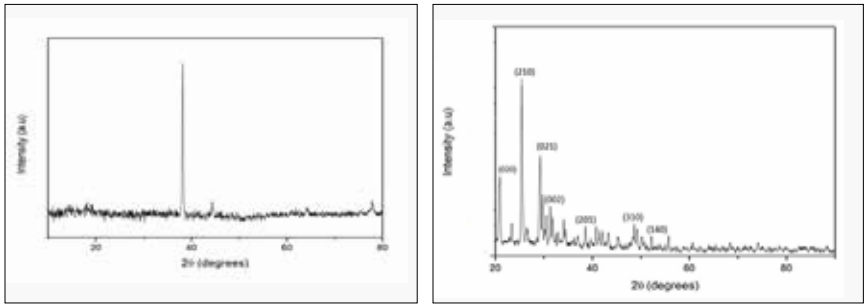


Fig. 16
XRD pattern of Calcium chloride and MCP nanoparticle

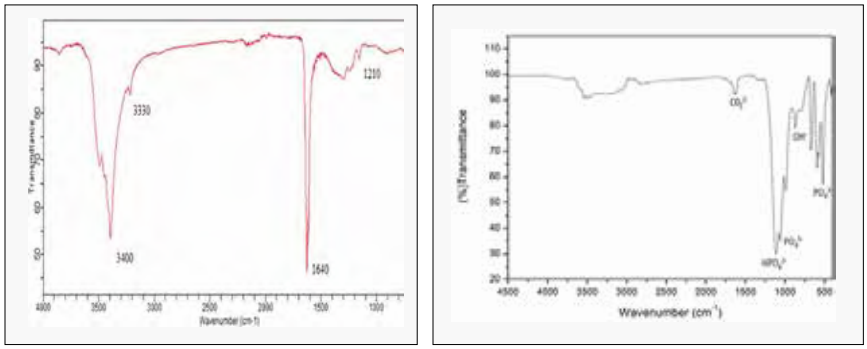


Fig. 17
Fig. 27. FTIR spectrum of C_aCl_2 and MCP nanoparticles

EVALUATION OF THE EFFICIENCY OF NANOMINERALS IN SHRIMP CULTURE

The analysis of prepared nanominerals showed that C_aCl_2 contains 35% calcium and MCP contains 27.7% calcium and 13.6% phosphorus. Nanomineral fortified feeds were prepared by replacing bulk form using 0 (control), 75 (T_1), 50 (T_2) and 25% (T_3). A yard experiment was carried out on *P. vannamei* to evaluate the efficiency of calcium and phosphorus nanominerals on shrimp, rearing with a density of 15 numbers (0.5-0.7gm weight) in 100 lit tanks for 45 days. Feed was applied based on the weight of animal (4-10%). The survival rate of the shrimp was good across the treatments. In the nano calcium experiment, animal weight increased 18.7% in T_2 compared to control followed by T_3 and T_1. Similarly, in the nano MCP experiment, animal weight increased 21.7% in T_2 followed by T_1 (Fig. 18). During the experiment, pH and total hardness were 7.7-7.9 and 6500-7667 ppm as C_aCO_3 respectively. Metabolites were within the permissible limit.

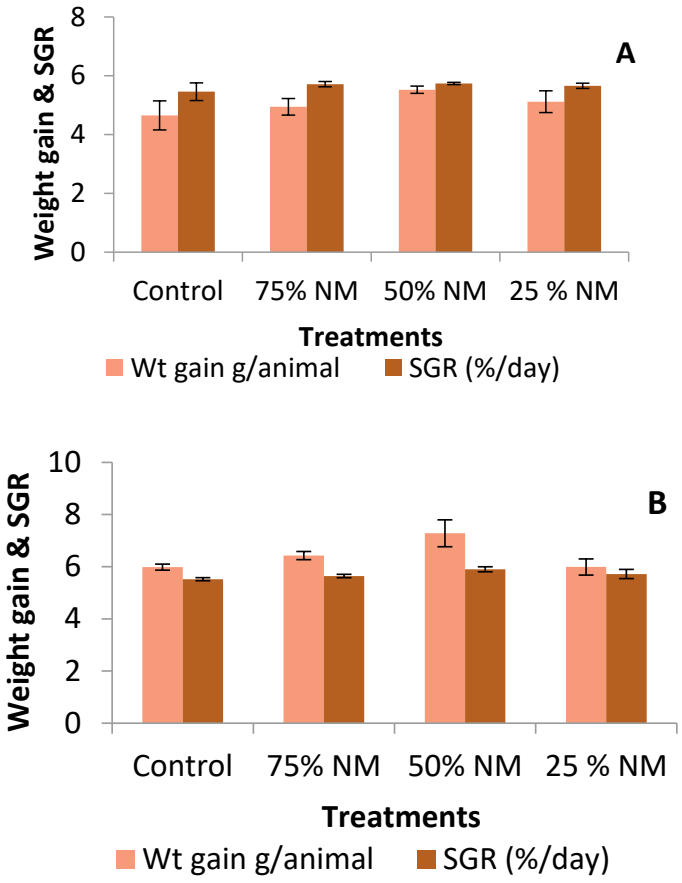
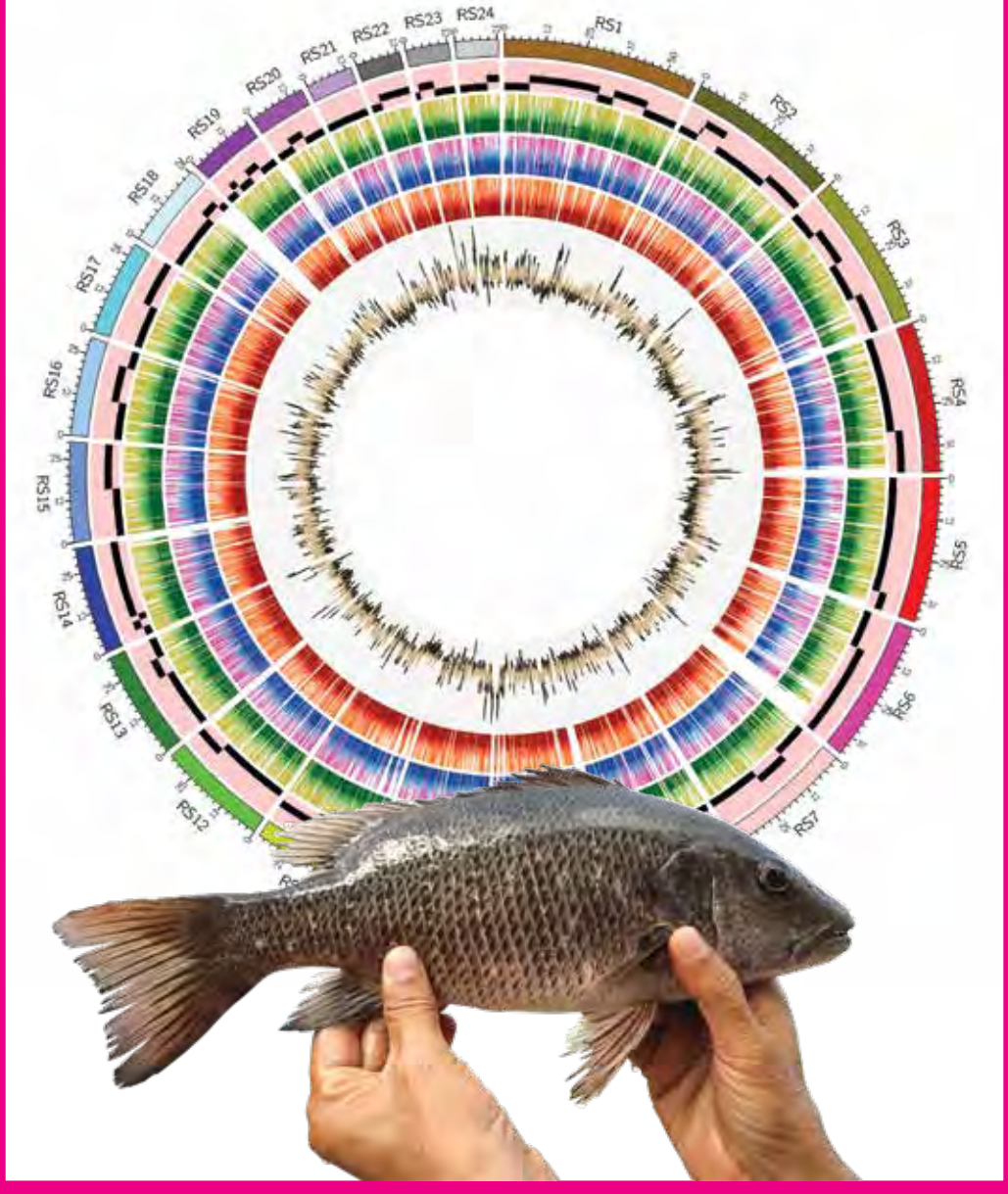


Fig. 18

Influence of calcium (A) and MCP (B) nanomineral on animal weight gain and SGR



GENETICS AND BIOTECHNOLOGY

GENOME ASSEMBLY AND FULL-LENGTH TRANSCRIPT RESOURCE FOR RED SNAPPER

A scaffold-level genome assembly was generated for *L. argentimaculatus* using PacBio Sequel II long reads and Arima Hi-C linked reads. The genome assembly is of 1.04 Gb comprising of 521 scaffolds with N50 of 32.5 Mb and the 24 longest scaffolds covered 73.8% (768 Mb) of the genome (Fig. 1). The genome was assessed to be 97.2% complete upon benchmarking with BUSCO Actinopterygyii_odb10 dataset and was predicted to contain 43.78% repetitive elements and 31,969 protein-encoding genes. The whole genome provides a new perspective for the genomics studies and have potential applications in the conservation, broodstock management and selective breeding programmes of *L. argentimaculatus*.

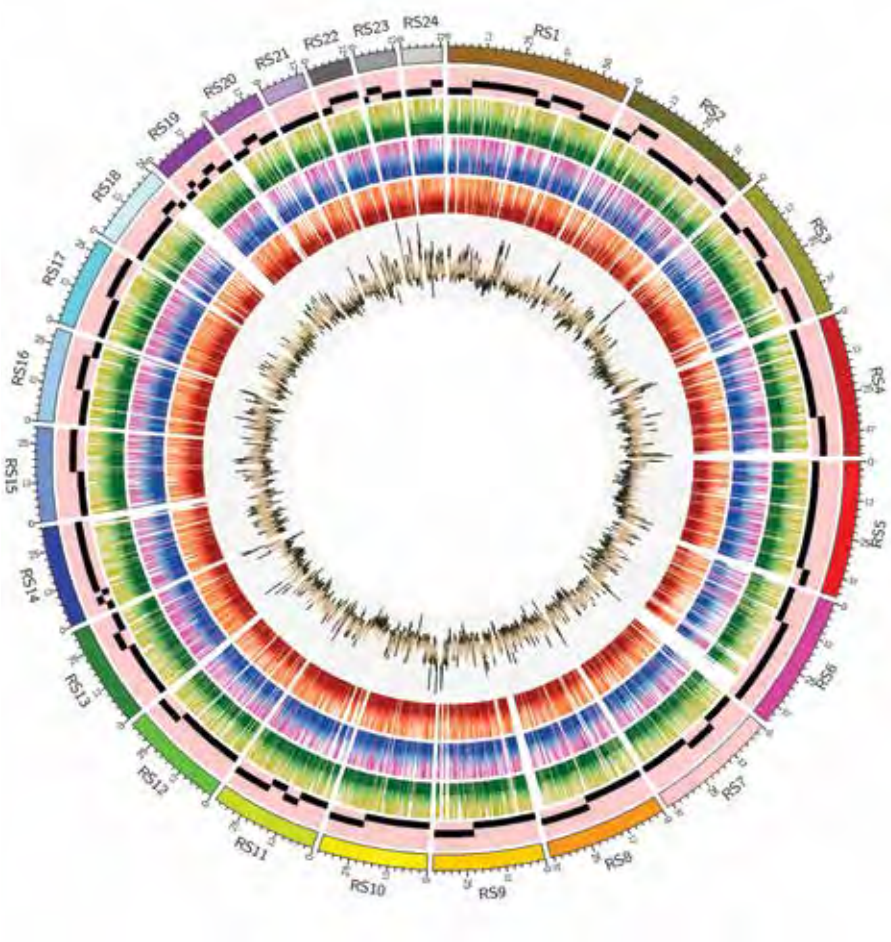


Fig. 1

Mangrove red snapper genome. From the outermost: Track1: 24 longest scaffolds of the genome assembly; Track2: Contigs corresponding to the scaffolds; Track3: Protein encoding genes plotted based on their length; Track4: Full length isoform sequences supporting the genes; Track5: RNAseq transcripts supporting the genes; Track6: GC content.

An isoform-level full-length transcriptome was generated for red snapper with Pacbio Iso-Sequencing strategy using six tissues (muscle, gills, liver, kidney, stomach, and gonad). The transcript resource contained 57,100 isoform-level transcripts belonging to 19,144 unique genes. About 45.84% of genes had only one isoform and about 14.14% genes had more than or equal to 6 isoforms. Higher proportion of genes with more isoforms indicated high degree of transcriptome complexity in red snapper fish. Further, 23,352 alternate splicing events were identified in 5,947 genes of which alternative first/last exon events were dominant (Fig. 2). The transcript resource is of value to understand tissue or development stage or treatment specific isoform level transcript expression in red snapper.

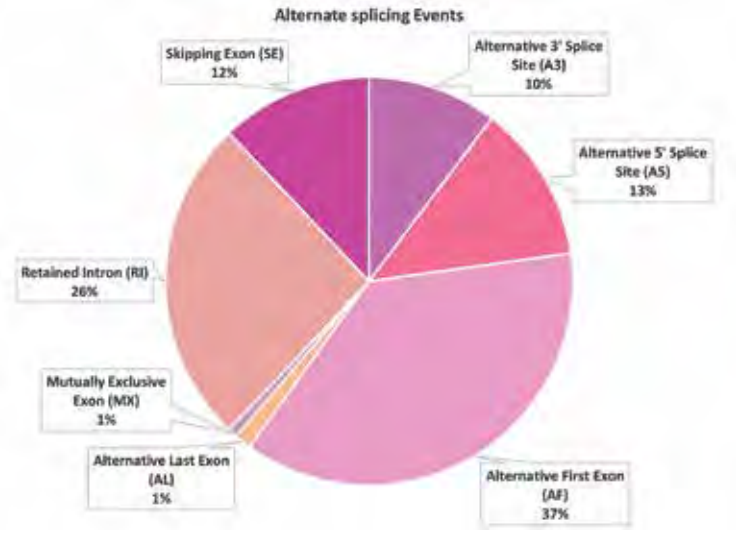


Fig. 2
Various alternative splicing events predicted for red snapper transcripts.

GENOME SEQUENCING OF BRACKISHWATER AQUACULTURE CANDIDATE SPECIES

With an objective to assemble and annotate the whole genome of candidate brackishwater aquaculture species and to develop genetic resources of high value for functional understanding brackishwater candidate aquaculture species, genome sequencing is envisioned in potential candidate brackishwater aquaculture species such as gold lined seabream (*Rhabdosargus sarba*),blacktip trevally (Caranx heberi), long whiskers catfish(*Mystus gulio*). The species confirmation was carried out using COI barcoding primers resulting in 690 bp amplification product. The genome size estimation was performed using BD Accuri™ C6 plus flow cytometer (BD Biosciences, USA), using propidium iodide which revealed genome size of 0.96 pg (*Rhabdosargus sarba*), 0.5 pg (*Caranx heberi*), 0.69 pg (*Mystus gulio*) (Fig 3). To foster the wider application of comprehensive, high-throughput genomics to decipher the whole genomes and to study functional pathways of brackishwater candidate species of commercial importance, analysis of high-throughput comprehensive data sets etc. in the area of genomics and bioinformatics is being utilized.

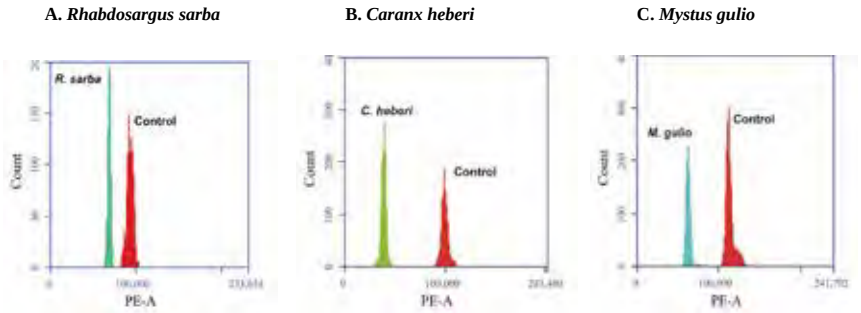


Fig. 3
Genome size estimation by flowcytometry in (A). *Rhabdosargus sarba* (0.96 pg) (B) *Caranx heberi* (0.5 pg) C. *Mystus gulio* (0.69 pg)

ISOFORM-LEVEL FULL-LENGTH TRANSCRIPT RESOURCE FOR PEARLSPOT

The specimens of six tissues (brain, gill, kidney, liver, muscle and spleen) from a single adult male fish and entire fish specimen at two developmental stages (1- and 15-day old larvae) were used for generating the tissue/stage-specific isoform-level full-length transcript resource for pearlspot (Table 1). High number of transcripts were recorded for 1-day old larvae (38,022) and low number for adult muscle tissue (16,137). The transcriptome completeness (Fig. 4) varied from 68.91% (1-day old larvae) to 41.23% (muscle). The transcript resource is of value to understand tissue or development stage specific isoform level transcript expression in pearlspot.

Tissue/stage	Full Length reads	No. of transcripts
Brain	435,876	31,753
Gills	424,522	32,670
Kidney	466,648	36,519
Liver	450,274	28,359
Muscle	347,609	16,137
Spleen	305,668	24,263
1-day old	504,380	38,022
15-day old	340,965	27,718

Table. 1

Statistics of Isosequencing data generated for various adult tissues and developmental stages of Pearlspot.

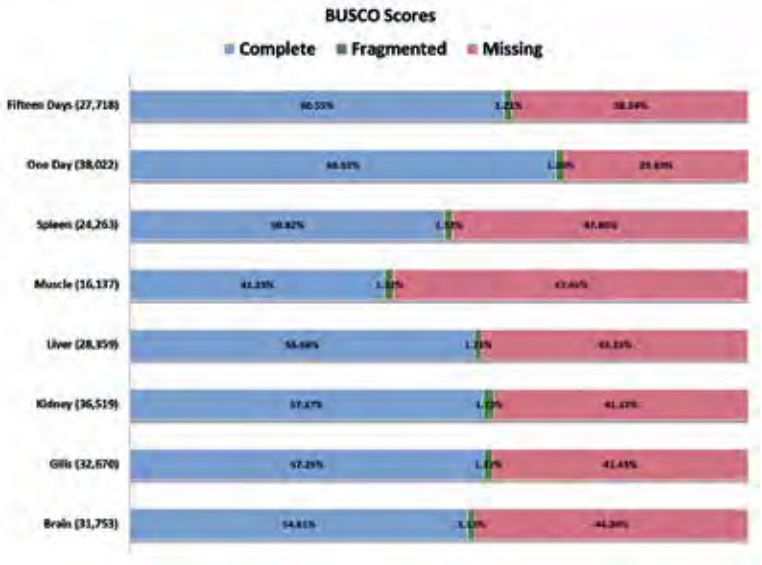


Fig. 4

Assessment of transcriptome completeness with BUSCO scores for adult tissues and development stages of pearlspot.

The isoform-level full-length transcript resource was compared with the genome assembly to identify the isoform categories and the alternative splicing events in samples of six tissues (brain, gill, kidney, liver, muscle and spleen) and two developmental stages (1- and 15-day old larvae) of pearlspot. About 35% of isoforms in all the samples are of *novel not in catalog* category with novel splicing sites (Fig. 5). Further, highest and lowest number of alternate splicing events were recorded for kidney and muscle tissues respectively. The retained intron is the predominant alternative splicing event observed in pearlspot transcripts (Fig. 6).

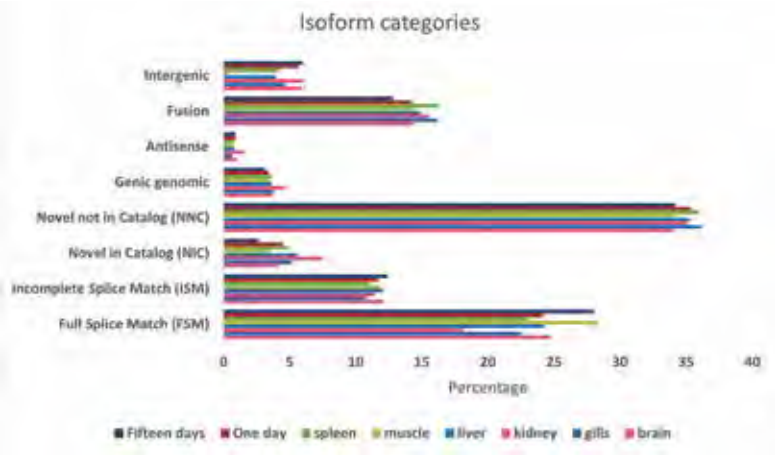


Fig. 5

Numbers of isoform categories documented for pearlspot transcripts in various tissues and development stages.

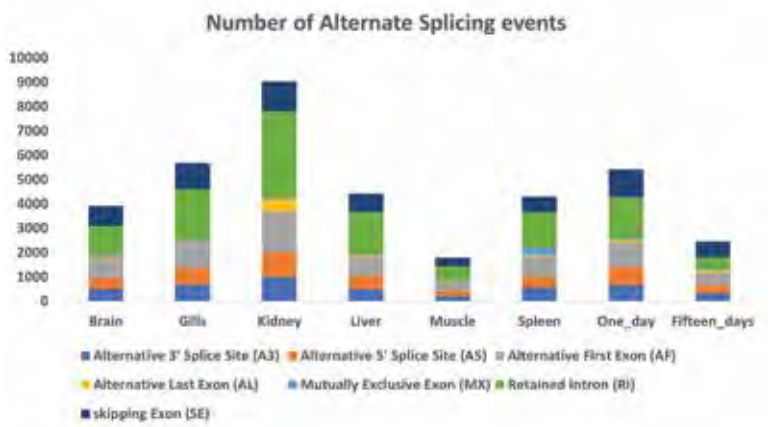


Fig. 6
Numbers of alternative splicing events documented for pearlspot transcripts in various tissues and development stages.

META-ANALYSIS TO UNRAVEL CORE TRANSCRIPTOMIC RESPONSES IN *Penaeus vannamei* EXPOSED TO BIOTIC AND ABIOTIC STRESSES

Study was conducted to identify the core transcriptomic responses in *Penaeus vannamei* exposed to various abiotic (Temperature, salinity, pH, Ammonia, Nitrite) and biotic stress conditions (*Vibrio*, white spot syndrome virus, Shrimp Hemocyte Iridescent Virus) and to decipher their functional importance. A total of 21 RNAseq datasets comprising twelve abiotic and nine biotic stress conditions were downloaded from NCBI. At first, read quality assessment was carried out using FastQC v.1.1.1 and Trimmomatic v0.39 (http://www.usadellab.org/cms/?page=trimmomatic) was used to remove adaptor sequences, ambiguous reads, and low-quality sequences (less than 22 phred score) from the raw data. Reference mapping tool STAR 2.7.9a was used to map Illumina high quality reads to the *P. vannamei* genome (ID: 10710; Assembly version: ASM378908v1). Differential expression analysis tool, edgeR v 3.38.1, was used to assess the differences in transcript accumulation among different stress conditions in *P. vannamei*. A common dispersion parameter of 0.3 was set for edgeR program. Differentially expressed genes (DEGs) were identified as transcripts with a p-adjusted < 0.05 and an absolute log2fold change threshold value set at 2. The R Bioconductor package, MetaVolcanoR v1.14.0 was used for combining the differentially expressed genes from different abiotic and biotic stress experiments. Here, the Meta-DEGs were generated based on p-values using Fisher method and combined fold change values of different studies by 'mean'. Meta-DEGs were annotated using OmicsBox software.

Through meta-analysis, 961 differentially expressed genes (meta-DEGs) for abiotic stress conditions and 517 meta-DEGs for biotic stress conditions were generated. A set of 19 genes were found to be upregulated in both abiotic and biotic stress conditions. Among these core genes, Tripartite motif-containing (TRIM) 32 gene, FAS1 domain-containing gene, Cuticle protein 19.8, Beta-N-acetylhexosaminidase, Putative iron-sulfur cluster assembly 1-like gene, Myosin heavy chain type 2, and Hemolymph Clottable Protein (CP) were found to be involved in stress response mechanisms. For abiotic stress, significant pathways associated with the stress response include tryptophan metabolism, starch and sucrose metabolism, fatty acid degradation, carbohydrate digestion and absorption, phenylalanine metabolism, drug metabolism - other enzymes, arachidonic acid metabolism, and fatty acid elongation. Similarly, for biotic stress, metabolism of xenobiotics by cytochrome P450, pentose and glucuronate interconversions, steroid hormone biosynthesis, and drug metabolism - cytochrome P450 were found to be significant pathway associations.

Potential stress-responsive regulatory elements were identified from meta-DEGs using motif discovery tool DREME. A total of 61 and 56 motifs were identified for abiotic and biotic stresses respectively. Gene ontology classification revealed 17 candidate motifs related to stress-response. For abiotic stress condition, annotations of down-regulated meta-DEGs include triplet codon-amino acid adaptor activity, heat shock-mediated polytene chromosome puffing, and chromatin assembly or disassembly. While, up-regulated meta-DEGs were associated with triplet codon-amino acid adaptor activity, translation, and gene silencing. Similarly, for biotic stress

condition, down-regulated meta-DEGs were associated with chromatin assembly or disassembly, DNA repair, and regulation of gene expression. While, up-regulated meta-DEGs were annotated as response to DNA damage stimulus, catalytic activity, and ATP binding (Fig 7). The metabolic pathways and regulatory motifs associated with abiotic and biotic stress factors identified through this study could be a valuable resource for developing stress management approaches in shrimp aquaculture.

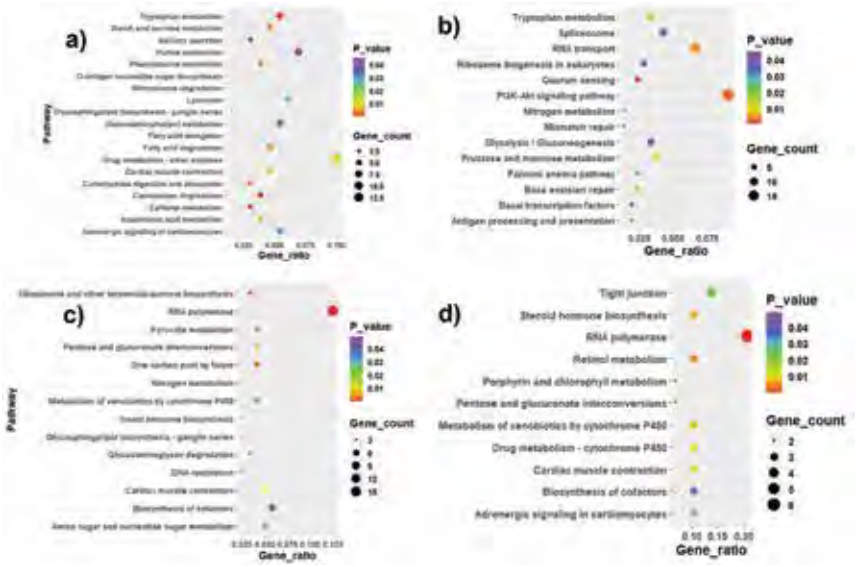


Fig. 7

Enriched KEGG pathways for a) up-regulated meta-DEGs in abiotic stress b) down-regulated meta-DEGs in abiotic stress c) up-regulated meta-DEGs in biotic stress d) down-regulated meta-DEGs in biotic stress.

CRISPR/CAS9 MEDIATED TARGETED MUTAGENESIS OF MYOSTATIN (MSTN) GENE IN ASIAN SEABASS

Myostatin (mstn), a key negative regulator of skeletal muscle growth, has been targeted to increase muscle growth in several teleosts. *Lates calcarifer* (Asian seabass) is an economically important brackishwater protandrous fish with standardized hatchery production technology. Differential growth is one of the major factors affecting the sustainable production of *L. calcarifer*. CRISPR/ Cas 9 mediated mutagenesis of myostatin (mstn) can promote growth and shorten culture duration of the species. In an attempt to knockout myostatin in Asian seabass, single guide RNA (sgRNA) targeting the mstn-exon 1 region was synthesized and PCR amplified to yield a product of 120 bp on a 2% agarose gel (Fig 8a). The PCR product was transcribed in vitro and purified. Using specific primers, a 1450-bp fragment of the mstn-exon1 genomic region was amplified, and subjected to sgRNA-directed Cas-9 mediated cleavage in a reaction containing recombinant Cas9 (rCas9) protein. The cutting efficiency of sgRNA was validated using a mutation detection kit. The designed sgRNA cleaved the amplified product, yielding two bands compared to the control, indicating its efficacy (Fig 8b). The synthesized sgRNA will be used to edit the myostatin gene using microinjection to develop eggs.

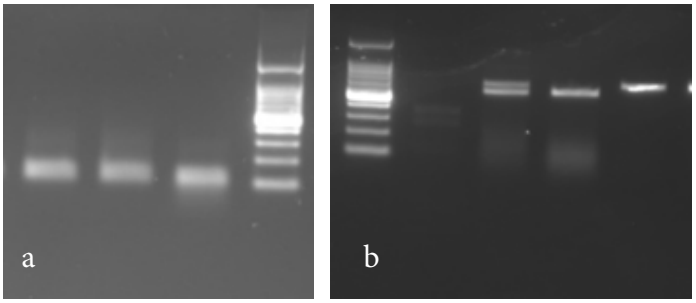


Fig. 8

a) Synthesis of single-guide RNA using in vitro transcription. Lane1-3: sgRNA (120bp) ; Lane 4-Marker (100bp)

b) Representative gel image showing CRISPR/Cas9 induced cleavage of mstn gene in Asian seabass. Lane 1: Marker (100bp); Lane 2: Positive Control; Lane 3: Cleaved fragments of target gene (mstn)

SOCIAL SCIENCES AND DEVELOPMENT

APPRAISAL OF ENERGY USE PATTERN, OPTIMAL ENERGY USE SCENARIO AND PREDICATION OF SHRIMP PRODUCTION USING AI TECHNIQUES

A study was carried out to analyse the energy use pattern in shrimp production for optimising energy use scenario and predication of shrimp production using AI techniques. Primary data were collected from 30 randomly chosen shrimp farmers in Navsari district, Gujarat. The distribution of total energy equivalent associated with the inputs in shrimp farming is given in Table 1. The quantities of inputs/ha used and output/ha obtained in shrimp farming are: a total of 2321.46 man hour of labour, 137.51 L of diesel, 14244.88 Kwh of electricity, 506 kg Yr of pump, 9333.33 kg Yr of tractor, 3600 kg Yr of leveller, 908.33 kg Yr of motor, 1458.33 kg Yr of aerator, 226.31 kg of mineral and vitamins, 3316.09 kg of disinfectants /probiotics/ environmental modifiers, 0.43 kg of seed, 10176.33 kg of feed and 15194.77 m3 of water. The total energy input used per ha for shrimp farming was 924028.72 MJ. The seed and disinfectants/probiotics/ environmental modifiers contributed for the minimum and maximum energy inputs of 23.91 MJ/ha and 397931.20 MJ/ha respectively representing 0.003% and 43.06% respectively of the total energy used per hectare. This may be because the energy equivalents for the disinfectants / probiotics/ environmental modifiers are higher than the other inputs. Feed and electricity also contributed 20.26% and 18.39% of the total energy input used per hectare for shrimp production.

Variables (Unit)	Percentage (%)
Inputs	
Human labour (Man hour)	0.49
Diesel (L)	0.84
Electricity (Kwh)	18.39
Machinery	
Pump (Kg Yr)	0.33
Tractor (Kg Yr)	9.09
Leveler (Kg Yr)	3.51
Motor (Kg Yr)	0.88
Aerator (Kg/Yr)	1.42
Mineral and vitamin (Kg)	0.04
Disinfectants / Probiotics/ Environmental modifiers (Kg)	43.06
Seed (Kg)	0.003
Feed	
Starter (Kg)	1.93
Pre grow out (Kg)	5.44
Grow out (Kg)	12.89
Water (m^3)	1.68
Total energy input (MJ/ha)	100.00

Table. 1
Energy use pattern in shrimp production per ha

The energy use efficiency (return on energy invested) was 0.29 indicting an inefficient use of energy in shrimp production. The average energy productivity is 0.005 Kg/MJ. This means that 0.005 units output is obtained per unit energy used. The net energy is negative (-652060.27MJ) which indicted that energy is being lost. The total consumed energy input could be classified as direct energy (21.40%) and indirect energy (78.60%) or renewable energy (22.44%) and non-renewable energy (77.56%). It was revealed that shrimp production was dependent fairly on non-renewable energy.

TECHNICAL EFFICIENCY OF ASIAN SEABASS PRODUCTION IN POND AND CAGES

The economic and technical efficiency of Asian seabass production systems were estimated. The data on cost and returns, production parameters and socio-economic characteristics were collected from major seabass-producing states viz., Tamil Nadu (TN), Andhra Pradesh (AP) and West Bengal (WB) on the east coast, Kerala (KL) and Karnataka (KA) on the west coast. Subsequently, nursery (n=60), pre-grow-out (n=20), grow-out pond (n=287) and cage (n=329) systems were designated as strata and simple random sampling was used to select farms within each stratum (Fig 1). The average productivity (Kg ha^{-1} yr^{-1}) in different farming stages was 2,566 (61,073 numbers) in the nursery, 2,111(19,449 numbers) in pre-grow out and 4,263 to 13,677 in grow-out ponds and 14 to 27kg/m^{-3} in grow out cages. The seabass culture models practised using hatchery-produced seed were significantly more productive and profitable, albeit requiring higher capital investments, operating expenses, and skilled personnel. The observed positive return on investment (nursery 54.09%, pond 70-88%, cage 28-78%), BC ratio (nursery 1.54, pond 1.69-1.87,cage 1.28-1.78) and internal rate of returns (nursery 51%, pond 67-90%, cage 50-80%) indicated the economic viability of seabass farming.

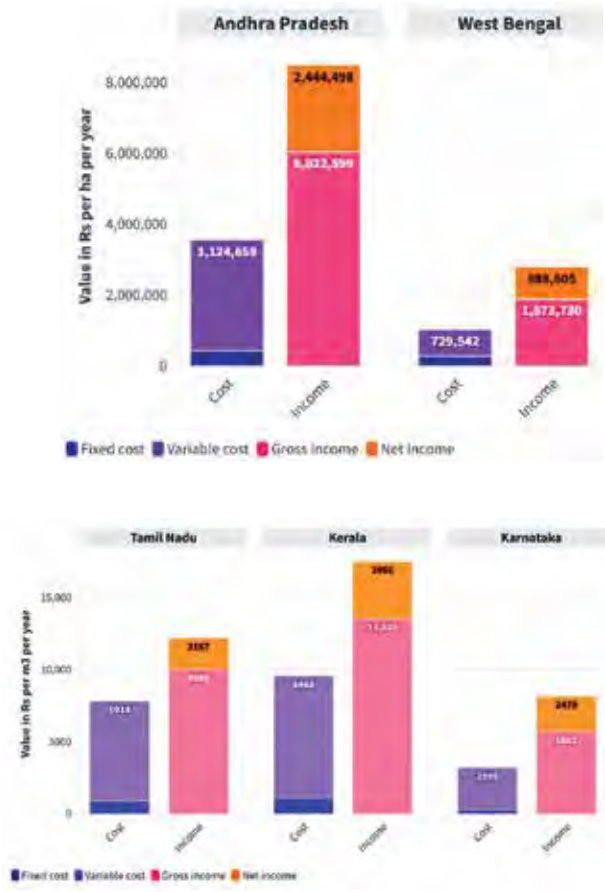


Fig. 1
Economic analyses of Seabass farming in different states

The technical efficiency analysis through stochastic frontier production function revealed the significant influence ($P<0.05$) of duration, stocking density/weight, survival and average body weight (ABW) at harvest on production, resulting in higher mean technical efficiency (cage 82.08%, pond 80.93%) (Fig. 2). The major constraints identified were the cost and availability of quality seed and feed, lack of institutional credit and insurance. Across all farming models, feed and seed were the major recurring costs. However, location-specific factors like productivity, input costs and market prices contribute to difference in profitability variations between the states. Optimizing feed, improving survival and adopting appropriate farm size could positively impact the returns. Overall, the results validate seabass aquaculture as a profitable livelihood avenue under optimal management.

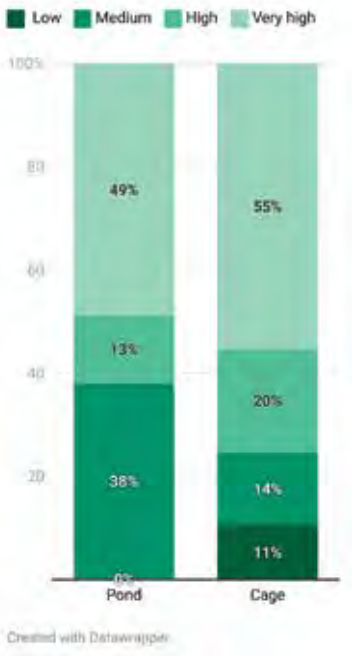


Fig. 2

Proportion of farms under various technical efficiency categories per m^3 per year

EXPORT PERFORMANCE OF INDIAN SHRIMP EXPORTS

Indian shrimp exports during 2022-23 was 7.11 lakh tonnes valued at Rs. 43,135 Crores (USD 5.48 billion) with a share of 40.98% in quantity and 67.4% in value of seafood exports. Indian shrimp exports declined by 5.9 per cent in dollar value and 2.3 per cent in quantity compared to 2021-22 (Fig-3). Compound growth rate (CGR) of shrimp exports is estimated at 10% during 2013-14 to 2022-23. The USA imported 38.8% in terms of quantity of shrimp followed by China (20.5%), European Union (13.4%), South East Asia (9.2%) and Japan (5.76%). The exports to USA declined by 19.5% compared to last year which was mainly due to competition from Ecuador whereas Indian shrimp exports to other countries have been increased (Table-3).

Countries	Exports quantity (tonnes)		Growth%
	2021-22	2022-23	
USA	342572	275662	-19.53
EU	90549	95377	5.33
South East Asia	44683	65466	46.51
Japan	38492	40975	6.45
China	125667	145743	15.98
Total exports	728123	711099	-2.34
Exports value (Million US $)	5828	5480	-5.97

Table. 3

Growth of Indian shrimp exports in 2022-23

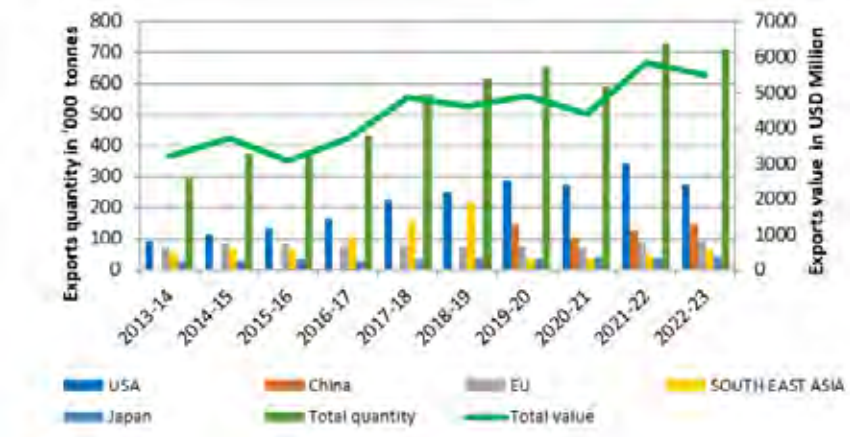


Fig. 3

Export performance of Indian shrimp

PROMOTION OF FISH FARMER PRODUCER ORGANIZATIONS (FFPO) IN SHRIMP FARMING SECTOR

Fish Farmer Producer Organization (FFPO) is increasingly seen as a game changer and promoted as a means for empowering the farmers and sectoral transformation in agriculture and allied sector. However, contrary to the expectations its adoption in shrimp farming sector is low albeit it is better fit to have more number of FFPOs. A survey conducted among the stakeholders (n=176) indicated that their awareness level on FPO scheme and its provisions was low (22%) (Fig. 4). The mean awareness levels of Fishery Extension Officials, shrimp farmers and research/academicians were respectively 26, 11 and 37% in the order research/academicians>FEOs>Farmers. Case studies of FFPOs functioning in fisheries sector revealed that they were in their nascent phases but have the potential to enhance the farmers' bargaining power and increase their economic returns. Further, SWOC analysis (strengths, weaknesses, opportunities and challenges) of FFPO vis-à-vis shrimp farming revealed that lack of institutional support to the sector, low financial incentives of the scheme, lack of direct involvement of key agencies and minimum 100 farmers per FFPO are some of the challenges in adopting the FFPO model in shrimp farming sector (Table 4). Sensitizing the progressive shrimp farmers by arranging exposure visits to successful FPOs in agriculture and allied sector, direct involvement of DoF/MPEDA in FFPO implementation, flexibility on size of FFPO membership, making the norms/guidelines for small and marginal farmers may be made as an optional rather than a mandatory provision for availing benefits for the FFPO, enhancing the financial incentives of FFPO scheme and engaging the existing informal farmers association/arrangement as CBBOs in place of a NGO are the measures suggested to promote FFPOs in shrimp farming sector.

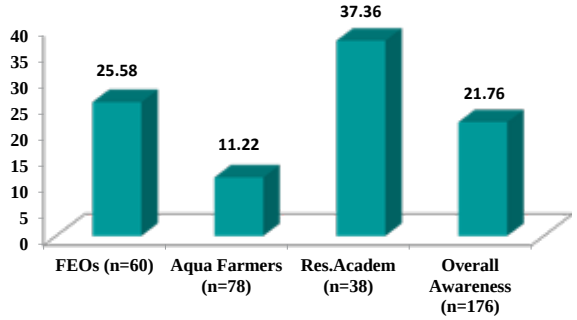


Fig. 4
Awareness levels of stakeholders on FFPO scheme

	Strengths	Weaknesses
Internal	1. Amenable for high-tech solutions/technologies 2. Most of the records and data pertaining to farms are readily available. 3. Members are entrepreneurial and informed. 4. Already shrimp farming is in business mode. 5. A collective institutional arrangement is functioning in many clusters as a formal or informal association.	1. The small and marginal farmer classification as that of agriculture may not fit in shrimp farming sector. 2. Too many leaders/hegemonic attitude of big farmers. 3. Lack of cooperation/unwillingness/trust among the farmers. 4. High risks in production and marketing. 5. High investments so expecting quick returns.
	Opportunities	**Challenges**
External	1. Economic efficiency through collective procurement of inputs and marketing of produce as a group/company. 2. Access to other schemes as FPO - scope for es tablishing feed mill, storage cum processing facility / common infrastructure etc. 3. Scope for domestic marketing with a brand – (60% for export and 40% partial harvested shrimps for domestic market). 4. Convergence of other programmes- all the line departments can channelize their programmes through FFPOs	1. Lack of institutional support to shrimp farming. 2. Financial incentives of the scheme are too low for shrimp farming. 3. Lack of direct involvement of agencies like MPEDA/DoF in FPO scheme. CBBOs/NGOs unfavourable attitude towards shrimp farming. 4. Size of FFPO-Bringing 100 farmers to form a FPO is unrealistic for shrimp farming. 5. All farmers are not small farmers as per the FFPO guidelines.

TECHNO-ECONOMIC EVALUATION OF ON-FARM SHRIMP NURSERY

Adoption of on-farm nursery facilitates the farmers in ensuring quality shrimp seed, reduced the energy cost and minimised the culture duration days due to compensatory growth potentials and paved the way for more than two crops in a year. A comparative study was conducted among the shrimp farmers who had on-farm nursery (n=33) with direct stocking farms. Though in both systems the seed had grown with an Average Daily Growth (ADG) 0.01g for first 30-35 days, but subsequently the nursery stunted seed had a faster growth rate with an ADG of 0.4-0.5 g, whereas the direct stocked shrimp grown with an ADG 0.2-.0.3g during the same period. The nursery grown seed attained a weight of 25 g in 100 days and 30 g in 110 days thereby had a count difference which fetched them higher price compared with direct stocked shrimp (Fig-5). The nursery adopted farmer had three crops in a year and planned his crops in tune with market scenario. Adoption of nursery ensured the supply of quality seed for the grow-out, minimised the disease risks and increases the productivity per ha/year. Similarly, nursery also helped in reducing the feed wastage, manpower and energy cost for the initial 30 days (Fig-6). Therefore, on-farm nursery should be part of the package of practices of shrimp farming and farmers need to be motivated to adopt the same.

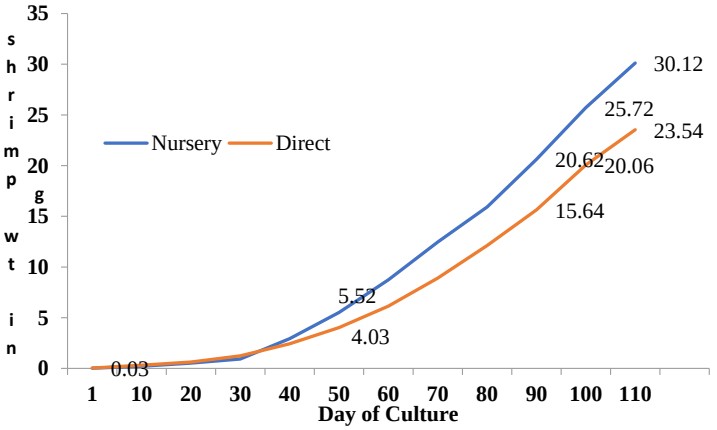


Fig. 5
Shrimp growth rate with and without on-farm nursery (n=33)

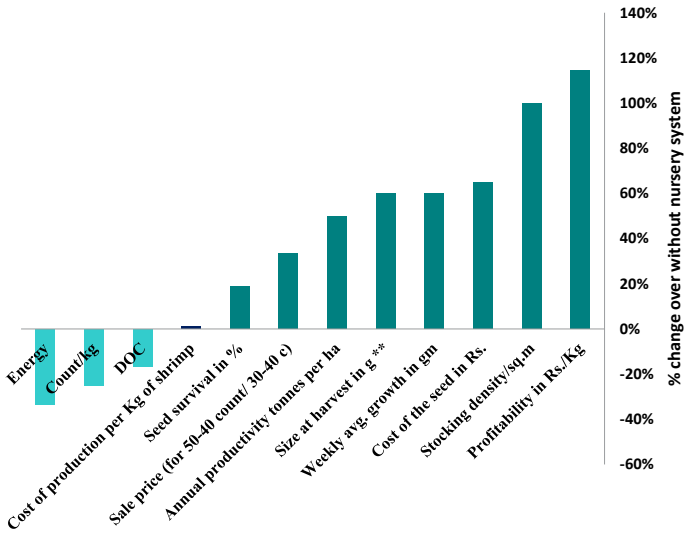


Fig. 6
Percentage change in key parameters with nursery system

EFFECTIVENESS OF SKILL DEVELOPMENT ON IMTA TECHNOLOGY ADOPTION

Skill development programmes were conducted through capacity development and demonstration of Integrated Multi-trophic Aquaculture (IMTA) as part of DBT funded project comprised of cage culture Seabass fish farming (*Lates calcarifer*), seaweed culture (*Kappaphycus alvarezii*) (*Gracillaria salicornia*), mussel culture (*Perna viridis*), clam culture (*Meretrix meretrix*) and ornamental fish culture (*Etroplus suratensis*). An evaluation conducted among the beneficiaries in Karankadu and Regunathapuram villages, Ramanathapuram district, Tamil Nadu, revealed that 50% of them perceived that

they acquired moderate level of knowledge and skills in establishing and managing the IMTA production system (Fig. 7). However, despite their increased knowledge and skills, only a minority expressed readiness to venture into new enterprises which is due to the high risk associated in terms of investment and skill involved in new enterprises. Therefore, financial assistance and handholding are required for them in continuing the established aquaculture production systems.

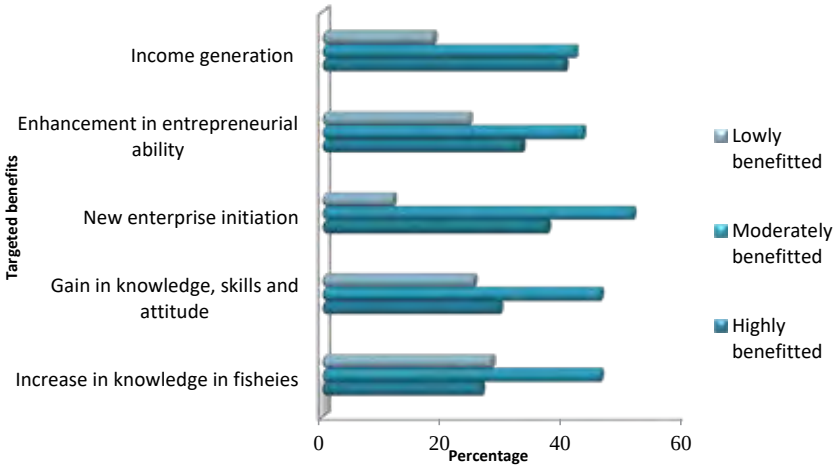


Fig. 7
Effectiveness of skill development on adoption of IMTA technology

TECHNO-ECONOMIC ANALYSIS OF IMTA TECHNOLOGY

In the Integrated Multi-Trophic Aquaculture (IMTA) pilot model demonstrated for the livelihood development of fisher families, seabass fish farming occupied the forefront as the primary crop, while seaweed and mussels served as supplementary crops. The profitability of Seabass outperformed that of seaweed and mussels. However, acquiring seed and feed for seabass incurred higher expenditure, whereas for seaweed and mussels, the expenditure was limited to seed alone. The waste generated by seabass served as a nutrient for seaweed and mussels thereby the IMTA system is observed to be environmentally sound.

The costs and profits associated with IMTA are given in Fig-. In IMTA system one culture of Seabass, three cultures of seaweed and one culture for mussel was done. The fixed cost incurred in each system was equally shared among the cycles of crops: seabass culture (10 cycles), seaweed raft culture (10 cycles) and mussel raft (10 cycles). In the IMTA model, feed cost emerged as a major expenditure, accounted for 37% of the overall cost and in case of seabass culture it was 56% (Fig. 7). Fingerlings accounted for 45%in IMTA, 89% in mussel culture, and 64% in seaweed culture. Seaweed seedlings were procured from nearby farmers for the first crop and the subsequent crops acquired seedlings from the previous culture.

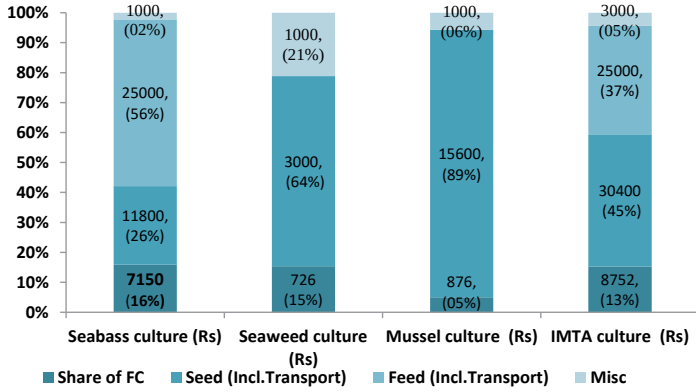


Fig. 8
Cost components of IMTA model

In the IMTA model both mussel and seaweed culture positively supported the seabass culture, presented potential environmental benefits. The beneficiaries with two hours of daily work earned their income and the model was found to be economically viable.

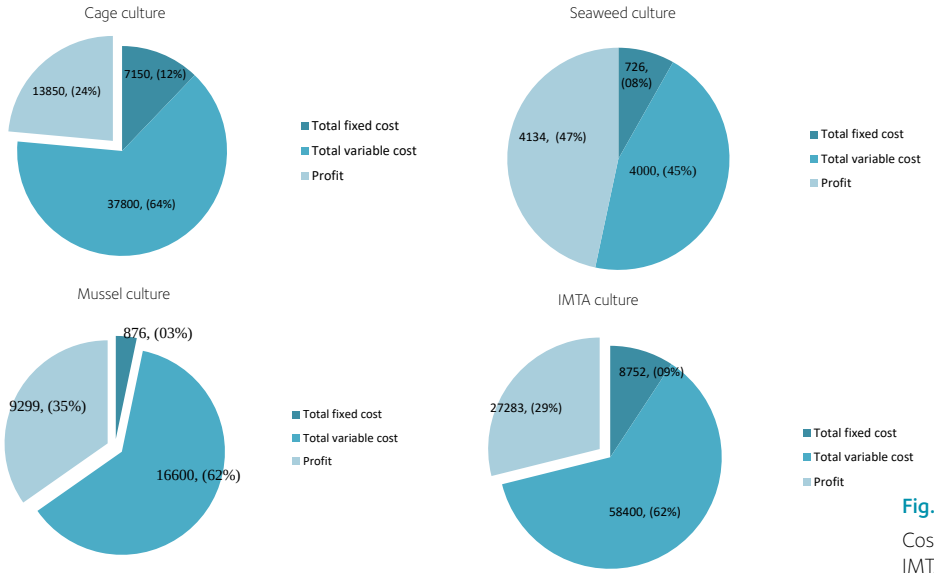


Fig. 9
Costs and profit of IMTA components

ORNAMENTAL FISH REARING IN RECIRCULATORY AQUACULTURE SYSTEM

Ornamental fish rearing in re-circulatory aquaculture system was demonstrated as livelihood development model for the youth. The cost and profit analysis indicated that the system yielded a profit of 24% (Fig.10) with a substantial contribution from variable costs, particularly seed, feed and miscellaneous constituting 40%. This underscores the efficiency and profitability of re-circulatory aquaculture technology.

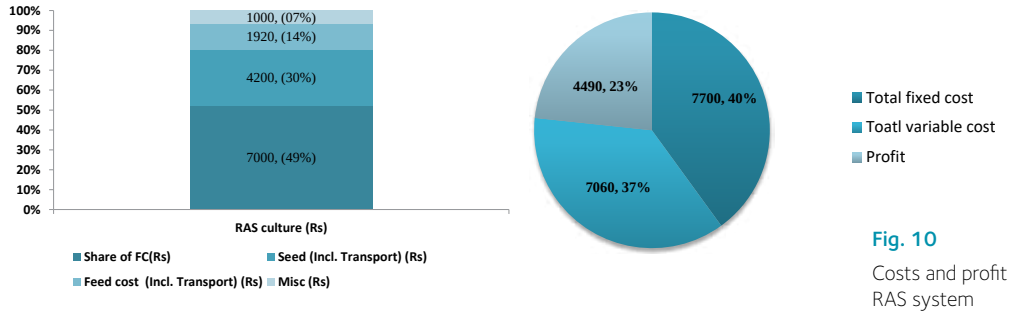


Fig. 10
Costs and profit of RAS system

FISHERS' PERCEPTION ON FISH WASTE-TO-WEALTH TECHNOLOGY OF CIBA

A study was undertaken in Ramanathapuram district of Tamil Nadu to analyse the fishers' perception on fish waste to value added products production technology. The fishers strongly agreed that the fish waste to value added product production technology has the potential in cleaning the fish markets across the country, minimizing the environmental problems generated by high amount of fish waste and as an alternative livelihood activity for the fishers in their village. They also agreed that the Plankton^{Plus}, and Horti^{Plus} are useful in commercial aquaculture and agriculture. The respondents ranked identification of location as the major challenge for establishment of fish waste to value added products production unit with a rank based quotient of 85.83 followed by the marketing linkages (84.38) and unity among the farmers (81.88). Establishment of fish waste to value added products production unit in the fish markets or landing centre (rank based quotient of 89.58) and creating of market linkages through offline and online (85.00) and Govt. subsidy to buy the inputs including machine and its accessories (81.67) were suggested for establishment of production unit (Fig.11).

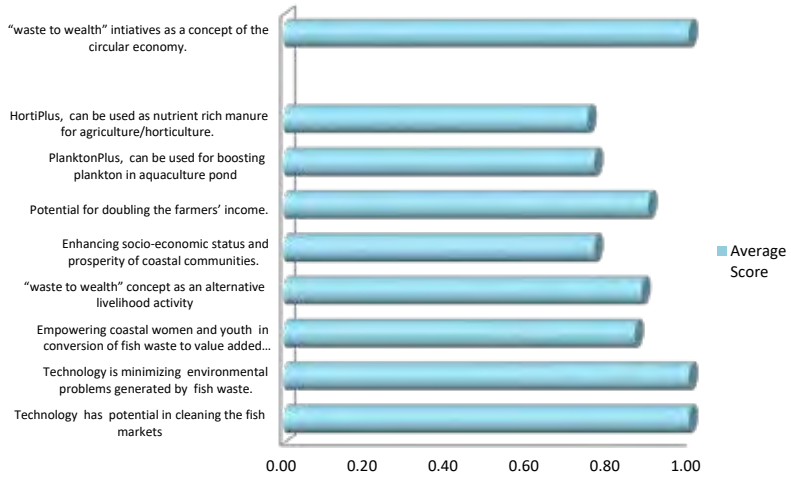


Fig. 11

Farmers' perception on fish waste to value added products production technology

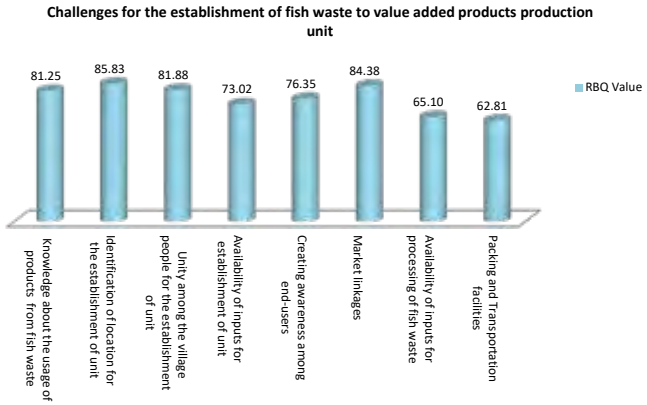


Fig. 12

Challenges in establishment of fish waste to value added products production unit

DEVELOPMENT OF AI BASED CONTINUOUS MONITORING SYSTEM IN AQUACULTURE

AI based continuous monitoring system (Fig.13) was designed for indoor aquaculture with pH, temperature, DO, and salinity sensors. The pH, temperature, DO, and salinity sensors were integrated with Raspberry Pi. Python and MySql programmes used for data acquisition from sensors and development of desk-top and mobile based application. Development of interactive module, installation of the system and monitoring of the parameters in the farmers pond have to be carried out to standardize the system.

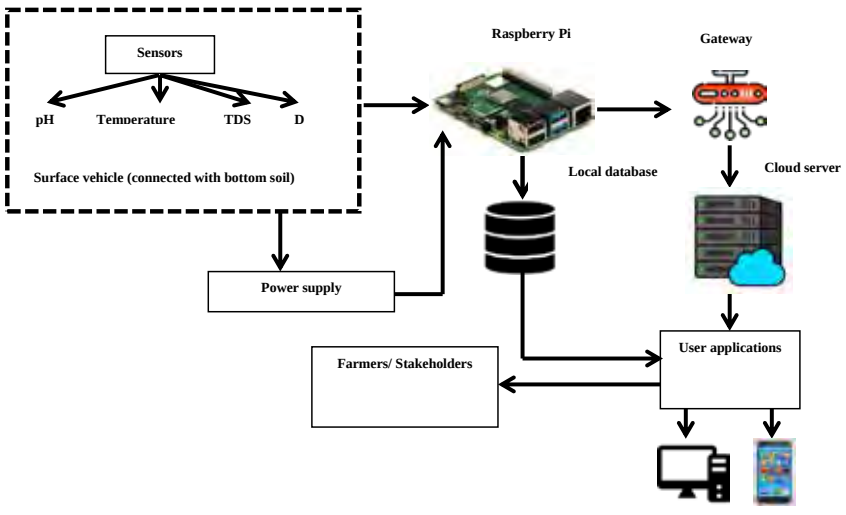


Fig. 13

Proposed framework of AI based continues monitoring system

SOCIETAL DEVELOPMENT PROGRAMMES AND TECHNOLOGY DEMONSTRATIONS

Aquaculture based livelihood development models were demonstrated under the Scheduled Tribe Component (STC) and Scheduled Caste Sub Plan (SCSP) programme to improve the socio-economic conditions of SC/ST households in the states of Tamil Nadu, Gujarat, Odisha and West Bengal. The models demonstrated and the progresses made are briefed below.

NURSERY AND GROW OUT CULTURE OF ASIAN SEABASS (*Lates calcarifer*) IN CAGES

An improved nursery rearing technology for growing fry to fingerlings in small net cages (Hapas) with formulated feed was demonstrated to create an additional livelihood avenue for the coastal SC fisherwomen. A group of 22 SC women beneficiaries from Kottaikadu Village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu who were originally involved in bivalve collection in the Buckingham canal backwaters were trained on this technology. A nursery rearing pen to prevent the entry of crabs measuring 30

Distribution of seabass fry for nursery rearing

Nursery rearing of seabass in backwaters

Grading of seabass fingerlings

Sale of seabass fingerlings to farmers

Fig. 1
Nursery and grow out culture of Asian Seabass (Lates calcarifer) in cages

meter width and 60 meter length (mesh size 25mm) was installed by involving fisherwomen Self Help Groups (SHGs). Hapas of 2 meter length x1.5 meter height x 1 meter width were installed inside the pen (Fig.1). CIBA hatchery produced seabass fish fry with a length of 2.0-3.0 cm and 1.00-1.20 g weight were stocked 300 nos/ hapa. The fishes were fed *ad libitum* twice/thrice a day with formulated nursery rearing feeds. Grading of seabass fry was done on weekly basis and after rearing for 48 days, the fishes attained a fingerling size of 10.52 cm length and 13.50 g weight. The fingerlings (4,220 nos.) were sold for growout culture and revenue of Rs. 2,03,800/- was generated. In addition to that cage farming of seabass using the nursery produced fingerlings was also undertaken in two cages by these SHGs and generated a revenue of Rs.1,58,000/- through sale of 493 kg of cage produced seabass fish with size range of 700-1,200g.

CAGE CULTURE OF ASIAN SEABASS

Four fish rearing cages made with Galvonized Iron frames of size 4m x 3m x 2.5m (30m^3) were fabricated. Seabass fingerlings were stocked @ 1,000 numbers/ cage in Kottaikadu and Kolathur villages in Chengalpattu district of Tamil Nadu. Fingerlings with an average size of 10-12 cm were stocked (41.6 Nos/ m^3). Fishers were fed with formulated floating pellet feed *CIBA Seabass^{+N}* twice a day and the estimated feed conversion ratio (FCR) realised was 2.2. Sampling was done once in 30 days and the survival rate was estimated to be 80-85%. Totally 4 SHGs consisted of 27 members in Kottaikadu and 12 in Kolathur were involved in the cage farming (Fig. 2). A partial harvesting of 350 fishes weighing 100 g size was sold at Rs.100 per fish and realized revenue of Rs.35000 during the month of October, 2023. An another 55 live fishes of 800 gram fishes were sold at Rs.500 to ICAR-CIBA for raising as brood stock and realized an income of Rs. 27500. The closure of bar mouth in the creek led to algal bloom and reduced water transparency was the major constraint reported by the farmers.

Cage farming of seabass | Cage farmed seabass

Partial harvest of seabass | Distribution of sale proceeds

Fig. 2
Cage culture of Asian seabass

NURSERY REARING AND FARMING OF ASIAN SEABASS *Lates calcarifer* IN PONDS

Nursery rearing and grow-out farming of seabass (*Lates calcarifer)* in a brackishwater pond was undertaken under the SCSP programme at Valamedu village, Vakkadu Mandal, Tirupathi District, Andhra Pradesh. A portion of a pond (0.25 acres) having a size of 1.25 acres water spread area was used for nursery rearing of seabass and the remaining area was used for farming of seabass (1.0 acre) by a group of 10 members belonging to Scheduled Caste community of the same village. A net fencing was made to separate the nursery rearing area from the grow-out farming. A catwalk was made in the nursery

rearing area and hapas were installed on both the sides. About 1,400 numbers of seabass fry of average length of 1.5 cm were stocked in the hapas for nursery rearing. Grading of fishes was done on weekly basis. After 85 days of rearing the nursery reared seabass attained 14.0 cm size with an average weight of 18 g. In the grow-out pond 1,200 numbers of seabass fingerlings of 4-5 inch size weighing 10-12 g were stocked and fed with formulated floating pellet feed. The excessive fingerlings other than that used for grow out stocking were sold for Rs.31,750/-. In the grow out a production of 610 Kg of seabass was harvested with an average size of 450g and realized a revenue of Rs.1,62,500/-. Through the participatory technology adoption of nursery rearing and farming of seabass, the scheduled caste community members have earned a total revenue of Rs. 1,94,250/- .

Nursery rearing happas installed in the pond

Grading of seabass fingerlings

Feeding zone installed in the pond

Harvested farmed seabass

Fig. 3

Nursery rearing and farming of Asian seabass *Lates calcarifer* in ponds

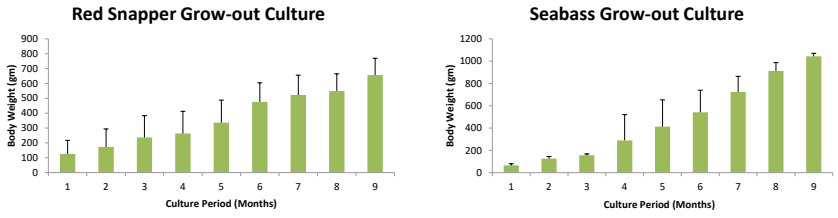
FARMING OF SNAPPERS AND ASIAN SEABASS USING FRP-HDPE HYBRID CAGE IN PULICAT LAKE WATERS

Farming of snappers and seabass fishes using FRP-HDPE Hybrid cages was demonstrated for a group of 12 SC beneficiaries at Thonirevu village, Pulicat, Thiruvallur District, Tamil Nadu. The snapper fingerlings with an average size of 100 g and seabass fingerlings with an average size of 20g were stocked in the month of April, 2023. The fishes were fed with formulated pellet feed twice a day. Regular growth, water quality and disease monitoring were carried out. After 7 months crop period 90% survival was obtained for snappers while 55% survival was obtained for seabass. Snapper fishes with an average size of 800 g were sold out for Rs.1,00,800 (@ Rs.280/ kg). Seabass were sold out for a total of Rs.1,66,100 (330kg of 1.00 kg size fishes sold @ Rs.350/kg and 220 kg fishes of 300g size range sold @ Rs.230). The detailed growth and cost economics were given in graphs (Fig. 4).

Stocking of snappers in the FRP-HDPE hybrid cage at Pulicat Lake waters

Sampling of cultured fishes

Harvested Snapper fishes



Growth rate of Snapper and Seabass fishes

Fig. 4
Farming of Snappers and Asian Seabass using FRP-HDPE hybrid cage in Pulicat Lake waters

DEMONSTRATION OF BRACKISHWATER AQUACULTURE TECHNOLOGIES AMONG IRULAR TRIBAL FAMILIES

Brackishwater aquaculture technologies Viz; milkfish farming in pond and pens, seabass nursery rearing in net cages (hapas) and crab farming in pen and boxes were demonstrated with 20 coastal Irular tribal families of Laximipuram village, Minjur taluk, Tiruvallur district, Tamil Nadu. Total 400 nos of seabass juveniles with an average size of 100 g were stocked during the month of January 2023. After a period of 6 months the fishes with a size range of 450 g to 900 g were harvested. A production of 85 kg seabass was harvested and sold at an average price of Rs.330/kg and revenue of Rs.28,000/- was realized.

Fig. 5
Harvested seabass by Irular tribals

INTEGRATED AQUA-AGRI-POULTRY-GOAT REARING - A SUSTAINABLE LIVELIHOOD MODEL FOR TRIBAL SHG OF SINGOD, NAVSARI

Navsari Gujarat Research Centre of ICAR-CIBA demonstrated an *Integrated Aqua-Agri-Poultry and Goat-rearing Model* for the livelihood and nutritional security of a Self-Help Group consisted of 40 tribal families – the *Singod Halpati Samaj Yuva Matsya Udhyog Juth*, in Singod Village, Navsari District, Gujarat (Fig.6). NGRC-CIBA distributed inputs like net cages, cage frames, fish seed, feed, vegetable and fruit tree saplings, goats, broiler chicks, etc., apart from providing technical know-how on cage-based fish farming in the village community pond. In addition, the tribal SHG was supported with supply of seabass fingerlings (3-4 inches), pearlspot fingerlings (2-4 inches), feed, bamboos, green shed nets, etc. The SHG purchased 12,000 numbers of Catla and Rohu seeds and 2 tonnes of feed with their previous year's income. They generated an income of Rs.5.8 lakhs through partial harvest and sale of fishes (Pangasius, Tilapia, Rohu and catla) and goats.

Fig. 6
Integrated Aqua-Agri-Poultry and Goat-rearing model

Upon witnessing the success of integrated Aqua-Agri-Poultry-Goat rearing model at Signod, Navsari, Gujarat, the Gujarat Fish Farmers Producer Co-op. Society Ltd. (GFFPO) Navsari, signed MoU with ICAR-CIBA, Chennai for the demonstration of brackishwater aquaculture technologies for the livelihood upliftment of tribal members of GFFPO. As part of this MoU, NGRC of CIBA adopted 40 scheduled tribal members of GFFPO and renovated 4,000 sq. m. pond at Mendhar village in Navsari district, Gujarat for the demonstration of above model. The pond (4,000 sq.m) with a depth of around 1.5 m was renovated for the model with a goat (20 x10 ft) and poultry shed (20 x 20 ft) on one side of pond dyke and 300 sq. m. area for horticulture crops on the other side dyke was developed. Inputs such as 10,000 nos seabass seed (1 inch size) ; 10,000 nos pearlspot seed (1 inch) ; crab boxes -1,000 nos; hapa-80 nos; feed-150 kg; feeding boats- 2 nos solar lamps - 8 nos; were distributed to the beneficiaries (Fig.7). The SHG earned ₹.1.8 lakhs from the sale of 3 - 4 inch size seabass and pearlspot fingerlings to the tribal fish farmers operating in Palghar, Maharastra state.

Inputs distribution to tribal beneficareis

Fig. 7
Stocking of seabass in hapas

Grading of seabass

NURSERY REARING AND POND-BASED CAGE CULTURE OF PEARLSPOT (*Etroplus suratensis*)

Nursery rearing of pearlspot fish fry followed by pond-based cage culture was demonstrated as a livelihood activity for SC beneficiaries in Navsari. The SC group comprised of 14 members from Jalalpore village in Navsari and the farming activity was taken up at Matwad Village, Navsari. The SC group was trained on hapa-based nursery, feeding and fish handling prior to commencement of the farming activity. Pearlspot fry (TL~ 2.5-3.5 cm), 4000 nos were stocked @ 400 nos./ hapa (100 fish/m^3) in ten hapas each measuring 2m x 2m x 1.75m (8 mesh, 2.0 mm) size erected in a brackishwater earthen pond. The fish were fed with 40% crude protein diet thrice a day for the first 30 days followed by twice a day for the rest of the period. The fry attained an ABW of 10.87 g and 29.19 g by 50 days and 95 days respectively with a size range of 18-52g by 95 DOC. The length-weight relationship of pearlspot during the trial was, W=0.011268 $L^{3.372}$ (n=663, R^2 = 0.978) and the fish demonstrated a positive allometric growth pattern (Fig-8). The Fulton's condition factor, allometric condition factor, and relative weight condition factor of pearlspot during the trial were 2.443, 1.133, and 1.0063 respectively indicating that the fish were growing optimally and the culture system was suitable for the species. The survival rate observed during the trial was 100%. On termination of the nursery rearing activity, the fish were size graded into small, medium, and large and stocked in to 5 m x 2 m x 1.75 m growout cages for further rearing to produce table sized fish.

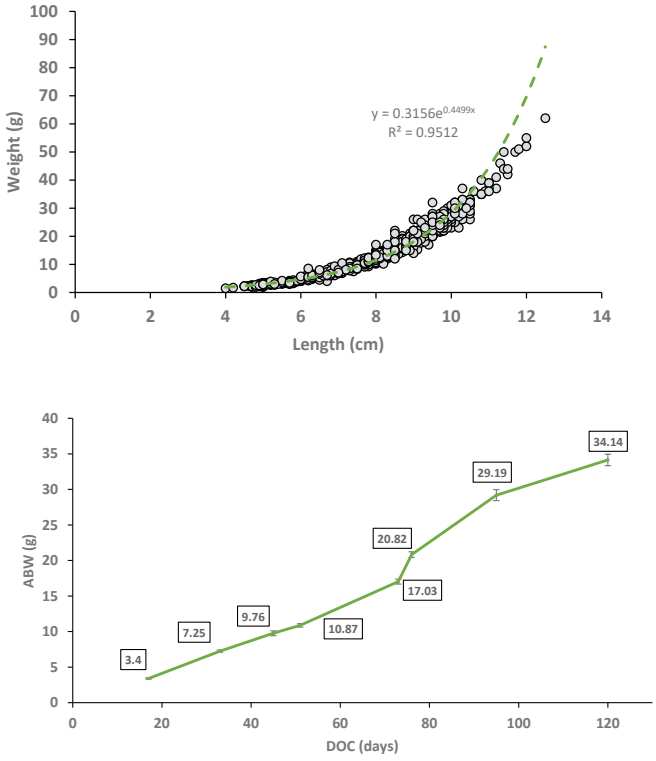


Fig. 8

Length weight relationship and Growth curve of pearlspot fry reared in hapas during 95 days of nursery

Sampling of pond-based cage culture of Pearlspot

EVALUATION OF PLANKTON *PLUS* IN CARP CULTURE IN THE SUNDARBAN REGION OF WEST BENGAL

Potential application of CIBA-Plankton*plus*(PPlus) in low saline carp culture was demonstrated as a livelihood activity for thirty six tribal farmers of Poila gheri, in Mousuni block. Eighteen ponds (200-1000sq.m) were taken for demonstration with 6 different treatments i.e., Control-Mustard oil cake (MOC) 200 kg/ha + farm yard manure (FYM) 1.5 t/ ha, T1- MOC+FYM+20ppm PPlus, T2-20ppm PPlus, T3-40ppm PPlus, T4- 60ppm PPlus, T5- 80ppm PPlus. Cost effective formulated feed was also used in carp culture. Ponds were stocked with Catla and Rohu (1:1) @1pc/ sq.m. Initial body weight of Catla and Rohu were 111.11g and 33.33 g, respectively. After 90 days of culture the average body weight (ABW) of Catla (Fig-9.) and Rohu (Fig.10) were 113.40,81.20; 136.60,104.33; 147.27,104.47; 124.33,84.67; 131.27,83.27; and 140.66,91.40 g, in control, T1,T2,T3,T4 and T5, respectively (Fig.9).

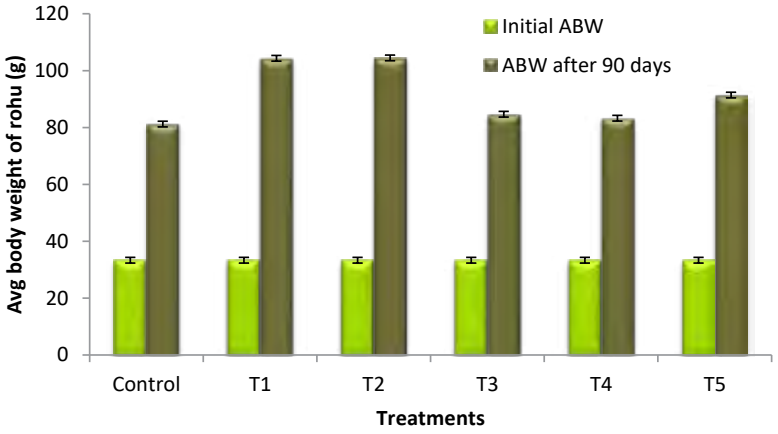


Fig. 9

Effect of Plankton^{Plus} supplementation on growth of Catla in low saline ponds

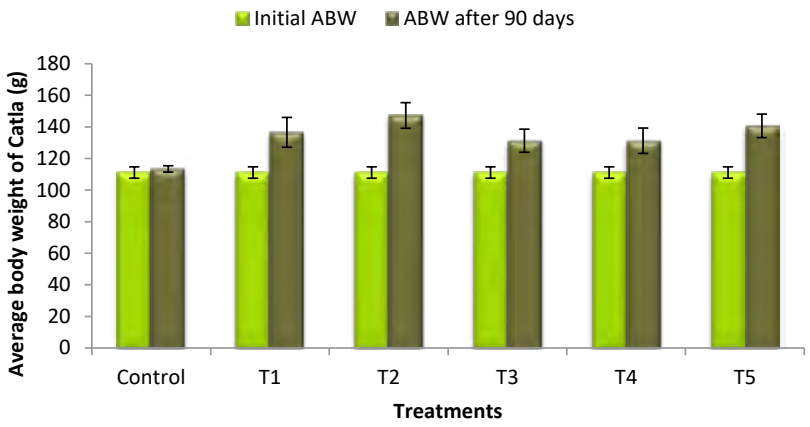


Fig. 10

Effect of Plankton^{Plus} supplementation on growth of Rohu in low saline ponds

Periodical sampling of fish

COST EFFECTIVE SHRIMP FARMING USING PLANKTON^{PLUS} AND POLY^{PLUS} INVOLVING SC FARMERS THROUGH LEARNING AND EARNING WHILE WORKING (LEW) MODEL

A demonstration was conducted at KRC farm using Plankton^{plus} and Poly^{plus} to validate the cost effective shrimp farming with 20 SC farmers through Learning and Earning while Working (LEW) model. Farming was done with two stocking densities (A) 40 PL/sq. m and (B) 60 PL/sq. m. Plankton^{plus} was used @ 40 ppm to boost the plankton density in culture ponds. At the end of 112 days culture, the shrimps attained an average bodyweight of 17.54g and 16.3g in the ponds A and B respectively (Fig.11). A total shrimp production of 1900Kg was attained and revenue of Rs.5.00 lakhs was generated.

Fig. 11
Harvest of *P. vannamei* shrimp produced using Plankton^{plus} and Poly^{plus}

ASSESSING THE POTENTIAL APPLICATION OF CIBA-PLANKTON^{PLUS} IN PADDY CULTIVATION

CIBA Plankton^{Plus}, a nutrient-rich hydrolysate derived from fish waste was assessed for its efficacy in paddy cultivation as a foliar spray in Thiruvallur District, Tamil Nadu with the participation of 40 SC farmers. The trial included three treatments: Control, in which conventional farming practices were followed; PP 5%, involving two applications of Plankton^{Plus} 5% (v/v) in conjunction with conventional practices; and PP 6%, which entailed two applications of Plankton^{Plus} 6% (v/v) alongside conventional practices (Fig.12).

Each field measured 1 acre. Results indicated that fertilizer such as ammonium sulphate applications has been reduced during panicle initiation stage in Plankton^{Plus} -treated fields and no significant difference in yield was found among the treatments. Moreover, no pest incidence was found in Plankton^{Plus} treated fields and as a result no pesticides were used in Plankton^{Plus} applied fields. These findings show that Plankton^{Plus} application along with conventional farming practices could reduce the need for synthetic inputs and pesticide application, thereby promoting sustainable agricultural practices.

Fig. 12
Application of Plankton^{Plus} as foliar spray in paddy

DIVERSIFIED FINFISH FARMING MODELS FOR LIVELIHOOD DEVELOPMENT AT BALASORE, ODISHA

Demonstration of diversified finfish farming including Asian seabass, milkfish and grey mullet was carried out with 30 tribal farmers at Balasore District, Odisha. About 4000 numbers of seabass fry (1.2-1.5 cm) were stocked in hapas for nursery rearing in a pond-based system. After 60 days of rearing, 2800 early fingerlings (4.0-5.0cm) were produced with a survival of 70%. Pre grow out was also carried out in hapas in the pond. Average survival of 45% was observed and 1260 number seabass juveniles (35-40 g) were produced. The juveniles were stocked in a pond along with 2500 numbers of stunted milkfish which were supplied for grow out farming. Milkfish reached an average 1.0 kg size and total of 2.2 t production is expected from multiple harvesting. The fishes were fed with CIBA nursery and grow out of 0.5 mm to 1.2 mm size. In another demonstration 10000 milkfish seed were supplied to beneficiaries. Milkfish fingerlings (5-8 cm) were reared for 60 days as pre-grow out and subsequently the juveniles (20-25g/12-15 cm) were stocked in an earthen pond along with grey mullets to demonstrate a polyculture model of farming. Milkfish reached an average size of 100g and total of 4.5 t production is expected from multiple harvesting (Fig.13).

Fig. 13
Partial harvest of milkfish

WORKSHOPS AND EXPOSURE VISITS ORGANIZED FOR THE SC/ST FAMILIES

A national workshop was organized jointly with Tamil Nadu Tourism Development Corporation on "Listening to the voices of coastal and tribal women and their success stories and awareness on livelihood opportunities including rural and aqua tourism" on 23rd June 2023. About 150 coastal and tribal women engaged in aquaculture based livelihoods from Tiruvallur, Kancheepuram, Cuddalore and Chengalpattu districts of Tamil Nadu and officials from the development departments, financial institutions and NGOs participated in the workshop. Dr Mrs Soumya Swaminathan, Chairperson, M.S. Swaminathan Research Foundation (MSSRF), Chennai and ThiruS. Annadurai, CLS, Director, Tribal Welfare Department, Govt. of Tamil Nadu graced this workshop and honored 18 women who presented their success stories.

Fig. 14
Application of Plankton^{Plus} as foliar spray in paddy

2. An awareness campaign for ST/SC beneficiaries on 'Livelihood Opportunities through Brackishwater Aquaculture Technologies integrated with Agro-based Technologies' through a traditional "Puppet Show was conducted on 13.10.2023. About 170 participants attended.

3. Organized a training and exposure visit for the tribal and schedule caste families on brackishwater aquaculture technologies under the ICAR CIBA-SCSP Scheme and STC component during 27- 29 December 2023 was conducted. About 25 ST/SC beneficiaries from Pulicat villages got benefited.

4. Eight coastal and tribal women beneficiaries of CIBA from Tiruvallur district received appreciation and honour from Ms. Iswariya Ramanathan, Sub-collector, Ponneri Taluk, Tiruvallur district, Tamil Nadu.

HUMAN RESOURCE DEVELOPMENT (HRD)

TRAINING PROGRAMMES ATTENDED

SCIENTISTS

S.No	Name and designation	Programme Name	Venue	Duration	Organized by
1.	Dr Sandeep KP, Scientist	Workshop cum international training on Good Aquaculture Practices (GAPs)	Chennai	9-13 January, 2023	USFDA, CAA and JIFSAN at Chennai
2.	Dr Aritra Bera, Senior Scientist	Workshop cum international training on Good Aquaculture Practices (GAPs)	Chennai	9-13 January, 2023	USFDA, CAA and JIFSAN at Chennai
3.	Dr J Raymond Jani Angel, Senior Scientist	Workshop cum international training on Good Aquaculture Practices (GAPs)	Chennai	9-13 January, 2023	USFDA, CAA and JIFSAN at Chennai
4.	Dr B. Shanthi, Principal Scientist	Participatory Gender Approaches for Agriculture Development	Online	23-28 January, 2023	ICAR-CIWA, Bhubaneswar and MANAGE, Hyderabad
5.	Shri Aravind R, Scientist	Mariculture Technologies for Income Multiplication, Employment, Livelihood and Empowerment	Online	7-27 February, 2023	ICAR-CMFRI, Kochi
6.	Shri Dani Thomas, Scientist	Mariculture Technologies for Income Multiplication, Employment, Livelihood and Empowerment	Online	7-27 February, 2023	ICAR-CMFRI, Kochi
7.	Shri Pankaj Amrut Patil, Scientist	Mariculture Technologies for Income Multiplication, Employment, Livelihood and Empowerment	Online	7-27 February, 2023	ICAR-CMFRI, Kochi
8.	Dr Sherly Tomy, Principal Scientist	Genome editing in farm animals for improved productivity and health	Online	3 March, 2023	Animal Biotechnology Division, ICAR-NDRI
9.	Dr R Geetha, Senior Scientist	Training programme on Multivariate data analysis	Online	20-27 March, 2023	ICAR – NAARM, Hyderabad
10.	Dr Aritra Bera, Senior Scientist	Hands-on training program on CRISPR/Cas-9-based gene editing technologies in plant	Hyderabad	12 -16 June, 2023	CGIAR-ICRISAT, Hyderabad
11.	Dr T. Bhuvaneswari, Senior Scientist	Hands-on training program on CRISPR/Cas9 Gene Editing technologies in plants	Hyderabad	12-16 June, 2023	ICRISAT, Hyderabad
12.	Dr B. Sivamani, Senior Scientist	Hands on training programme on CRISPR / Cas based molecular diagnostic platforms	TRPVB, Chennai	3-7 July, 2023	TRPVB- TANUVAS, Chennai
13.	Dr Sherly Tomy, Principal Scientist	Hands on training programme on CRISPR/Cas based Molecular Diagnostics Platforms	TRPVB, Chennai	3-7 July, 2023	TRVBP- TANUVAS, Chennai

14.	Dr R.Ananda Raja, Senior Scientist	Hands on training programme on CRISPR/Cas based molecular diagnostic platforms	TRPVB, Chennai	3-7 July, 2023	TANUVAS, Chennai
15.	Dr N.Lalitha, Scientist	National Training cum Workshop on Trends in Genomics	Chennai	07-11 August, 2023	Madras Veterinary College, Chennai
16.	Dr M. Jayanthi, Principal Scientist	Training Programme on Deep Learning about Ms Excel and PowerPoint for effective Research Management and Scientific Communication	Online	10-24 August, 2023	Xanthus Institute, Goa
17.	Dr R. Geetha, Scientist	Training Programme on Deep Learning about Ms Excel and PowerPoint for effective Research Management and Scientific Communication	Online	10-24 August, 2023	Xanthus Institute, Goa
18.	Mr C. Siva, Scientist	Professional Certificate Program on Animal breeding and Genetics	Online	05 September-05 December, 2023	Wageningen University, Netherlands
19.	Dr S.K. Otta, Principal Scientist	Strengthening Institutional capacity in surveillance & monitoring of AMR & AMU in the animal health sector	NIPHM, Hyderabad	26-27 October, 2023	FAO, India
20.	Dr B. Shanthi, Principal Scientist	DST Sponsored Training Programme on Research For Societal Good Through Social Responsibility	Coimbatore	20–24 November 2023	Amrita School of Business, Coimbatore

TECHNICAL STAFF

S.No	Name and designation	Programme Name	Venue	Duration	Organized by
1.	Dr R. Suburaj, ACTO	Workshop cum international training on Good Aquaculture Practices (GAqP)	Chennai	9-13 January, 2023	USFDA, CAA and JIFSAN at Chennai
2.	Shri S. Nagarajan, ACTO	Training program on E-Governance Applications in ICAR for Technical Personnel	Online	22-28 February, 2023	ICAR-IASRI, New Delhi
3.	Dr A. Nagavel, ACTO	RPTO (Remote Pilot Training Organisation) Training	Online	3-13 April, 2023	Agni College of Technology, Chennai.

ADMINISTRATIVE STAFF

S.No	Name and designation	Programme Name	Venue	Duration	Organized by
1.	B. Prasanna Devi, UDC	Workshop on Pay Fixation	Online	24-26 July, 2023	ISTM, New Delhi
2.	B. Prasanna Devi, UDC	Training Program on PFMS/TSA & CNA Module-1	RTC-INGA, Chennai	19 October, 2023	ICAR, New Delhi

TRAINING PROGRAMMES CONDUCTED

S.No	Name of the Training	Duration	No. of Participants
1.	Risk Management in Shrimp Aquaculture: Sensitization Programme to Officers of Banks and Insurance Sector	1-3 March, 2023	26
2.	Hands on training programme on "Molecular techniques for fish and shrimp diseases" under the aegis of National Surveillance Programme for Aquatic Animal Diseases (NSPAAD), Phase-II	24 July-4 August, 2023	9
3.	Recent Advances in Seed Production and Farming of Brackishwater Finfishes	7-11 August, 2023	20
4.	Recent developments in brackishwater aquaculture technologies for farmers of Ramanathapuram district, Tamil Nadu	4-8 September, 2023	30
5.	Skill and entrepreneurship development training program on 'Aquafeed Preparation Techniques and Quality Control'	12-14 September, 2023	26
6.	Hatchery seed production, nursery rearing and farming of Asian seabass (*Lates calcarifer*)	3-7 October, 2023	27
Kakdwip Research Centre, West Bengal			
7.	Training program on Recycling of fish waste to value added products, Plankton^{Plus} & Horti^{Plus} for members of FishFED India at Navi Mumbai, Maharashtra	6 -10 February, 2023	7
8.	Training Programme on Nutrition, feed formulation and management for brackishwater shellfishes and fishes for NEWS members at KRC-CIBA	11-12 April, 2023	7
9.	Training Programme on Seed production and farming technology of brackishwater finfishes at KRC-CIBA	23-29 August, 2023	14
10.	Training programme on "Hatchery Seed production, nursery rearing and farming of Asian Seabass (*Lates calcarifer*)" at KRC- CIBA Kakdwip	3-7 October, 2023	27
11.	Training programme on Brackishwater Aquaculture with Special Emphasis on Improved Traditional Farming Sponsored by NABARD at KRC of CIBA	7-9 November, 2023	26
Navsari Gujarat Research Centre, Gujarat			
12.	Orientation training for farmers of Rajasthan on "Inland Fisheries and Brackishwater Aquaculture"	15-17 March, 2023	12
13.	Hands on training on "Rural Fisheries Work Experience Program" for B.F.Sc. 4th Year Students of College of Fisheries Navsari, Kamdhenu University	19-25 March, 2023	20
14.	Training Programme on "Mud crab box culture and finfish nursery culture in brackishwater ponds and creeks" for project associates and farmers of Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra	28 September - 1 October, 2023	30

PH.D. AWARDED

S.No	Name of the Student	Thesis Tittle	Supervisor	Date of award
1.	Shri Sowmya Brata Sarkar	Bioremediation efficiency and culture potential of indigenous seaweed (*Agarophyton tenuistipitatum*) in brackishwater system	Dr P. Nila Rekha, Principal Scientist	25.04.2023
2.	Shri M. Sundaram	Elucidating the mode of action of probiotics in biofloc based shrimp culture of *Penaeus vannamei* (Boone.1931)	Dr A. Panigrahi, Principal Scientist	11.05.2023
3.	Shri Arul Raj	Prevalence, Seasonal variation and characterization of important shrimp viral and bacterial pathogens and their coinfection in *Penaeus vannamei* cultured ponds form east coast of India	Dr S.K. Otta, Principal Scientist	30.05.2023
4.	Dr T. Sathish Kumar (Scientist)	*Enterocytozoon hepatopenaei* (EHP) in *Penaeus vannamei*: Characterization, epidemiology, host-pathogen interaction and diagnostics	Dr M. MAKESH, Principal Scientist	14.06.2023
5.	Dr Ashok Kumar Jangam (Scientist)	Mining Shrimp Transcriptomes for functional information on Economic Traits	Dr Vinaya Kumar Katneni, Senior Scientist	20.10.2023

WORKSHOPS, SEMINARS AND MEETINGS

ICAR CIBA CELEBRATED 74TH REPUBLIC DAY AND LAUNCHED THE INTERNATIONAL YEAR OF MILLETS 2023

ICAR CIBA celebrated 74th Republic Day on 26th January 2023 with traditional pride and honour to the country and the tricolour National Flag was hoisted by Dr Kuldeep K. Lal Director ICAR CIBA. In his Republic Day address, Dr Kuldeep Lal appreciated the overall research performance of the institute and stated that the real challenge lies in the large-scale adoption of CIBA technologies by farmers and other stakeholders. Dr Kuldeep K. Lal also highlighted the importance of farm diversification and the significance of millet in Indian agriculture and in the food chain and formally launched the International Year of Millets 2023 in brackishwater aquaculture based farming systems.

Shri Parshottam Rupala, Honourable Union Minister of Fisheries, Animal Husbandry and Dairying, Govt. of India launched the National Surveillance Programme on Fish Diseases – Phase-II and Genetic Improvement Programme of Indian White Shrimp (*Penaeus indicus*)

Shri Parshottam Rupala, Honorable Union Minister of Fisheries, Animal Husbandry and Dairying, Govt. of India on 27.02.2023 launched the two flagship programmes viz. National Surveillance Programme on Fish Diseases (NSPAAD) – Phase-II and Genetic Improvement Programme (GIPPI) of Indian White Shrimp (*Penaeus indicus*) in the presence of several dignitaries, researchers, officials, farmers, industry representatives, press and media at ICAR-CIBA campus, Chennai. In his address the minister expressed his happiness in launching the NSPAAD and GIPPI programmes both are important for the development and sustainability of aquaculture sector which eventually lead to Blue Revolution in India. Dr L. Murugan, Hon'ble Union Minister of State for Fisheries, Animal Husbandry and Dairying & Information Broadcasting, Govt. of India gave a detailed account of various initiatives undertaken by the Govt. of India for the fisheries development in the country which are culminated in increased fisheries production of 16.50 million metric tonnes. Shri Jatindra Nath Swain, IAS, the Secretary, Department of Fisheries, Government of India, Dr J.K.Jena, DDG (Fy), ICAR, Dr J. Balaji, Joint Secretary, Department of Fisheries, Government of India, Shri A. Karthik, IAS, Principal Secretary, Fisheries Department, Govt. of Tamil Nadu, Dr Kuldeep K. Lal, Director, ICAR-Central Institute of Brackishwater Aquaculture, Chennai and Dr U. K. Sarkar, Director, ICAR-National Bureau of Fish Genetic resources, Lucknow along with team of scientists and staff attended the event.

INTERNATIONAL WOMEN'S DAY

ICAR-CIBA, Chennai, observed International Women's Day on 8th March, 2023. The theme for 2023 International Women's Day is "Embrace Equity". Dr Kuldeep K. Lal, Director, ICAR-CIBA, highlighted the significance of celebrating the International Women's Day and the relevance of balancing emotions in family life and work place. In his address, the Chief Guest, Dr Babu Rengarajan, Clinical Psychologist stressed the importance of emotional intelligence and conflict management. He applauded the women's capabilities of balancing and handling the work and home efficiently and effectively. Staff and Scientist from CIBA regional centers and other ICAR institute joined the programme through online mode.

THE 28TH RESEARCH ADVISORY COMMITTEE (RAC) MEETING

Research Advisory Committee (RAC) of an institute is the apex advisory group to review the on-going research and development programmes and provides need-based directions to re-orient/modify the research programs for the ensuing year. The first meeting of the newly constituted RAC meeting was held during 24-25th March 2023. Dr Iddya Karunasagar, Former Senior Fish Safety and Quality Specialist, FAO, Rome is the Chairman of the RAC along with him the following members of RAC: Dr M. Sudhakar, Former Director, Central Marine Living Resources Institute (CMLRI), Kochi, Dr A. K. Pal, Former Joint Director, ICAR-CIFE, Mumbai, Dr A. Laxminarayana, Former Head, Fisheries Environment Management Division, CMFRI, Kochi, and Prof. T. J. Abraham, Faculty of Fisheries Sciences, WBUAFS, Kolkata attended the meeting. Dr Shubhadeep Ghosh, Assistant Director General (Marine Fisheries) ICAR representing the fisheries SMD attended the meeting by on-line as an ex-officio member. Dr Kuldeep K. Lal, Director, ICAR-CIBA, made a presentation on the institute's research programmes, participation in the national mission programmes and salient achievements of the institute in the previous year. The Director also highlighted the priority research areas of ICAR-CIBA for the next five years.

WORLD INTELLECTUAL PROPERTY DAY

ICAR-Central Institute of Brackishwater Aquaculture (CIBA) celebrated the World Intellectual Property Day, on 26th April 2023 with the theme "Women and IP: Accelerating Innovation and Creativity" celebrating the "can do" attitude of women inventors, creators, and entrepreneurs around the world and their ground-breaking work. Dr Kuldeep K. Lal, Director, CIBA pointed out the importance of Intellectual Property Rights (IPR), the importance of better identification, planning, commercialization, rendering, and thus preservation of inventions or creativity in the modern world. Dr V. Parimalavarsini, Assistant Controller of Patents & Designs, Patent Office, Chennai was the Guest speaker. She covered distinct aspects of amendments in IP legislations, copyrights, designs, trademarks, guidance in IP filing, adopting efficient and paperless service.

40TH INSTITUTE RESEARCH COUNCIL MEETING

40th Institute Research Council of ICAR-CIBA held during 26-28th April and 1st May, 2023 for reviewing on-going research projects in 2022-23 and planning the research activities for the year 2023-24. Dr Kuldeep K. Lal, Director, ICAR CIBA and Chairman of the IRC in his opening remarks highlighted the major research achievements in the past one year like formal inauguration of flagship project on 'Genetic Improvement Programme of Penaeus indicus Phase-I, launching shrimp crop insurance and achievements in national disease surveillance project. Subsequently, salient achievements in all the research projects were presented and discussed in detail and the technical programmes for the research year 2023-24 were also outlined thematic wise. Research on genetic improvement of indigenous shrimp species, disease surveillance, nutrigenomics and nutrition management, aquaculture in inland saline soils, and technology transfer through mass media and outreach programmes would be given priority in the ensuing year.

WORLD ENVIRONMENT DAY-2023

ICAR-CIBA and its regional centres observed the World Environment Day (WED) on 5th June, 2023 with the theme 'solution to plastic pollution' to create awareness among the public on protection and conservation of environment. A similar theme (Beat Plastic Pollution) was adopted in WED- 2018 also indicating the importance mitigating plastic pollution. Dr P.S.G. Krishnan, Principal Director, Central Institute of Petrochemicals Engineering & Technology (CIPET), Chennai was the chief guest and in his talk he highlighted that reduction, reuse, recycling and segregation are the methods to minimise the plastic pollution. Dr Kuldeep K. Lal, Director, stated that though plastics are for good, their management has to be better. He emphasised need to look into our contribution on keeping the environment safe for the future generation. Tree plantations were organised in CIBA regional centres at Kakdwip, West Bengal and Navsari, Gujarat in connection with the WED 2023.

INTERNATIONAL YOGA DAY CELEBRATIONS

ICAR- CIBA, Chennai and its regional stations celebrated the International Yoga Day on 21st June 2023. Dr Janani Subburaj, Yoga & Naturopathy Junior Doctor conducted Yoga practice session. The scientists, Officers, Staff and Students have actively participated in the practical yoga session along with family members. In addition, Dr Y. Deepa, Head of Division, Manipulative Therapy, Government Yoga and Naturopathy Medical College, Chennai has delivered a talk on "Significance of Yoga in the Modern Day Life". Dr Kuldeep K. Lal, Director ICAR-CIBA presided over the function.

NATIONAL FISH FARMERS DAY

Kakdwip Research Centre of ICAR- CIBA celebrated National Fish Farmers' Day on 10th July, 2023 to commemorate the invention of induced breeding in Carp fish. A total of 50 brackishwater aquaculture farmers from three brackishwater districts of West Bengal viz. North 24 Parganas, South 24 Parganas and Purba Medinipur attended the event at KRC of ICAR-CIBA. A Scientist-Farmer interaction was held wherein farmers raised their queries on various aspects of farming and problems faced by them. Fish seed of Pearlspot and Orange chromide were distributed among the Scheduled Caste farmers of Buddhapur village of Kakdwip.

SHRIMP FARMERS CONCLAVE-2023

ICAR-CIBA conducted the Shrimp Farmers Conclave-2023 on 1st August, 2023 at the Faculty of Marine Sciences, Annamalai University wherein about 431 shrimp farmers cutting across the coastal districts of Tamil Nadu participated. Inaugurating the conclave Dr RM. Kathiresan, the Vice Chancellor, Annamalai University articulated that both 'top-down and bottom up approaches' (Lab-to-land & Land-to-Lab) are essential to develop and solve practical solutions of the farming community. Further, Private-Public-Farmer-Partnership is the mantra for making the farming science-led and hi-tech based to increase the food production and ensure the entrepreneurship and attracting the youth towards farming. A MoU was signed between the ICAR-CIBA and Annamalai University for R&D collaboration during the occasion. Dr Kuldeep K Lal, Director, ICAR-CIBA, briefed the Govt. of India schemes under the Prime Minister's Matsya Sampada Yojana (PMMSY) to the farmers.

ICAR-CIBA CELEBRATED THE 77TH INDEPENDENCE DAY OF OUR NATION

ICAR- CIBA celebrated the country's 77th Independence Day by unfurling the National Flag at the Main Campus, Field and Regional Centres with full respect and honour. Dr Kuldeep K Lal hoisted the National Flag at the headquarters. In his Independence Day speech, he conveyed his wishes to all and

outlined importance of keeping the stakeholders needs in mind while planning the research and development activities. Engaging the stakeholders in our research as partners for technology validation and refinement at the field level that would make our technologies need based he added. Private-public partnership in R&D is the focus in the day to come and sourcing Corporate Social Responsibility (CSR) funds from the corporate firms for the technology-led societal development is important he highlighted. Dr S. Kannappan, Principal Scientist & OIC, Muttukadu Experimental Station, DrDebasis De, Head of Kakdwip Regional Centre of CIBA and Mr Pankaj Patil, Officer-in-Charge, Navasari-Gujarat Regional Centre of CIBA unfurled the national flag at their respective office premises and celebrated the Independence Day with the families of the staff.

Shri Parshottam Rupalaji, Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying, Government of India launched the shrimp crop insurance schemes in the Second Edition of ICAR-CIBA's Shrimp Farmers Conclave-2023

ICAR- CIBA conducted the second edition of its Shrimp Farmers Conclave-2023 on 14th September, 2023 at the Navsari Agricultural University Campus, Navsari, Gujarat. About 410 aquafarmers across the coastal districts of Gujarat participated in the conclave. In addition to that officials, technicians, faculty and students were also participated in large number. ShriParshottam Rupalaji, Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying, Government of India was the Chief Guest and inaugurated the Conclave. A special session on 'Shrimp Crop Insurance' was convened wherein the Agricultural Insurance of Corporation of India, United India Insurance Corporation of India and the mediator Alliance Insurance Brokers along with Dr T.Ravisankar, Principal Scientist, CIBA and DrL.Narashima Murthy, the Chief Executive of the National Fisheries Development Board participated and explained about the insurance product developed by the United India Insurance for shrimp farming. The farmers were optimistic about the scheme and expressed their willingness to participate.

VIGILANCE AWARENESS WEEK 2023

ICAR-CIBA observed Vigilance Awareness Week (VAW) 2023 from 30th October to 5th November 2023. 'Integrity pledge' for institution was administered by the Dr Kuldeep K. Lal, Director, ICAR-CIBA among all the staff of the Institute including Regional Centers. All the family members of employee, stakeholders & collaborators were sensitized to take 'Integrity pledge' for citizen on website of Central Vigilance Commission (CVC) and commit to the nation on corruption free India.

55TH INSTITUTE MANAGEMENT COMMITTEE (IMC) MEETING

ICAR-CIBA had its 55th Institute Management Committee (IMC) meeting on 31.10.2023 at its headquarters, Chennai. The meeting was chaired by Dr Kuldeep K. Lal, Director-ICAR CIBA & chairman, IMC, Members of the IMC viz. Smt Noorjahan Beevi, Additional Director of Fisheries Tamil Nadu, Dr G. S. Saha, PS, ICAR-CIFA, Dr P. K. Pradhan, PS, ICAR-NBFGR, Smt Usharani V. Administrative Officer & member secretary, IMC and several co-opted members from CIBA representing Administration, Finance, PME & Engineering Cell participated in the meeting. During the meeting a scientific presentation was given by Dr C.V. Sairam, SIC of PME Cell on R&D programme & achievements of the institute during last one year.

WORKSHOP ON COMMUNITY BASED MANGROVE RESTORATION (CBMR)

Nature environment and wildlife society (NEWS) in association with Kakdwip research centre of ICAR-CIBA organized a one day workshop on Community Based Ecological Mangrove Restoration (CBEMR) at KRC of ICAR-CIBA, Kakdwip, West Bengal on 11 December 2023. Dr Debasis De, Head of research centre, KRC, CIBA delivered inaugural address for the programme. Two foreign delegates, Dr Laura Michie, PhD, Program Manager & CBEMR Trainer and Mr Leo Thom, Creative director, Mangrove action project, Seattle, United States were the key resource persons in the programme. Dr Laura Michie, in her key note address, presented the brief about the various activities of Mangrove action project. She also emphasized the various methodologies of community based mangrove restoration projects handled by the team. Around 40 delegates and environmental activists in and around the Sundarbans participated in the workshop

NATIONAL FARMERS DAY

National Farmers Day or Kisan Diwas is celebrated every year 23rd December 2023 in the honor of Chaudhary Charan Singh who was the fifth Prime Minister of India. ICAR-CIBA, Chennai, Tamil Nadu, observed the Kisan Diwas as an activity of Swachhata Pakhwada at Kasimedu fishing harbour, Chennai, Tamil Nadu, by conducting awareness programme on waste to wealth and sharing of experience of different stakeholders who has used CIBA-Plankton^{Plus} and CIBA Horti^{Plus}, products developed from fish waste. Dr P. Mahalakshmi, Principal Scientist and Nodal Officer of Swachh Bharat Mission of CIBA, highlighted the importance of National Farmers Day. She also informed the attending participants about the importance of Swachh Bharat Mission and waste to wealth concept and how to utilize farm waste effectively.

WORLD SOIL DAY

ICAR- CIBA, Chennai organised "Brackishwater Aquaculture Farmers Meet" at Ellavur, Tiruvallur district, Tamil Nadu on 22nd December, 2023 to observe the World Soil Day. About 75 shrimp farmers from the Gummidipoondi taluk participated in the programme. In his presidential address, Dr M. Muralidhar, Principal Scientist emphasized the importance of maintaining the soil health in shrimp ponds for pond fertility, productivity and free from metabolites. Shri V.K. Gangadharan, Assistant Director of Fisheries, Ponneri explained about the different schemes of Government of India for the aquaculture farmers as well as fishermen under the PMSSY such as subsidy for biofloc culture, processing plants, etc.

AWARDS & RECOGNITIONS

KAKDWIP RESEARCH CENTRE (KRC) OF ICAR-CIBA PARTICIPATED IN THE KRISHI MELA AT SASYA SHYAMALA KRISHI VIGYAN KENDRA, WEST BENGAL AND BAGGED THE BEST EXHIBITION STALL AWARD

ICAR- CIBA participated in the Krishi mela organized by Sasya Shyamala Krishi Vigyan Kendra, Ramkrishna Mission Vivekananda Educational and Research Institute (RKMVERI), Sonarpur, West Bengal during February 14-16, 2023. The main themes of the Krishi mela were Natural farming and Farmers Producers Organizations (FPO). ICAR-CIBA in the Krishi Mela organized institute stall exhibiting the achievements and technologies developed by the institute along with aquariums of brackishwater candidate species. More than 2000 people including aquaculture farmers, students and entrepreneurs visited the stall of ICAR-CIBA. The leaflets describing major achievements of ICAR- CIBA were distributed to various stakeholders. ICAR-CIBA was judged as the best exhibition stall of the Krishi mela.

CIBA RECEIVED 2ND PRIZE FROM TOWN OFFICIAL LANGUAGE IMPLEMENTATION COMMITTEE (TOLIC)

Under the aegis of Chennai Town Official Language Implementation Committee (TOLIC), ICAR-CIBA received 2nd prize under small institute category. This was awarded to ICAR-CIBA for the best performance in the progressive use of Official Language during the year 2023 amongst the 188 PSU working under Govt. of India, Chennai. Dr Sujeet Kumar, Senior Scientist and member of OLIC received the award from Mr Kaushal Kishore, Additional General Manager, Southern Railway and TOLIC chairman, and Dr N. Anandavalli, Director, CSIR- Structural Engineering Research Centre (CSIR-CERC), Chennai. The award was presented on 22.12.2023 at CSIR-CERC. Dr Kuldeep K. Lal, Director, CIBA and chairman of official language implementation committee (OLIC) and Mr Navin Kumar Jha, Chief Administrative Officer and member secretary OLIC expressed their happiness for the gradual improvement in implementation of official language at the institute.

Awarded Fellow-Indian Virological Society (IVS), December 2023 – **Dr S.K.Otta**

Received Certificate of Excellence for outstanding paper on "Development of nano-mineral fortified smart feed package for improving production, optimizing gut health and environmental security" authored by P.N.Chatterjee, A Mahato, S.sarkar, A. Pal, A.Tah, S. Garai, I, De, S.Das and D.De in the 30th West Bengal State Science & Technology Congress held on 28th Feb-1st March, 2023 at Science City, Kolkata. - **Dr Debasis De**

Received the 2nd best oral presentation award for paper on Spermatophore development and effect of different mediums on the short term chilled storage in Indian white shrimp P. indicus" in the international conference of "Current advances in agriculture, animal husbandry and allied sciences" (CAAAAS 2023) organized by Agricultural research council of Nigeria and National agriculture development cooperative Ltd. (NADCL), Baramulla, J & K at Shri, Mata vaishno Devi university, Katra, India from July 10-11, 2023- **Sri I.F. Biju**

Received the Young scientist award in the international conference on "Aquatic resources and sustainable management" organized by the international academy of science and research (IASR) Kolkata, West Bengal at CIFRI, Barrackpore from August 30-31, 2023. - **Sri I.F. Biju**

Awarded "Young Researcher Award 2023" by the International Academy of Science and Research in the International Conference on "Aquatic Resources and Sustainable Management "held on August 30 – 31th, 2023 in ICAR-CIFRI, Barrackpore- **Dr Babita Mandal**

Awarded DrC.V.Kulkarni Best Ph.D research award for the year 2022-23 in the all India category by ICAR-CIFE - **Dr T. Sivaramakrishnan**

Best paper presentation award (Changes in digestive enzyme activities during the early ontogeny of milkfish, Chanos chanos larvae) during

National Conference on "Transforming Rural Poverty to Prosperity through Sustainable Fisheries" 19th – 21st July, 2023 held at Kishanganji, Bihar, India - **Dr T. Sivaramakrishnan**

Best oral presentation in the Indian Conference on Bioinformatics 2023 - Inbix'23, Theme: Application of Bioinformatics in Healthcare organized by School of Bio Sciences and Technology, Vellore Institute of Technology, Vellore during November 24-26, 2023 for the presentation of the paper "Insight Into the Bacterial Gut Microbiome of Penaeus vannamei Fed with Functional Feed Additives Lactiplantibacillus plantarum by Amplicon Sequencing" - **Dr N. Lalitha**

Received Young Scientist Award in Fisheries Science during the 8th International Conference on "Recent Advances in Agriculture, Animal Husbandry, Sciences & Technology for Sustainable Entrepreneurship" organized by Agro Environmental Development Society, Rampur held at Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh during 26-28, March, 2023 - **Mr Pankaj Amrut Patil**

Best oral presentation award for the paper entitled "Integrating culture of finfish, shellfish, livestock, poultry and horticulture crops in brackishwater farming system as a livelihood activity for coastal communities of Gujarat" in 8th International Conference on "Recent Advances in Agriculture, Animal Husbandry, Sciences & Technology for Sustainable Entrepreneurship" organized by Agro Environmental Development Society, Rampur held at Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh during 26-28, March, 2023 - **Mr Pankaj Amrut Patil**

Awarded the Best Paper Presentation award for the paper entitled'Artificial Intelligence Based Optimal Location Model for Aquaculture Development' in the International Conference on Current Advances in Agriculture, Animal Husbandry and Allied Science (CAAAAS-2023), during 10 -11, July 2023, Katra, India- **Dr P. Mahalakshmi**

Awarded the Best Oral Presentation award for the paper entitled 'Recycling of fish waste to Plankton Plus and Horti Plus production technology, a viable option for doubling the coastal communities income: A Sustainable Livelihood Model in the 2nd International Conference on Prospects and challenges of environment and biological sciences in food production system for livelihood security of farmers (ICFPLS–2023), Port Blair, Andaman & Nicobar Islands, India, 18-20, September, 2023- **Dr P. Mahalakshmi, Debasis De and K.P. Sandeep**.

Top 2% of the researcher in the world released by Stanford University for most influenced scientist (2023) in a Single year.- **Dr A. Panigrahi**

LINKAGE & 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 – National Academy of Agricultural Research Management, Hyderabad

OTHER CENTRAL / STATE GOVERNMENT DEPARTMENTS, SAUS / FOREIGN INSTITUTIONS

Agricultural and Processed Food Products Export Development Authority, New Delhi
Centre for Advanced studies in Marine Biology, Annamalai University, Parangi Pettai
Centre for Environment Fisheries and Aquaculture Science (CEFAS), Weymouth, Dorset, UK
Coastal Aquaculture Authority, Chennai
College of Fisheries, University of Agricultural Sciences, Mangalore
College of Fisheries, Sri Venkateswara Veterinary University, Muthukur
Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, New Delhi
Department of Biotechnology, New Delhi
Fisheries College and Research Institute, Thoothukudi
ISRO Telemetry Tracking And Command Network (Istrac) Peenya Industrial Area, Bangalore
Department of Fisheries, Govt. of Maharashtra
Agency for Development of Aquaculture Kerala (ADAK), Government of Kerala
Indian Institute of Technology, Chennai
Indian Institute of Technology, Kharagpur

Mangrove Cell, Government of Maharashtra, Mumbai
Ministry of Science and Technology, New Delhi
Ministry of Water Resources, New Delhi
Marine Products Export Development Authority, Kochi
MS Swaminathan Research Foundation, Chennai
National Fisheries Development Board, Hyderabad
National Institute of Ocean Technology, Chennai
Navsari Agricultural University, Navsari, Gujarat
Sundarban Development Board, Govt. of West Bengal
Department of Agriculture, Govt. of West Bengal
Ramkrishna Ashram KVK, Nimpith, South 24 Parganas
Sasya Shyamala Krishi Vigyan Kendra, Ramkrishna Mission Vivekananda Educational and Research Institute, South 24 Parganas.
Nature Environment and Wildlife Society (NEWS), Kolkata
South Asian Forum for Enviromment (SAFE), Kolkata
Pinnacle Biosciences, Agasteeswaram, Tamil Nadu
Tamil Nadu Agricultural University, Coimbatore
Tamil Nadu Veterinary and Animal Science University, Chennai
Tamil Nadu Dr J. Jayalalithaa Fisheries University, Nagapattinam
The Pirbright Institute, UK
University of Madras, Chennai
University of Southampton, UK
Vellore Institute of Technology, Vellore
Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Chennai
West Bengal University of Animal and Fisheries Science, Kolkata
Crescent Innovation Incubation Council (CIIC) BSAR Crescent Institution of Science & Technology, Chennai
Sathyabama Institute of Science and Technology, Rajiv Gandhi Salai, Chennai
Shri A. M. M. Murugappa Chettiar Research Centre, Chennai
SSN College of Engineering, Tamil Nadu
SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu

STATE FISHERIES DEPARTMENTS

The institute has well established linkage with state fisheries departments mainly for transfer of technologies.

CONSULTANCIES, TECHNOLOGY DEVELOPMENT & TRANSFER

ICAR-Central Institute of Brackishwater Aquaculture (CIBA) signed MoU with M/s. Pinnacle Bioscience for marketing of farmed indigeneous brackishwater seaweeds

ICAR-CIBA signed a Memorandum of Understanding (MoU) with M/s. Pinnacle Bioscience, Kanyakumari, Tamil Nadu on 06.02.2023 to create market linkage for the CIBA mentored seaweed farmers to sell the cultivated indigenous brackishwater seaweed species. While signing the MoU Dr Kuldeep K. Lal, Director, ICAR-CIBA emphasized the importance of seaweed cultivation as a viable livelihood option, a rich source of nutritious food and a major solution for bioremediation of waterbodies. Mr Burosothaman, Research Fellow, M/s. Pinnacle Bioscience added that seaweeds being nutrient rich has high value when converted into energy products, biofertilizers and food products. Dr P. Nila Rekha, Principal Scientist and team leader briefly outlined the genesis of the brackishwater seaweed culture starting from bioremediation in shrimp farm discharge water, biofliter for RAS and standardisation of culture practices for indigeneous seaweed.

ICAR-CIBA signed MoU with Aquapreneurs under start-up initiative for technical support on nursery rearing of Asian seabass (*Lates calcarifer*) and consultancy services on fish feed processing and production

ICAR-CIBA formed a strategic alliance with young entrepreneurs for establishing a seabass fingerlings production nursery rearing unit and for consultancy services on fish feed processing and production at Nellore, AP. In this context, the current initiative is to establish a nursery rearing facilities and small scale feed mill to process indigenous formulated feeds for use in farmed species by signing a MoU on 13th March 2023 at CIBA, HQ, Chennai. During the event, Dr Kuldeep K. Lal, Director, CIBA emphasised that seed and feed are the two major inputs essentially required for the farmers for large scale adoption of seabass farming and impressed upon the quality of feed vis-a-vis the cost of production and also highlighted the momentum in seabass culture especially the scientific farming using hatchery produced seed and formulated feed. Mr B. Mohan Reddy & Mr M. Kiran Kumar as joint partners, opined that there is a considerable demand for quality fingerlings and cost effective feeds for seabass aquaculture. Dr M. Kailasam, Principal Scientist, Fish Culture Division highlighted the genesis of this initiative and the uniqueness of this MOU where in simultaneously nursery rearing and feed production is being taken up. Dr K. Ambasankar, Principal Scientist and team leader for Nutrition and Feed biotechnology programs of CIBA briefed about the significance of this initiative and opined that the success of this small scale feed mill would pave the way for diversification and growth of the sector in a faster trajectory.

ICAR-CIBA inked MoU with Ms. Siri Industries, Karnataka under Make in India programme for consultancy services on production of indigenous fish feeds

ICAR-CIBA inked MoU with M/s. Siri Industries, Tumakuru, Karnataka for technology support to produce indigenous fish feeds on consultancy basis. CIBA has the technology for fish feed formulations and branded as plus series of feeds. Considering the demand for cost effective feeds for finfishes, M/s. Siri Industries approached ICAR- CIBA for technology support on fish feed formulations, processing and production and has entered into a MoU on 14th March 2023, at CIBA, HQ, Chennai. Dr K. Kuldeep Lal, Director CIBA underscored that this effort undoubtedly improve the economic benefits, contribute to innovation and growth, and encourage sustainability and competitiveness in the aqua-feed sector in the longer run. Dr B. Vinod, Managing Partner of M/s. Siri Industires felt that outcome of this MOU would help the small and medium fish farmers in the state of Karnataka. Dr K. Ambasankar, Principal Scientist and team leader for nutrition and feed technology, briefed about the work plan of this initiative's in line with make in India programme.

In the august presence of Shri Parshottam Rupala, Hon'ble Union Minister of Fisheries, Animal Husbandry, and Dairying, Government of India ICAR-CIBA, Chennai signed MoU with Agriculture Insurance Company of India (AICL) Limited, New Delhi for "Development of Aquaculture Insurance Solutions" on 20 March, 2023.

ICAR-CIBA, Chennai signed MoU with Agriculture Insurance Company of India (AICL) Limited, New Delhi for "Development of Aquaculture Insurance Solutions" on 20th March 2023 at the Maharashtra Sadan, New Delhi, in the august presence of Shri Parshottam Rupala, Hon'ble Union Minister for Fisheries, Animal Husbandry and Dairying, Government of India. The Hon'ble minister mentioned that aquaculture is becoming increasingly important to provide food to a growing global population and societal development. The MoU was signed by Ms.Girija Subramanian, Chairman and Managing Director, AICL and Dr Kuldeep K. Lal, Director ICAR-CIBA, accompanied by team leader Dr T. Ravisankar, Principal Scientist.

Shri Sudhir Mungantiwar, Hon'ble Minister for Fisheries, Government of Maharashtra presided over the MoU signing between ICAR-CIBA and Department of Fisheries, Govt. Maharastra for the brackishwater aquaculture development in Maharastra state

ICAR-CIBA, Chennai and the Department of Fisheries, Maharashtra signed Memorandum of Understanding for the sustainable development of brackishwater aquaculture in Maharashtra in the presence of Shri Sudhir Mungantiwar, Hon'ble Minister for Fisheries, Government of Maharashtra at Vidhan Bhawan, Mumbai, Maharashtra on 21.3.2023. During the interaction, Dr Kuldeep K. Lal, Director, ICAR-CIBA, Chennai expressed that CIBA would initiate mapping of coastal and inland saline resources of Maharashtra, development of brackishwater aquaculture model farm, demonstration of finfish and shellfish livelihood culture models, training of fisheries officials and farmers, etc, in partnership with Department of Fisheries, Maharashtra. Shri Atul Patane, IAS, Secretary-in-Charge and Commissioner of Fisheries, Department of Fisheries, Maharashtra underscored that brackishwater aquaculture can provide livelihood options for the coastal fishers aiding in augmenting fish production, income and employment generation in the state.

ICAR-CIBA inked MOU with Ms. Ultra Nutri India, Pvt. Ltd., Chennai for harnessing insect Black Soldier Fly (BSF) (Hermetia illucens) larvae meal as an ingredient in aqua feeds for better growth, immunity and disease resistance

ICAR-CIBA is partnered with Ms.Ultra Nutri India, Pvt. Ltd., headed by Dr Nitish Satyanarayanan, Director and a team of young entrepreneurs by signing a memorandum of understanding (MoU) on to explore the possibilities of using BSF meal which is rich in Anti-Microbial Peptide (AMP) as a functional ingredient in aqua feeds for improving the growth, immunity and disease resistance on 27th March 2023. Ms. Ultra Nutri India, a biotech startup aims providing sustainable and scalable proteins for aquaculture feed formulations. Dr K. K. Lal, Director, CIBA, underlined that this effort will undoubtedly provide a cost-effective alternative protein source to the fish meal and there is a scope to modify the fatty acid profile of the larvae that would also help in finding an alternative to fish oil. Dr K. Ambasankar, Principal Scientist and team leader for the feed technology, briefed about the significance of this MoU and outlined scope of its use in aquaculture feed production sector.

ICAR-CIBA signed MoU with Vellore Institute of Technology (VIT), Tamil Nadu for CIBA-Plankton^{Plus} technology transfer

ICAR-CIBA signed Memorandum of Understanding (MoU) with Vellore Institute of Technology (VIT), Vellore, Tamil Nadu on 3rd April, 2023 for transferring the CIBA-PlanktonPlus production technology on non-exclusive basis. CIBA-Plankton^{Plus} is a value added product developed from fish waste/trimmings using a unique technology which helps in maintaining healthy phytoplankton and zoopalknkton bloom in shrimp and fish culture ponds and also aids in efficient feed management. Dr Kuldeep K. Lal, Director, ICAR-CIBA while signing the MoU stressed upon generating adequate data on the field performance of Plankton^{Plus} in agriculture and horticulture crops. He complimented the VIT for recognising the technology and coming forward to sign the MoU. Dr Debasis De, Principal Scientist, CIBA and team leader of this technology briefly explained the potential of CIBA-Plankton^{Plus} in enhancing the aquaculture productivity.

ICAR-CIBA joined hands with Shri A.M.M. Murugappa Chettiar Research Centre for exploring the potential benefits of CIBA-Plankton^{Plus} in paddy crops

ICAR-CIBA signed a Memorandum of understanding (MoU) with Shri A.M.M. Murugappa Chettiar Research Centre (MCRC), Chennai, Tamil Nadu on 4th July, 2023 for evaluation the efficacy of fishwaste converted CIBA-Plankton^{Plus} in paddy crop. Dr Kuldeep K. Lal, Director, ICAR-CIBA stressed upon the need to explore the use of Plankton^{Plus} in agriculture and horticulture crops to increase the demand for the product. Dr Debasis De, Principal Scientist, CIBA and team leader of CIBA-Plankton^{Plus} technology informed that the potential use of CIBA-Plankton^{Plus} in agriculture can be explored at the field level through collaborative research with MCRC. Dr N. Unnamalai, Principal Scientist, MCRC said that they are hopeful that application of CIBA-Plankton^{Plus} will improve the yield and quality of paddy.

ICAR-CIBA signed Memorandum of Understanding (MoU) with Sai Aqua Feeds for large scale field demonstration of 'CIBA EHP Cura I'.

ICAR-CIBA has developed a cure for EHP named 'CIBA EHP Cura- I' after 5 years of exclusive research on EHP therapeutics. 'CIBA EHP cura-I' significantly controls the proliferation of EHP, reduces bacterial load and significantly improves the immunity, health, and growth of shrimp. ICAR-CIBA signed a Memorandum of Understanding (MoU) with Sai Aqua Feeds, Guntur, Andhra Pradesh on 6th September 2023 for a collaborative research for field validation of CIBA EHP Cura I'- technology. Dr Kuldeep K. Lal, Director, ICAR-CIBA highlighted the severity of EHP pathogen in shrimp aquaculture and the significance of CIBA EHP cura I in the field. Dr T. Sathish Kumar, Scientist and principal investigator of CIBA EHP cura I, briefed about the importance of this product and informed the association with Sai aqua feeds in initial field trials.

ICAR-CIBA inks MOU with Kings Infra for development of sustainable brackishwater aquaculture during the Global Summit at New Delhi

ICAR-CIBA, Chennai signed MoU with Kings Infra Ventures Pvt. Ltd for scientific collaboration during a seminar on "Sustainable Aquaculture: India's potential to be the Global Reader" was hosted by Kings Infra, a BSE- listed market leader in sustainable aquaculture on September 25, 2023, in New Delhi. The partnership, inter-alia will cover promoting domestication of indigenous native species like Indian white shrimp and promote diversified systems including Biofloc/ RAS/ IPRS based systems for sustainable aquaculture. This partnership also will provide need-based training, demonstrations and technical support for brackishwater finfish, shellfish and seaweed farming. Dr Kuldeep K. Lal, Director, ICAR-CIBA, Chennai, called for emphasizing diversification and recommended best management practices for a sustainable farming. Dr Akshya Panigrahi, Principal Scientist and team leader of the collaboration explained the need for thrust on indigenous species and system diversification.

KRC of ICAR-CIBA inked MoU with M/s. Kamala Feeds, West Bengal for operation of KRC feed mill on Public Private Partnership mode

KRC of ICAR-CIBA and M/s. Kamala Feeds, North 24 Parganas, West Bengal inked a Memorandum of Understanding on October 3, 2023 for operating the feed mill at KRC, Kakdwip and production of the different aqua feeds developed by ICAR-CIBA on public private partnership mode. The MoU was signed by Dr Debasis De., Head of Research Centre, KRC of ICAR-CIBA, Kakdwip and Mr Swapan Kumar Barui, Proprietor of Ms. Kamala Feeds in the presence of Dr Kuldeep K. Lal, Director, ICAR-CIBA. Dr Kuldeep K Lal., Director, ICAR-CIBA, stressed the importance of formulated feed for the commercial production of fish or shrimp. He expressed that the partnership in operating the feed mill will help in popularizing and up-scaling the CIBA cost effective feed technologies.

ICAR-CIBA and SRM Institute of Science and Technology, Chennai signed MoU for collaborative research on using engineering techniques in fish breeding

ICAR- CIBA signed a Memorandum of Understanding (MOU) with SRM Institute of Science and Technology (SRMIST), Chennai for collaborative research on 02.11.2023. The main area of collaboration is development of deep learning based ultrasound non-invasive tool for assessing the gonadal maturity of brackishwater fish species. Dr Kuldeep K Lal, Director, CIBA in his introductory talk briefed about the importance of bringing in the latest techniques of engineering into the aquaculture in broader manner and in fish reproduction and breeding in specific focus. Dr T. Senthil Murugan, Principal Scientist and team leader explained in detail about the proposed plan of work to be taken up on developing non-invasive ultrasound tool for assessing the gonadal maturity of brackishwater fishes, Dr R. Gopal, the Dean, College of Engineering and Technology, SRMIST explained about the facilities available with them in the fields of image pre-processing and processing using AI and DNN.

ICAR-CIBA signed MoU with D-NOME Pvt. Ltd., Hyderabad a synthetic biology start-up company, to develop point-of-care diagnostics for aquaculture

ICAR-CIBA, Chennai signed MoU on November 3, 2023 with M/s. D-Nome Pvt. Ltd., Hyderabad for collaborative research programme on R&D of innovative point-of-care diagnostics for infectious diseases in aquaculture. The partnership will cover development of field level sensitive diagnostic kits for detection of pathogens like white spot syndrome virus (WSSV), and microsporidian *Enterocytozoon hepatopenaei* (EHP) which are globally most prevalent and lethal for shrimp aquaculture industry resulting in severe economic loss. Dr Kuldeep K. Lal, Director, ICAR-CIBA, emphasized on the need of simple and cost effective diagnostic kits which can be applied in field without the use of sophisticated equipments enabling farmers to undertake effective measures in controlling the spread of the disease. Dr Divya Sriram, CEO and CO-founder of D-NOME explained about their experience in developing rapid and affordable diagnosis of rising infectious diseases using molecular techniques. Team leader of the program, Dr M. S. Shekhar, Principal Scientist and Head, Aquatic Animal Health and Environment Division, explained the need for thrust on innovations in offering simple and easy disease diagnosis at farm level for adoption of timely management measures for effective control and spread of the diseases.

ICAR-CIBA signed MoU with M/s. Manjha Technologies Pvt. Ltd., Haryana to promote aquaculture activities in the inland saline areas of North India

ICAR-CIBA signed a Memorandum of Understanding (MoU) with M/s. Manjha Technologies Private Limited, Haryana on 1st November, 2023 to promote research and extension services for shrimp aquaculture in the inland saline areas of North India. Dr Kuldeep. K. Lal, Director CIBA highlighted the strength of CIBA in improved production techniques, transfer of technologies in addition to providing technical guidance to stakeholders. He expressed the possibility of collaboration in the areas of training, extension services to disseminate the best management practices, prevention and control of diseases and to enhance the sustainability of aquaculture. This collaboration is aimed at promoting responsible and environmentally friendly aquaculture in the inland saline areas. Mr Shobhit Aggarwal, Co-founder of M/s. Manjha Technologies highlighted the importance of this partnership and expressed that this will be a successful initiative program to attain the goals of promoting responsible and environmentally friendly aquaculture in the inland saline areas.

REVENUE GENERATED

SERVICES OFFERED AND NAME OF THE FIRM	REV. GEN. (in lakhs)
Consultancy service for Asian Seabass Seed Production for Billion Aqua INC, B-96 Journalist colony, Jubilee Hills, Hyderabad, Telangana - 500 033	2.36
Consultancy service for setting up of Pearlspot hatchery to Dr Dinesan Cheruvat, Executive Director (Matsyafed), Agency for Development of Aquaculture Kerala (ADAK), Government of Kerala, Matsyafed Fish Farm, Palaikari, Kottayam, Kerala	2.32
Technical Support on the Nursery Rearing of Asian Seabass (*Lates calcarifer*) for Aqua Farmer, Mr B. Mohan Reddy & Mr M. Kiran Kumar, No. 310, 4th floor, Sunrise towers, Hare Krishna Towers, Near Anamayaa Circle, Nellore, Andhra Pradesh.	1.18
Consultancy Services on Fish Feed Processing And Production for Aqua Farmer, Mr B. Mohan Reddy & Mr M. Kiran Kumar, No. 310, 4th floor, Sunrise towers, Hare Krishna Towers, Near Anamayaa Circle, Nellore, Andhra Pradesh.	1.18
Consultancy services on fish feed formulations, processing and production for M/s. Siri Industries, No. 37, Opp. KIADB Water Tank. 2nd Phase, Antharasanahalli Ind. Area, Tumakuru, Karmataka	1.18
Contract research service for evaluation of Black Soldier Fly larvae meal (*Hermetia illucens*) for growth and disease resistance properties in penaeid shrimps for M/s. UltraNutri India Pvt. Ltd. located at 9th Floor Prestige Meridian -1, 29, M.G. Road Bangalore, Karnataka 560001	13.5
Transfer of Technology Of Plankton^{Plus} Production Registrar, Vellore Institute of Technology, Vellore- 632014, Tamil Nadu	5.9
Contract Research fee for the usage of Black Soldier Fly (BSF) Frass for shrimp farming M/s. BIOADAPTIS, VPO, Mahalon, Banga Raod, Nawanshahr, Punjab.	0.29
Contract research for the amelioration of glucosinolates in rapeseed meal for tilapia and milkfish feed production for M/s. Proteos Uno., located at Flat No. 7P (C Block), Jains West Minister Apartment, Arunachalam Road, Saligramam, Chennai	1.77
Contract research for the evaluation of therapeutic efficacy of organic acid based product against shrimp pathogens (*Vibrio* sp. – phase – i, *Enterocytozoan hepatopenaei* – phase - ii) for M/s. Trouw Nutrition India Private Limited, Plot No. G 24, Polepally Village Jadcherla Mandal, Mahabubnagar-509350, Telangana, India	12.17
Consultancy services on fish feed processing and production for Sri Raju Bhogil	1.18
Collaborative research programme to carry out the field demonstration trials for the evaluation of "Ciba EHP Cura I" technology with M/s. Meenam Aqua Needs, Door no. 4-60/4, Plot no.114, Bahadurpally village, Dundigal- Gandimaisamma Mandal, Medchal-Malkajgiri District, Hyderabad, Telangana	2.36
Consultancy Services & collaborative research for the usage of black soldier fly (BSF) meal for aquaculture for Insectika Biotech Private Limited located at Plot: 1034, Phase – II, Dumduma Housing Board Colony, Bhubaneswar, Pincode – 751019,	3.54

Consultancy Service For Shrimp Feed Processing And Production Mr Chandrasekhar Varma, Lalitha Feeds, 2-103, Vasanth Vihar, Kothavalasa, Vizianagaram, Andhra Pradesh	3.54
Providing technical services for shrimp crop insurance for Agriculture Insurance Corporation of India, New Delhi	7.83
Collaborative research programme to carry out the field demonstration trials for the evaluation of "Ciba EHP Cura I" technology with M/s. Sai Aqua Feeds having its office at # 505, Gayatri Prince, Bapatla, Guntur District, Andhra Pradesh	2.36
Evaluating the Utility of phytogenic feed additive (Economix) in shrimp diet for M/s. Proteos Uno, Chennai	8.49
Collaboarative research programme for R & D of point of care diagnostics for M/s. D-Nome Pvt. Ltd., 3rd Floor, CCMB Annex-2, Habsiguda, Hyderabad 500007 Telangana	0.59
Technology transfer for the establishment of shrimp larval feed production M/s. Amiti Empiric Technologies LLP, No. 9, 10th B cross, Amruth Nagar, Bengaluru – 560092, Karnataka.	1.18
TOTAL	**72.92**

AGRI-BUSINESS ACTIVITY

Patents Applied

Composition and method of controlling EHP and improving growth and survival of shrimp. Date of Application : December 12, 2023

Patents Granted

Microbial consortia for removal of toxic nitrogenous metabolites in brackishwater aquaculture. Patent Granted Patent Number: 446373. Date of Grant: August 22, 2023.

Providing incubator facility to M/s. Kamala Feeds

Skill cum entrepreneurship development training program on "Aquafeed Preparation Techniques and Quality Control" organized at ICAR CIBA

राजभाषा कार्यान्वयन

आईसीएआर-सीबा में 14-20 सितंबर, 2023 के दौरान हिंदी सप्ताह का आयोजन

राजभाषा के रूप में हिंदी के उपयोग को बढ़ावा देने के लिए आईसीएआर-सीबा ने 14-20 सितंबर 2023 के दौरान हिंदी सप्ताह का आयोजन किया। सप्ताह के दौरान, हिंदी टिप्पण- प्रारूप लेखन, कविता और गीत गायन, आशु भाषण, शब्दावली, प्रश्नोत्तरी जैसी विभिन्न प्रतियोगिताओं का आयोजन किया गया, जिसमें सीबा के वैज्ञानिकों, कर्मचारियों और अनुसंधान विद्वानों ने उत्साहपूर्वक भाग लिया। उपरोक्त के अलावा, आधिकारिक कामकाज में हिंदी के उपयोग को बढ़ावा देने के लिए "हिंदी प्रोत्साहन योजना" के तहत एक और प्रतियोगिता भी आयोजित की गई थी। इन प्रतियोगिताओं में कुल 143 प्रतिभागियों ने भाग लिया। संस्थान की गृह पत्रिका जल तरंग (अंक-8) का विमोचन माननीय केन्द्रीय मत्स्य एवं पशुपालन मंत्री, भारत सरकार श्री परषोतम रुपाला जी एवं अन्य गणमान्य के उपस्थिति में हिन्दी दिवस के शुभ अवसर पर संस्थान के नवसारी केंद्र पर संपन्न हुआ।

समापन समारोह के दौरान श्रीमती कोमल श्योकंद, वरिष्ठ वित्त एवं लेखा अधिकारी ने क्विज प्रतियोतिता का संचालन किया जिसमें लगभग 105 प्रतिभागी ने भाग लिया. समापन समारोह 20 सितंबर, 2023 को आयोजित किया गया था जिसमें डॉ. ए. श्रीनिवासन, राजभाषा अधिकारी, दक्षिण रेलवे मुख्यालय, चेन्नई मुख्य अतिथि थे। श्री नवीन कुमार झा,, प्रभारी अधिकारी, हिंदी सेल ने वर्ष 2022-23 के दौरान हिंदी सेल की उपलब्धियां प्रस्तुत कीं। श्री झा ने प्रतिभागियो को सूचित किया कि हिंदी सप्ताह के दौरान कार्यालय के फाईल संबंधी कार्य में लगभग 10% पत्राचार एवम टिप्पण में राजभाषा के प्रयोग में वृद्धि देखा गया. इस अवसर पर संस्थान के निदेशक डॉ. कुलदीप के. लाल ने वर्तमान गतिशील विश्व में हिंदी, क्षेत्रीय भाषा एवं अंग्रेजी के महत्व पर बल दिया। अध्यक्षीय भाषण में, निदेशक ने भारत की भाषाई विविधता और पूरे देश के संचार में हिंदी के महत्व पर टिप्पणी की।

अपने भाषण में मुख्य अतिथि ने कर्मचारियों को दैनिक कार्यालय कार्यों में हिंदी का यथासम्भव प्रयोग करने के लिए प्रेरित किया। निदेशक महोदय एवम मुख्य अतिथि ने सीबा वार्षिक रिपोर्ट-2022 (हिंदी संस्करण) का विमोचन भी किया और विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कार वितरित किए। हिंदी सेल के सदस्य डॉ. एम. शशि शेखर, डॉ. सुजीत कुमार, डॉ. जे. रेमंड जानी एंजेल एवम कुंदन कुमार आदि ने कार्यक्रमों के संचालन में सक्रिय सहयोग किये। कार्यक्रम का समापन डॉ. प्रसन्न कुमार पाटिल एवं सदस्य, हिन्दी कक्ष के धन्यवाद ज्ञापन के साथ हुआ।

सीबा के काकद्वीप शोध केंद्र में हिंदी सप्ताह समारोह

आईसीएआर-सीबा के काकद्वीप अनुसंधान केंद्र ने कर्मचारियों के बीच राजभाषा के रूप में हिंदी के उपयोग को बढ़ावा देने और प्रोत्साहित करने के लिए 14 से 20 सितंबर 2023 तक हिंदी सप्ताह मनाया गया। उद्घाटन कार्यक्रम में काकद्वीप अनुसंधान केंद्र के प्रमुख डॉ. देबासिस डे ने कार्यालय कार्य में हिंदी के प्रयोग की आवश्यकता पर बल दिया. प्रश्नोत्तरी, टिप्पण और प्रारूपण, गायन, कविता पाठ और तात्कालिक भाषण जैसी प्रतियोगिताएँ आयोजित की गईं। केंद्र के वैज्ञानिकों, कर्मचारियों और अनुसंधान विद्वानों सहित कुल 54 प्रतिभागियों ने उत्साहपूर्वक भाग लिया। समापन समारोह 20 सितंबर, 2023 को केआरसी के सेमिनार हॉल में आयोजित किया गया था। भारतीय स्टेट बैंक, काकद्वीप शाखा के मुख्य प्रबंधक श्री संजीव कुमार को मुख्य अतिथि के रूप में आमंत्रित किया गया था। उन्होंने विभिन्न प्रतियोगिताओं के सभी विजेताओं को पुरस्कार प्रदान किये। अपने भाषण में उन्होंने कर्मचारियों को दैनिक कार्यालय कार्यों में हिंदी का अधिकाधिक प्रयोग करने के लिए प्रेरित किया। कार्यक्रम का संचालन सुश्री बबीता मंडल एवं सुश्री मौमिता ऐश ने किया।

RESEARCH & ADMINISTRATIVE MEETINGS

RESEARCH ADVISORY COMMITTEE (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F. No. 18-3/2016-ASR-I dated 10.02.2023) for a period of three years with effect from 01.01.2023 to 31.12.2025.

Chairman	**Dr Iddya Karunasagar**
Members	Dr A. Laxminarayan Prof T. J. Abraham Dr A. K. Pal Dr M. Sudhakar Dr Shubhadeep Ghosh, ADG (M.Fy.) Dr Kuldeep K. Lal, Director ICAR CIBA
Member Secretary	**Dr K. P. Kumaraguru Vasagam**

The 28th meeting of the Research Advisory Committee (RAC) of CIBA was held during 24th and 25th March, 2023 at CIBA Headquarters, Chennai.

INSTITUTE RESEARCH COUNCIL (IRC)

The Institute Research Council (IRC) of CIBA has been constituted as follows:

Chairman	**Dr Kuldeep K. Lal, Director**
Members	Dr C. P. Balasubramanian, Principal Scientist & HOD- CCD Dr M. Kailasam, Principal Scientist & HOD -FCD Dr M. S. Shekhar, Principal Scientist & HOD-AAHED Dr K. Ambasankar, Principal Scientist & HOD-NGBD Dr T. Ravisankar, Principal Scientist & SIC-SSD Dr Debasis De, Principal Scientist & HOD – KRC Dr Akshaya Panigrahi, Principal Scientist & SIC-NGRC And Principal Investigators of all the projects
Member Secretary	**Dr C.V. Sairam, Principal Scientist, OIC PME, & Member Secretary, IRC**

The 40th IRC Meeting was held on 26-28th April 2023 at CIBA Headquarters, Chennai and the progress of research work was reviewed.

INSTITUTE MANAGEMENT COMMITTEE (IMC)

The Institute Management Committee has been constituted as follows:

Chairman	**Dr Kuldeep K. Lal, Director**
Members	Dr T. K. Ghoshal, Principal Scientist, ICAR-CIFE, Mumbai, Maharashtra Dr P. R. Divya, Principal Scientist, ICAR - NBFGR , Kochi Dr G. S. Saha, Principal Scientist, ICAR-CIFA, Bhubaneswar Odisha Dr Pravata K. Pradhan, Principal Scientist, ICAR-NBFGR, Lucknow (UP) Commissioner of Fisheries, Govt. of Tamil Nadu, Chennai Director of Fisheries, Govt. of Kerala, Trivandrum The Dean, College of Fisheries, WBUAFS, PO Panchasagar, Chakagaria, Kolkata (WB) Dr Shubhadeep Ghosh, Assistant Director General (Marine Fisheries) , ICAR, New Delhi. Shri Kunal Kalia, Deputy Director (Finance), ICAR, New Delhi
Member Secretary	**Smt V. Usharani, Administrative Officer**
Co-opted Members	Dr C. V. Sairam, Principal Scientist & OIC, PME Cell Dr P. Mahalakshmi, Principal Scientist & OIC Engineering Cell & AKMU Shri Navin Kumar Jha, CAO & Head of Office Smt Komal Sheokand, Senior Finance & Accounts Officer Smt E. Amudhavalli, AAO (C&B) Shri A. Sekar, AAO (Estt.) Shri P. Srikanth, AFAO Smt E. Mary Desouza, AAO (Stores)
Non-Official Members	Shri P. Senthil Nathan. Farmers' Representative Shri S. Elangovan, Farmers' Representative

The 55th meeting of the Institute Management Committee (IMC) of CIBA was held in the CIBA Headquarters, Chennai on 31st October, 2023.

INSTITUTE JOINT STAFF COUNCIL (IJSC)

The composition of the Institute Joint Staff Council was reconstituted by CIBA for a period of three years w.e.f. 13.09.2022 to 12.09.2025 vide Office Order F. No. 13-1/2012-Admn. Vol-VIII dated 14.09.2022 is as follows:

Official Side	
Chairman	**Dr Kuldeep K. Lal, Director**
Member Secretary	Dr T. Ravisankar, Principal Scientist
Members	Dr M. Jayanthi, Principal Scientist Dr S. Kannappan, Principal Scientist Shri Navin Kumar Jha, CAO & Head of Office Smt Komal Sheokand, Senior Finance & Accounts Officer Smt V. Usharani, AO
Staff Side Secretary & CJSC Member Representative	
	Shri N. Jagan Mohan Raj, Technical Officer
Members	Shri Solin Igneshus, LDC Shri Kishorkumar.V, LDC Shri S. Prabhu, Technical Assistant Shri R. Mathivanan, Skilled Support Staff Shri Indra Kumar, Skilled Support Staff

GRIEVANCE COMMITTEE

The composition of the Institute Grievance Committee (reconstituted by CIBA vide Office Order F.No.48-16/2010-Admn. dated 02.07.2019) is as follows:

Chairman	**Dr Kuldeep K. Lal, Director**
Elected Members	
Scientific Members	Dr K. Ambasankar, Principal Scientist & SIC-Nutri. Dr Nila Rekha, Principal Scientist
Technical Member	Dr Joseph Sahaya Rajan, ACTO
Administrative Members	Mrs V. Usha Rani, AO Shri P. Srikanth, AFAO
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, Technical Officer Smt E. Mary Desouza, AAO
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 reconstituted vide F. No. 48-16/2010-Admn. dated 28.06.2022 as follows:

Chairman	**Dr Sherly Tomy, Principal Scientist**
Members	Dr P. Mahalakshmi, Principal Scientist Smt K. Jacquline, ACTO Smt E. Mary Desouza, AAO Smt S. Nalini, Private Secretary Smt K. Subhashini, Personal Assistant
Member Secretary	Smt V. Usharani, AO

The meeting of the Women cell of CIBA with the new members was held in the CIBA Headquarters, Chennai on 30th January 2023 & 19th February 2023.

SERVICES & ASSIGNMENTS

Dr Kuldeep K. Lal, Director

- Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai.
- ICAR Regional Committee No. VIII
- Executive Committee Member - National Centre for Sustainable Aquaculture (NaCSA)
- Coastal Aquaculture Authority
- Director – Board of Tamil Nadu Fisheries Development Corporation Limited, Chennai.
- Extension Council of ICAR-Central Institute of Fisheries Education, Mumbai
- Board of Management of ICAR - Central Institute of Fisheries Education, Mumbai
- Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur
- Scientific Advisory Committee, Dr Perumal Krishi Vigyan Kendra
- Scientific Advisory Committee, ICAR- Krishi Vigyan Kendra, Tiruvannamalai
- National Committee on Introduction of Exotic Aquatic Organisms into Indian waters, constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi.
- Advisory Committee on Hilsa Conservation and Research.
- 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.
- 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.
- 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.
- Expert Committee to assess the situation of AHPND in the affected countries and the possible risks in such import in the present situation and suggest measures to be adopted in case of lifting the existing ban in India, constituted by Coastal Aquaculture Authority.
- Scientific Panel on Fish and Fisheries Research Products, constituted by the Food Safety and Standards Authority of India, New Delhi.
- Expert Committee to draft Rules/Regulations and Guidelines for 'The Coastal Aquaculture Authority (Amendment) Act, 2023, constituted by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India.
- Technical Committee constituted to oversee and monitor the functioning of the Aquatic Quarantine Facility (AQF), constituted by Coastal Aquaculture Authority.
- Sub-Committee on "SPS & Quality Assurance for Marine Products Export Promotion" constituted by MPEDA, Kochi
- Sub-Committee on Species Diversification & New Technology Adoption for Marine Products Export Promotion, constituted by MPEDA, Kochi.
- Sub-Committee on Aquaculture Regulation & Traceability for Marine Products Export Promotion, constituted by MPEDA, Kochi.
- Society of Coastal Aquaculture and Fisheries (SCAFi)
- Member - Asian Fisheries Society Indian Branch & Councilor, Asian Fisheries Society, Kuala Lumpur

Scientists:

Member of Expert Committee to develop Standard Operating Procedures for the import of SPF broodstock of crustaceans from South East Asian Countries, April 2023 – **Dr S.K. Otta**

Academic Council member, KUFOS, Kerala – Dr S.K. Otta

Associate member of the aquaculture subcommittee under FAD 12.1 of BIS – **Dr S.K. Otta**

Member of Advisory Committee for monitoring the DBT PGT-sponsored MSc in Marine Biotechnology at Nitte University, Mangalore – **Dr S.K. Otta**

Member, national organising

committee for International conference on "Aquatic Animal Epidemiology (AquaEpi III)", NBFGR, Lucknow, 29th November to 1st December 2023 – **Dr S.K. Otta**

Editorial Advisory Board Member, Aquaculture Journal – **Dr Sherly Tomy**

Board member of TNJFU, Nagapattinam – **Dr S. Kannappan**

Member, Student Advisory Committee of Tamil Nadu Dr J. Jayalalitha Fisheries University, OMR, Chennai – **Dr R. Jayakumar**

Member, Committee constituted by the National Ocean Technology, Chennai for development of open sea fish cage technologies – **Dr R. Jayakumar**

Member, Editorial Advisory Committee, Journal of Marine Biosciences - **Dr R. Jayakumar**

Member, National Committee on Introduction of Exotic Aquatic Species into Indian waters- **Dr R. Jayakumar**

Acting as a Academic Editor of the Aquaculture Research journal of Hindawi/Wiley publisher - **Dr Ritesh Shantilal Tandel**

External Member of Institute Biosafety Committee of Madras Veterinary College, TANUVAS, Chennai – **Dr P. Ezhil Praveena**

Member (Outside) - for Internal Complaints Committee of ICAR – National Research Centre for Banana, Thriuchirapalli, Tamil Nadu - **Dr P. Ezhil Praveena**

Acting as alternate member of BIS Sectional Committee, TXD 18, Textile Materials for Marine/Fishing Purposes - **Jose Antony**

Member of CAA committee for inspection and registration of hatcheries in Gujarat - **Jose Antony**

CCSEA nominee to the IAEC of Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), BCG Vaccine Laboratory (BCGVL), Government Kilpauk Medical College (GKMC), M/s. Bioklone biotech Pvt. Ltd., Christian Medical College, and Ramachandra Medical College and Research Institute, Tamil Nadu during 2023 – **Dr R. Ananda Raja**

National Accreditation Board for Testing and Calibration Laboratories (NABL) Assessor as per ISO/IEC 17025:2017 to Captain Srinivasa Murti Regional Ayurveda Drug Development Institute, Translational Research Platform for Veterinary Biologicals (TRPVB), Centurion University of Technology and Management (CUTM), BAIF Analytical Laboratories, SRM Institute of Science and Technology – SRM DBT platform for advanced life science technologies, and National Dairy Development Board (NDDB) Research and Development Laboratory during 2023 – **Dr R. Ananda Raja**

Technical and Inspection Committee member for registration and renewal of 49 *Litopenaeus vannamei*, three *Penaeus monodon* and one multi-species finfish hatcheries located in Tamil Nadu, Andhra Pradesh and Odisha during 2023 – **Dr R. Ananda Raja**

Technical and Inspection Committee member for inspection of the Broodstock Multiplication Centre (BMC) facility on 28th October, 2023 at M/s, Kona Bay India Private Limited, Kotapalem, Ranastalam, Srikakulam District, Andhra Pradesh constituted by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India – **Dr R. Ananda Raja**

Member of expert panel for imported Live SPF Polychaete worms In-House quarantine facility of Animal Quarantine and Certification Service, Chennai. Quarantine facility at M/S. NSR Traders, Andhra Pradesh; M/S DNA World, Pondicherry; M/S Amiti Blue Tech Solutions, Andhra Pradesh – **Dr T. Bhuvaneswari**

Acted as a member for inspection of shrimp hatchery for registration and renewal of hatcheries located at SPSR, Nellore, Andhra Pradesh on 02.11.23 - **Dr Sujeet Kumar**

Swachh hi Sewa

Swachhta Pakhwada Activities

ICAR-CIBA, Chennai, has organised Swachh Hi Sewa and Swachhta Pakhwada 2023 during 15 September to 2nd October 2023, and 16-31 December 2023 respectively at headquarters, Chennai, Muttukadu Experimental station (MES) of CIBA, Muttukadu, Kovalam Experimental Station (KES) of CIBA, Kelambakkam, Kakdwip Research Centre (KRC) of CIBA, Kakdwip, West Bengal, and Navsari-Gujarat Research Centre (NGRC) of CIBA, Navsari, Gujarat. CIBA scientists, staff and students have organized various activities at Institute campuses and adopted villages such as weeding of files, disposal of office scrap materials, and outdoor special swachhta programmes on waste to wealth, cleanliness drives, rallies, tree planation, waste management, kitchen garden, quiz competition, drawing competition etc. More than 960 participants, scientists, staff, farmers and students participated in the various activities.

Swachhata Pledge was taken by the Scientists, Officers, Staff and Students of CIBA. Dr Kuldeep K. Lal, Director, CIBA, Chennai, sensitizes the participants about reduce, reuse and recycle of waste materials, to shun the usage of single use plastics in their working place, residential places and also the nearby water bodies and its maintenance. CIBA scientist highlighted the scholars for reduction in use of plastic materials, awareness creation, promoting individuals responsibility and monitoring and implementation of the programmes like "Clean India" are the measures for beating the plastic pollution.

Swachhata Pledge at ICAR headquarters, Chennai, Tamil Nadu

Massive mobilization for plastic waste shramdaan and safe disposal of degradable/ non- degradable items among school students and farming communities were conducted to create awareness on waste management, cleanliness, hygiene, sanitation and taken pledge for single use plastic ban and discharge the use of plastics in the programme. Single use plastics related videos were showed to students for creating awareness. In addition coastal and beach areas in Tamil Nadu were cleaned with active participation of CIBA staff and college students. Followed by students were planted trees inside experimental station as a simple of go green campus. Various placards explaining about different means to avoid plastic waste 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. Single use plastics related videos were showed to students for creating awareness.

Community mobilization for plastic waste shramdaan, Elavur village, Tiruvallur, Tamil Nadu

Awareness cum cleaning program at coastal area, Kottaikadu, Kancheepuram district, Tamil Nadu

Cleaning of Muttukadu beach area, Muttukadu, Kancheepuram district, Tamil Nadu

Tree planation by school students of Sri Sankara Global Academy, Kilattalai, Chennai at MES of CIBA, Muttukadu, Tamil Nadu

Awareness program on shun single use plastics for scheduled caste and scheduled tribe farmers at KRC of CIBA, Kakdwip, West Bengal

Rallies on shun single use plastics at M.R.C Road, ICAR-CIBA, Chennai

Awareness on safe disposal of degradable/non- degradable items and shut single use plastic and Distribution of Materials among pulicat farmers, Tamil Nadu

CIBA scientists addressed the farmers about the importance of utilization of homestead and fish pond fallow land by converting to kitchen garden for cultivation of horticultural crops that provide extra incomes, meet up domestic needs for vegetables and nutrition, and create clean and esthetic surroundings of a house. This would also help in keeping house premise weed free and maintaining healthy organic environment. Therefore, maintenance of kitchen garden as a household activity by small and marginal farmers is promoted in the adopted tribal village. In addition to organise awareness programmes, CIBA has distributed fish waste to valued added products, Planktonplus and Horti^{Plus}, vegetable farming materials, tanks, drip irrigation items, vegetable seeds and cloth bags were distributed to the farmers, villagers and students.

Awareness programme on Kitchen gardening and distribution vegetable saplings at Singod Village, Navsari, Gujarat

Awareness cum distribution of Materials to Villagers, Maathampattinam village, Sirghazi taluk of Mayiladuthurai district of Tamil Nadu

As a part of programme, drawing competition and quiz competition were organized for school students with the theme, "Clean India, Green India" and "Protection of environment and avoiding of food waste" respectively. The certificates and prize for the winners of the competition was distributed.

ICAR-CIBA, Chennai distributed cloth bags to school students at Regunathapuram village, Ramanathapuram district, Tamil Nadu

Drawing competition among students at Kakdwip Research Centre of CIBA, West Bengal

Prize and certificate distribution - quiz competition at Sundarban Adarsha Vidyamandir, Kakdwip, West Bengal

MERA GAON MERA GAURAV PROGRAMME

ICAR-CIBA has implemented the innovative imitative of Mera Gaon Mera Gaurav Scheme in three adjacent districts viz., Chennai, Chengalpattu and Thiruvallur. Multidisciplinary team of scientists regularly visit the MGMG villages and update the villagers about new farming practices and Government schemes. During the visit, focussed group discussions and interface meetings were also held with village leaders, fish farmers and women to make them recognize that MGMG programme could play a vital role in their day to day farming activities. They were provided with required information, knowledge and advisories on shrimp/fish culture aspects. The Scientists team also focussed on :

- Awareness for sensitizing villagers about the drive of the developmental programmes, knowledge and advisories.
- Free water sample analysis and recommendations to the farmers.
- Dissemination of women friendly technologies.
- Development of women leadership and entrepreneurship.
- Distribution of extension literatures in local language on the culture aspects for the benefit of the farming community.
- Mobile advisories
- Wealth from waste
- Local specific problems were addressed.

ICAR-CIBA organised 85 activities under MGMG such as visit to villages, interface meetings, trainings and demonstrations, mobile advisories, literature support and general awareness programmes. The team of Scientists had undertaken 45 visits to the villages, conducted 17 interface meetings and one training programme, under the patronage of the MGMG programme. In addition, 12 demonstrations were conducted, 68 mobile advisories have been disseminated, and 4 awareness campaigns were organized. The total number of activities conducted was 45 and 1306 coastal farmers got benefitted out of it.

DISTINGUISHED VISITORS

Sl. No.	Details of visitors	Date of visit
Headquarters		
1	Shri Parshottam Rupala, Honourable Union Minister of Fisheries, Animal Husbandry and Dairying, Govt. of India	27th February, 2023
2	Dr L. Murugan, Hon'ble Union Minister of State for Fisheries, Animal Husbandry and Dairying & Information Broadcasting, Govt. of India	27th February, 2023
3	Shri Jatindra Nath Swain, IAS, Secretary, Department of Fisheries, Government of India	27th February, 2023
4	Dr J. K.Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi.	27th February, 2023
5	Dr J. Balaji, Joint Secretary, Department of Fisheries, Government of India	27th February, 2023
6	Shri A. Karthik, IAS, Principal Secretary, Fisheries Department, Govt. of Tamil Nadu	27th February, 2023
7	Dr U. K. Sarkar, Director, ICAR-National Bureau of Fish Genetic resources, Lucknow	27th February, 2023
8	Dr Suvana, IFS, Chief Executive, National Fisheries Development Board (NFDB), Govt. of India	1st -3rd March, 2023
9	Smt Usha P. T, Regional Manager, NABARD, Regional Office, Chennai	1st -3rd March, 2023
10	Dr S. Santhanakrishnan founder president Society of Aquaculture Professionals (SAP)	1st -3rd March, 2023
11	Dr Arul Victor Suresh, President, Society of Aquaculture Professionals (SAP)	1st -3rd March, 2023
12	Ms. Girija Subramanian, Chairman Cum Managing Director, AIC India	1st -3rd March, 2023
13	Dr V. Kripa, Member Secretary, Coastal Aquaculture Authority, Chennai	1st -3rd March, 2023
14	ShriN.Venkatesh, IAS, Senior Executive Director, National Fisheries Development Board (NFDB), Govt. of India	16th March, 2023
15	Mrs Joyce Olive Rachel, Executive Director, NFDB	16th March, 2023
16	Dr V. Parimalavarsini, Assistant Controller of Patents & Designs, Patent Office, Chennai	26th April, 2023
17	Dr Krishnan Pandian, Director, Bay of Bengal Programme, an Inter-Governmental Organization, Chennai	4th May, 2023
18	Dr P.S.G. Krishnan, Principal Director, Central Institute of Petrochemicals Engineering & Technology (CIPET)	5th June, 2023
19	Thiru S. Annadurai, CLS, Director, Tribal Welfare Department, Govt. of Tamil Nadu	23rd June, 2023
20	Dr Vibha Ahuja, Chief General Manager, BCIL	25th July 2023
21	Shri Sanjiv Kumar, I.A.S., Additional Secretary & Financial Advisor Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying	26th October 2023
Muttukadu Experimental Station (MES) of ICAR-CIBA		
22	Dr C. Suvarna, IFS, Chief Executive, National Fisheries Development Board (NFDB), Govt. of India	1st March, 2023
23	Smt N. Chandra, Executive Director, NFDB	1st March, 2023
Kakdwip Research Centre, West Bengal		
24	Dr Jithendra Kumar Yadav, ADG, NASF	9th September, 2023
25	Dr K. K. Vass, Chairman, Advisory committee of NASF project on Hilsa, Former Director, ICAR-CIFRI	26th -27th December, 2023
26	Dr S. Raizada, Member, Advisory committee of NASF project on Hilsa, Former ADG (Inland Fisheries)	26th -27th December, 2023
Navsari Gujarat Research Centre, Gujarat		
27	Shri Parshottam Rupalaji, Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying, Government of India.	14th September, 2023
28	Shri C. R. Patil, the Honourable Member of Parliament, Navsari	14th September, 2023
29	Dr Z. P. Patel, Hon'ble Vice Chancellor, Navsari Agricultural University, Navsari, Gujarat	14th September, 2023
30	Dr J. K. Jena, the Deputy Director General (Fisheries) of ICAR	14th September, 2023

Shri Parshottam Rupala, Honourable Union Minister of Fisheries, Animal Husbandry and Dairying, Govt. of India visited ICAR-CIBA, Chennai.

Shri Parshottam Rupala, Honorable Union Minister of Fisheries, Animal Husbandry and Dairying, Govt. of India visited ICAR-CIBA, Chennai on the occasion of launching of the two flagship programmes viz. National Surveillance Programme on Fish Diseases – Phase-II and Genetic Improvement Programme of Indian White Shrimp (*Penaeus indicus*) at ICAR-CIBA, Chennai on 27.02.2023. Dr L. Murugan, Hon'ble Union Minister of State for Fisheries, Animal Husbandry and Dairying & Information Broadcasting, Govt. of India who was the guest of honour in his speech gave a detailed account of various initiatives undertaken by the Govt. of India for the fisheries development in the country. Shri Jatindra Nath Swain, IAS, the Secretary, Department of Fisheries, Government of India articulated that two landmark schemes, the NSPAAD phase-II and GIPPI are launched today at CIBA. Dr J. K.Jena in his welcome address expressed his acknowledgment and thankfulness to the Department of Fisheries, Government of India for supporting the NSPAAD and GIPPI. Dr J. Balaji, Joint Secretary, Department of Fisheries, Government of India in his address mentioned that management of diseases and species diversification are the two key aspects for the sustainability of aquaculture. Shri A. Karthik, IAS, Principal Secretary, Fisheries Department, Govt. of Tamil Nadu congratulated the CIBA scientists in unraveling the full genome sequence of P. indicus shrimp which facilitated the genetic improvement programme on the species.

Dr C. Suvarna, IFS, Chief Executive, National Fisheries Development Board (NFDB), Govt. of India visited ICAR-CIBA, Chennai.

Dr C. Suvarna, IFS, Chief Executive, National Fisheries Development Board (NFDB), Govt. of India, visited CIBA on 1st March, 2023 as Chief Guest to inaugurate a training course on Risk Management in Shrimp Farming organised for the officials of the insurance companies.

Shri N. Venkatesh, IAS, Senior Executive Director, National Fisheries Development Board (NFDB), Govt. of India visited ICAR-CIBA, Chennai.

Shri N. Venkatesh, IAS, Senior Executive Director, NFDB chaired the consultation meeting on implementation of aquaculture crop insurance at CIBA Chennai on 16.03.2023 and highlighted that the pilot scale implementation of aquaculture insurance product is to learn the experiences and based on that the product can be refined in tune with the production system, region/ state and farmers affordability and NFDB would support CIBA in developing an aquaculture crop insurance that should be a sustainable and balanced one. Mrs Joyce Olive Rachel, Executive Director, NFDB detailed the insurance product being implemented by the United India Insurance company with a support of NFDB on pilot scale.

Dr V. Parimalavarsini, Assistant Controller of Patents & Designs, Patent Office, Chennai visited ICAR-CIBA, Chennai.

Dr V. Parimalavarsini, Assistant Controller of Patents & Designs, Patent Office, Chennai visited ICAR-CIBA, Chennai as the Guest speaker on the occasion of World Intellectual Property Day, on 26th April 2023 at ICAR-CIBA, Chennai.

Dr Krishnan Pandian, Director, Bay of Bengal Programme, an Inter-Governmental Organization, Chennai visited ICAR-CIBA, Chennai.

Dr Krishnan Pandian, Director, Bay of Bengal Programme, an Inter-Governmental Organization, Chennai graced as Guest of Honor for the four-day workshop cum training programme on Biofloc technology conducted at ICAR-CIBA, Chennai during 1st-4th May, 2023.

Dr P.S.G. Krishnan, Principal Director, Central Institute of Petrochemicals Engineering & Technology (CIPET) visited ICAR-CIBA, Chennai.

Dr P.S.G. Krishnan, Principal Director, Central Institute of Petrochemicals Engineering & Technology (CIPET), Chennai was the chief guest on the occasion of celebration of World Environment Day (WED) at ICAR-CIBA on 5th June, 2023 and in his talk he highlighted that reduction, reuse, recycling and segregation are the methods to minimise the plastic pollution.

Thiru S. Annadurai, CLS, Director, Tribal Welfare Department, Govt. of Tamil Nadu visited ICAR-CIBA, Chennai

ThiruS. Annadurai, CLS, Director, Tribal Welfare Department, Govt. of Tamil Nadu was the Chief Guest for the inaugural session during the national workshop on "Listening to the voices of coastal and tribal women and their success stories and awareness on livelihood opportunities including rural and aqua Tourism" on 23rd June 2023 organized by the ICAR-CIBA.

Dr Vibha Ahuja, Chief General Manager, Biotech Consortium Pvt. Ltd (BCIL) visited ICAR-CIBA, Chennai

Dr Vibha Ahuja, Chief General Manager, Biotech Consortium Pvt. Ltd (BCIL) visited ICAR-CIBA during the workshop on "GM crops and their derivatives for the aqua sector: Opportunities and way forward" on 25 July 2023.

Shri Sanjiv Kumar, I.A.S., Additional Secretary & Financial Advisor Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi visited ICAR-CIBA, Chennai

Shri Sanjiv Kumar, I.A.S., Additional Secretary & Financial Advisor Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying visited the Experimental Station of ICAR-Central Institute of Brackishwater Aquaculture, Muttukadu, Chennai on 26th October, 2023 to review the ongoing PMMSY projects in operation at CIBA. During interactions with scientists, Sanjiv Kumar, I.A.S., emphasized the importance of developing innovative and efficient technology options for the farming community.

Shri Parshottam Rupalaji, Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying, Government of India; ShriC.R. Patil, the Honourable Member of Parliament, Navsari; Dr J.K. Jena, the Deputy Director General (Fisheries) of ICAR visited Navsari Gujarat Research Centre, Gujarat

Shri Parshottam Rupalaji, Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying, Government of India was the Chief Guest and inaugurated the second edition of its Shrimp Farmers Conclave-2023 on 14th September, 2023 at the Navsari Agricultural University Campus, Navsari, Gujarat. ShriC.R.Patil, the Honourable Member of Parliament, Navsari constituency participated in the Conclave as Guest of Honour appreciated ICAR-CIBA for conducting this mega event in Navsari and assured the Navsari-Gujarat Regional Centre of CIBA for all the support. Dr J.K. Jena, the Deputy Director General (Fisheries) of ICAR in his Guest of honour address highlighted that shrimp is the major item contributing about 70% Indian seafood exports in value terms worth Rs.35,000 crores.

PERSONNEL

Sl. No.	NAME	DESIGNATION	REMARKS
1	Dr Kuldeep K. Lal	Director	
2	Dr C. P. Balasubramanian	Head, CCD	Joined on 21.06.2023
3	Dr M. Kailasam	Head, FCD	Joined on 21.06.2023
4	Dr K. Ambasankar	Head, NGBD	Joined on 10.07.2023
5	Dr M. Shashi Shekhar	Head, AAHED	Joined on 17.07.2023
6	Dr K. P. Jithendran	Principal Scientist	
7	Dr C. V. Sairam	Principal Scientist	
8	Dr T. Ravisankar	SIC, SSD	Joined on 10.02.2023
9	Dr M. Muralidhar	Principal Scientist	
10	Dr (Smt) M. Jayanthi	Principal Scientist	
11	Dr (Smt) B. Shanthi	Principal Scientist	
12	Dr (Smt) D. Deboral Vimala	Principal Scientist	
13	Dr (Smt) P. Nila Rekha	Principal Scientist	
14	Dr J. Syama Dayal	Principal Scientist	
15	Dr Akshya Panigrahi	Principal Scientist	
16	Dr M. Kumaran	Principal Scientist	
17	Dr S. Kannappan	Principal Scientist	
18	Dr (Smt) M.Poornima	Principal Scientist	
19	Dr (Smt) R. Saraswathy	Principal Scientist	
20	Dr M.Makesh	Principal Scientist	
21	Dr (Smt) Sherly Tomy	Principal Scientist	
22	Dr Prasanna Kumar Patil	Principal Scientist	
23	Dr Subhendu Kumar Otta	Principal Scientist	
24	Dr (Smt) P. Mahalakshmi	Principal scientist	
25	Dr K.P. Kumaraguru vasagam	Principal Scientist	
26	Dr R. Jayakumar	Principal Scientist	
27	Dr T. Senthil Murugan	Principal Scientist	
28	Dr Vinaya Kumar Katneni	Senior Scientist	
29	Dr Ashok Kumar Jangam	Senior Scientist	
30	Dr (Smt) P. Ezhil Praveena	Senior Scientist	
31	Dr R. Ananda Raja	Senior Scientist	
32	Dr (Smt) Shyne Anand	Senior Scientist	
33	Dr Sujeet Kumar	Senior Scientist	
34	Dr B. Sivamani	Senior Scientist	
35	Dr (Smt) R. Geetha	Senior Scientist	
36	Dr P. Kumararaja	Senior Scientist	
37	Dr (Smt) T. Bhuvaneswari	Senior Scientist	Promoted to next higher grade w.e.f. 10.02.2023
38	Dr (Smt) N. Lalitha	Scientist	
39	Dr (Smt) Vidya Rajendran	Senior Scientist	Promoted to next higher grade w.e.f. 01.01.2023

40	Dr Satheesha Avunje	Senior Scientist	• Promoted to next higher grade w.e.f. 01.01.2023. • Transferred to ICAR-CIFA, Regional Station, Bengaluru on 29.12.2023
41	Dr J. Raymond Jani Angel	Senior Scientist	Promoted to next higher grade w.e.f. 01.01.2023
42	Dr Aritra Bera	Senior Scientist	Promoted to next higher grade w.e.f. 01.01.2023
43	Dr T. Sathish Kumar	Scientist	
44	Dr K.P. Sandeep	Scientist	
45	Smt Mary Lini	Scientist	
46	Shri C. Siva	Scientist	
47	Shri T. Sivaramakrishnan	Scientist	
48	Shri Dani Thomas	Scientist	
49	Shri R. Aravind	Scientist	
50	Shri K. Anantharaja	Scientist	Joined on 20.12.2023
Navsari-Gujarat Research Centre Of CIBA, Gujarat			
1	Shri Ritesh Kumar Shantilal Tandel	Scientist & Nodal officer, NGRC	Joined on 26.12.2023
2	Dr (Smt). Pragyan Dash	Scientist	Joined on 26.12.2023
3	Shri Pankaj Amrut Patil	Scientist	
4	Shri Jose Antony	Scientist	
KAKDWIP RESEARCH CENTRE OF CIBA SCIENTISTS			
1	Dr Debasis De	Head, KRC Regional Centre	Joined on 11.07.2023
2	Dr T. K. Ghoshal	Principal Scientist	Joined ICAR-CIFE, Kolkata on 20.07.2023
3	Dr Sanjoy Das	Principal Scientist	
4	Dr Prem Kumar	Senior Scientist	Transferred to ICAR-CIFE, Mumbai on 22.03.2023
5	Mrs Babita	Scientist	
6	Dr N. S. Sudheer	Scientist	
7	Mrs Leesa Priyadharsani	Scientist	Transferred to ICAR-CIFE, Kolkata on 21.03.2023
8	Shri Biju. I. F.	Scientist	
9	Ms. Misha Soman	Scientist (on study leave)	
10	Mrs Moumita Ash	Scientist	Joined on 11.04.2023
TECHNICAL (19)			
1	Dr S. Sivagnanam	Chief Tech. Officer	
2	Shri D. Raja Babu	Chief Tech. Officer	
3	Shri R. Puthiavan	Chief Tech. Officer	
4	Smt K. Jacquline	Assistant Chief Tech. Officer	

5	Shri Joseph Sahayarajan	Assistant Chief Tech. Officer	
6	Shri S. Rajamanickam	Assistant Chief Tech. Officer	
7	Shri S. Nagarajan	Assistant Chief Tech. Officer	
8	Dr A. Nagavel	Assistant Chief Tech. Officer	
9	Shri R. Subburaj	Assistant Chief Tech. Officer	
10	Shri S. Saminathan	Technical Officer	Retired on superannuation on 30.06.2023
11	Shri N. Jagan Mohan Raj	Tech. Officer	
12	Shri D. M. Ramesh Babu	Tech. Officer	
13	Shri G. Thiagarajan	Tech. Officer	
14	Shri K. Karaiyan	Senior Tech. Asst.	
15	Shri S. Prabhu	Technical Asst.	
16	Shri K. V. Delli Rao	Technical Asst.	
17	Shri C. Saravanan	Technician	Promoted to Technician (T-1) on 18.12.2023
18	Shri C. Ragu	Technician	Promoted to Technician (T-1) on 18.12.2023
19	Shri R. Indrakumar	Technician	Promoted to Technician (T-1) on 18.12.2023
TECHNICAL - KRC			
1	Smt Chhanda Mazumder	Technical Officer	
ADMINISTRATION (18)			
1	Shri Navin Kumar Jha	Chief Administrative Officer	
2	Smt Komal Sheokand	Senior Finance & Account Officer	
3	Smt V. Usharani	Senior Administrative Officer	
4	Shri M. Krishna Moorthy	Principal Private Secretary	Relieved on VRS on 31.10.2023
5	Shri P. Srikanth	Assistant Finance Accounts Officer	
6	Smt E. Amudhavalli	Asst. Admn. Officer	
7	Shri A. Sekar	Asst. Admn. Officer	
8	Shri Raghavendra.K	Asst. Admn. Officer	Resigned on 27.06.2023
9	Smt E. Mary Desouza	Asst. Admn. Officer	
10	Smt S. Nalini	P.S	
11	Shri Gopala Krishna Murthy	P.S.	Relieved on VRS on 03.08.2023
12	Smt K. Hemalatha	P.A.	
13	Smt K. Subhashini	P.A.	

14	Smt R. Vetrichelvi	Assistant	
15	Smt M. Mathuramuthu Bala	Assistant	
16	Smt B. Prasanna Devi	Upper Division Clerk	
17	Shri R. Kumerasen	Upper Division Clerk	
18	Shri A. Paul Peter	Upper Division Clerk	
19	Shri V. Kishorkumar	Lower Division Clerk	
20	Shri S. Solin Igneshus	Lower Division Clerk	
ADMINISTRATION – KRC			
1	ShriSanjoy Some	Lower Division Clerk	
SKILLED SUPPORT STAFF (8)			
1	ShriV.Kumar	Skilled Support Staff	Retired on superannuation on 30.04.2023
2	Shri S. Selvababu	Skilled Support Staff	
3	Shri P.G. Samuvel	Skilled Support Staff	
4	Shri M. Sakthivel	Skilled Support Staff	
5	Shri R. Mathivanan	Skilled Support Staff	
6	Shri G. Dayalan	Skilled Support Staff	
7	Shri Kanaka Prasad	Skilled Support Staff	
8	Shri J. Murugan	Skilled Support Staff	
SKILLED SUPPORT STAFF - KRC			
1	Smt L. R. Bhuiya	Skilled Support Staff	Retired on superannuation on 31.07.2023
2	Shri P. C. Das	Skilled Support Staff	

INFRASTRUCTURE DEVELOPMENT

Sl. No.	Name
1.	Construction of laboratory building at KES of CIBA at Kelambakkam
2.	Renovation of grill and shed around High Tension Electrical panel structures at MES of ICAR- CIBA, Muttukadu
3.	Strengthening of the dike and providing HDPE sheet lining in the Shrimp hatchery brood stock ponds at MES of CIBA, Muttukadu
4.	Pond lining and elevation of Polyculture and mud crab ponds at MES of CIBA, Muttukadu
5.	Construction 25 ton RCC tank in Fish hatchery at MES of CIBA
6.	Renovation of false ceilings in various labs in the shrimp & fish hatchery, all roof sheets with packing of silicone paste & renovation of aluminium window & door in all building at MES of ICAR-CIBA, Muttukadu.
7.	Renovation of ponds at KES of ICAR-CIBA, Kelambakkam
8.	Renovation of damaged name boards with focusing lights at KES of ICAR-CIBA, Kelambakkam.
9.	Renovation/repair the seed bank shed and cobia shed at MES of CIBA, Muttukadu
10.	Repair and painting works for main and annex building at CIBA Hqrs, campus, R.A. Puram Chennai-28
11.	Providing Semi-Permanent experimental shed at NGRC of CIBA, Navsari, Gujarat
12.	Repair of farm road, pond dykes surface and grey mullet shed base at NGRC of CIBA, Navsari Gujarat
13.	Renovation of room No. 107,109,111,209,301 and 308 at CIBA Hqrs, R.A.Puram, Chennai-28
14.	Customised modification of the National Referral Laboratory for Brackishwater Aquatic Animal Disease at CIBA Hqrs, R.A.Puram, Chennai-28
15.	Renovation of auditorium, Pantry room, cold room
16.	Implementation of the intake water line work for sea water transportation from MES of CIBA, Muttukadu to KES of CIBA as required under the PMMSY project for Genetic Improvement program for P.indicus
17.	Implementation of the construction of Brood stock domestication Centre facilities at KES of CIBA under the PMMSY project for Genetic Improvement program for P.indicus
18.	Renovation of store at KRC of CIBA Kakdwip, Dist south 24 Parganas, West Bengal
19.	Renovation of barbed wire fencing at KRC of CIBA, Kakdwip
20.	Repairs of approach road to the B and C sector farms at KRC of CIBA, Kakdwip, Dist- south 24 Parganas, West Bengal
21.	Renovation of staff quarters (Type-I, II, & III) and Trainees hostel at KRC of CIBA, Kakdwip
22.	Renovation of boundary wall to safe guard the property at KRC of CIBA, Kakdwip
23.	Renovation of main dyke in the river side of the sector A at KRC of CIBA, Kakdwip.
24.	Renovation and modification of old transformer building is to be used as fish waste processing unit at KRC of CIBA, Kakdwip
25.	Re-construction of three main feeder sluices of farms at KRC of CIBA at Kakdwip
26.	Repairs of security cabins of three sectors at KRC of CIBA, Kakdwip, Dist. South 24 Parganas, West Bengal

Renovation crab ponds at MES of CIBA

Renovation brood stock pond at CCD hatchery at MES of CIBA

Renovation of Grill and shed around HT Electrical panel at MES of CIBA

Renovation of seed bank shed at MES of CIBA

Construction 25 ton RCC tank in Fish hatchery at MES of CIBA

Renovation of staff Quarters type-1,2&3 at KRC of CIBA at Kakdwip

Renovation of staff Quarters type-1,2&3 at KRC of CIBA at Kakdwip

Renovation of main dyke at KRC of CIBA at Kakdwip

Renovation security cabin at KRC of CIBA at Kakdwip

Reconstruction of three main feeder sluices at KRC of CIBA at Kakdwip

Renovation of boundary wall to safeguard the property at KRC of CIBA at Kakdwip

LIBRARY& E-RESOURCE CENTRE

LIBRARY AND DOCUMENTATION

ICAR- CIBA maintains a comprehensive library and e-resource centre hosting essential reference books and journals covering aquaculture, physiology, nutrition, aquatic health, environment, biotechnology, genetics, bioinformatics, socio-economics and extension. These resources cater to the needs of scientists, research scholars, scientific personnel of other research organisations, academicians, university students and other stakeholders.

LIBRARY AND E-RESOURCE CENTRE

CIBA library has been upgraded as Library and e-Resource Centre to access e-books, online journals, Institute publications and scientists' publications for easy retrieval and use by scientists and scholars.

LIBRARY RESOURCES

ICAR-CIBA library has a rich collection of around 3,089 referral books, 1,631 journal back volumes, 6,900 journal issues, 4,840 abstracts, newsletters and reports, 144 Ph.D. thesis and 2,650 other publications are available in the CIBA library. The library is expanding 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 200 international and national journals related to fisheries and aquaculture. It can be accessed online by scientists at headquarters and research centres at Kakdwip and Navasari.

DATA REPOSITORY

The CIBA digital library system has been established to manage library holdings and maintain records. The system provides inventory of books available in the library, journals under CeRA, scientists and Institute publications. It is programmed to monitor the lending of books and scientists can indent the books required for purchase within 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 familiarise 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).

AUTOMATION

CIBA library is fully automated on the KOHA library management system platform 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.

UTILIZATION OF FUNDS

The funds allotted to the library were effectively utilized to procure referral books and journals, for the scientists and staff of Headquarters, KRC and NGRC.

LIBRARY

Refferral Books
3,089

Ph.D. Thesis
144

Journals
6,900

Newsletter & Reports
4,840

Journal Back Volumes
1,631

Other Publications
2,650

PUBLICATIONS, ORAL PRESENTATIONS

INSTITUTE PUBLICATIONS

1. Annual Report (English) 2022
2. Annual Report (Hindi) 2022
3. Jal Tarang 2022

PEER REVIEWED ARTICLES (40)

Ahmed, J., Navabshan, I., Unnikrishnan, S., Radhakrishnan, L., Vasagam, K.P.K., Ramalingam, K., 2023. In Silico and In Vitro Investigation of Phytochemicals Against Shrimp AHPND Syndrome Causing PirA/B Toxins of Vibrio parahaemolyticus. Appl. Biochem. Biotechnol., 195, 7176–7196 (https://krishi.icar.gov.in/jspui/handle/123456789/81644)

Ahmed, J., Vasagam, K.P.K., Ramalingam, K., 2023. Nanoencapsulated Aquafeeds and Current Uses in Fisheries/Shrimps: A Review. Appl. Biochem. Biotechnol., 195, 7110-7131 (https://krishi.icar.gov.in/jspui/handle/123456789/81643)

Anand, P.S., Aravind, R., Balasubramanian, C.P., Kumar, S., Antony, J., Biju, I.F., Sangeetha, V.L., Ambasankar, K., Vijayan, K.K., 2023. Growth, survival, and osmo-ionic regulation in post larval and juvenile Indian white shrimp, *Penaeus indicus*, reared under three levels of salinity in a semifloc system. Aquaculture, 564, p.739042. (http://krishi.icar.gov.in/jspui/handle/123456789/81550)

Anand, P.S., Balasubramanian, C.P., Aravind, R., Biju, I.F., Rajan, R.V., Vinay, T.N., Panigrahi, A., Sudheer, N.S., Rajamanickam, S., Kumar, S., Antony, J., 2023. Reproductive performance of captive-reared Indian white shrimp, *Penaeus indicus*, broodstocks over two generations. Frontiers in Marine Science, 10, p.1101806. (http://krishi.icar.gov.in/jspui/handle/123456789/81551)

Biswas, G., Kumar, P., Mandal, B., Ghoshal, T.K., De, D., Bera, A., Kailasam, M., 2023. Effects of feeding frequency on growth, survival, body composition and size variation in long whiskers catfish, Mystus gulio (Hamilton, 1822) fry reared in net cage system. Regional studies in Marine Science, 61, 102851. (http://krishi.icar.gov.in/jspui/handle/123456789/81992)

Das, R.R., Panigrahi, A., Sarkar, S., Saravanan, A., Biju, I.F., Ambikanandham, K., Jayanthi, M., Kannappan, S., 2023. Growth, survival, and immune potential of post larvae of Indian white shrimp, Penaeus indicus (H. Milne Edwards, 1937) in different salinities with biofloc system (BFT) during nursery phase. Aquacul. Int., 31, 273-293.

Das, S., De, D., Biswas, G., Kumar, P., Lalramchhani, C., Kumar, S., Ghoshal, T.K., 2023. Effect of molasses supplementation on growth performance, water quality and microbial dynamics during indoor rearing of pacific white shrimp *Penaeus vannamei* Boone, 1931. Indian J. Fish., 70, 70-76. (http://krishi.icar.gov.in/jspui/handle/123456789/81993)

Devika, N.T., Katneni, V.K., Jangam, A.K., Suganya, P.N., Shekhar, M.S., Jithendran, K.P., 2023. In silico prediction of potential indigenous microbial biomarkers in *Penaeus vannamei* identified through meta-analysis and genome-scale metabolic modelling. Environmental Microbiome, 18(1):2. (https://krishi.icar.gov.in/jspui/handle/123456789/75913)

Elangeswaran, S., Thirunavukkarasu, A.R., Kumar, P., Kailasam, M., Musthafa, M.S., Subburaj, R., Thiagarajan, G., 2023. Hematological and Biochemical Parameters in Female Black King Fish Cobia (Rachycentron canadum). Fishery Technology, 60, 138–142. (http://krishi.icar.gov.in/jspui/handle/123456789/81548)

Jayakumar, R., Tamilmani, G., Sakthivel, M., Rameshkumar,

P., Anikuttan, K.K., Sankar, M., Johnson, B., Rao, G.H., Thomas, T., Krishnaveni, N., Moulitharan, N., Mercy, A.A., Nazar, A.K.A., 2023. Optimization of packing and transportation of the fingerlings of the cobia (*Rachycentron canadum*) and the silver pompano (*Trachinotus blochii*). Indian J. Geo-Mar. Sci., 52(04): 198-204. (http://krishi.icar.gov.in/jspui/handle/123456789/81546)

Kabiraj, S., Jayanthi, M., Samynathan, M., Thirumurthy, S., 2023. Automated delineation of salt-affected lands and their progress in coastal India using Google Earth Engine and machine learning techniques. Environ. Monit. Assess., 195, 418. (http://krishi.icar.gov.in/jspui/handle/123456789/80357)

Krishnan, K., Katneni V.K., Prabhudas S.K., Kaikkolante N., Jangam A.K., Katneni U.K., Hauton C., Peruzza L., Shekhar, M.S., Koyadan V.K, Poochirian JK, Jena J., 2023. MRF: a tool to overcome the barrier of inconsistent genome annotations and perform comparative genomics studies for the largest animal DNA virus. Virol J. 20(1):72. (http://krishi.icar.gov.in/jspui/handle/123456789/81531)

Krishnan, K., Prabhudas, S.K., Jayaraman, K., Angel, J.R.J., Jangam, A.K., Katneni, V.K., Shekhar, M.S., 2023. Transcriptomic variations associated with salinity stress in *Penaeus indicus*. Mol. Biol. Rep., 50 (11), 9295-9306. (http://krishi.icar.gov.in/jspui/handle/123456789/81530)

Kumar, P., Chandan N.K., Biswas, G., Babita, B., Hussain, T., Kailasam, M., Jithendran, K.P., 2023. Fatty acid mobilization and histological cages at different maturation stages of female hilsa, Tenualosa ilisha. Aquaculture, 576, 739887.

Lalitha, N., Ronald, B.S.M., Ananda Chitra, M., Jangam, A.K., Katneni, V.K., Suganya, P.N., Hemalatha, S., Senthilkumar, T.M.A., M. Muralidhar, 2023. Exploration of the candidate beneficial bacteria for *Penaeus vannamei* culture by core microbiome analysis using amplicon sequencing. Lett. Appl. Microbiol., 76(8). https://krishi.icar.gov.in/jspui/handle/123456789/80777)

Makesh, M., Satyanarayana, N.V., Muddukrishnaiah, K., Sujeet, K., Thiagarajan, G., Ashok, K.J., Subburaj, R., Kailasam, M., Vijayan, K.K., 2023. Humoral immune response in Asian seabass vaccinated with inactivated and recombinant viral nervous necrosis vaccine. Aquaculture, 569:739384. (http://krishi.icar.gov.in/jspui/handle/123456789/78168)

Muddukrishnaiah, K., Makesh, M., Prabaharan, D., Balasubramaniyan, S., Prasad, S., 2023. Isolation and identification of bioactive compounds with antimicrobial activity from marine facultative anaerobe, Bacillus subtilis. Curr. Pharm. Biotechnol., 24(5): 698-707. (http://krishi.icar.gov.in/jspui/handle/123456789/80198)

Muralidhar, M., Ashok Kumar, J., Suvana, S., Jayanthi, M., Vishwajeet, P., Syama Dayal, J., 2023. Dynamic modelling of coastal aquaculture systems: A Review. Aquatic Ecosystem Health and Management, 26(3), 4052. http://krishi.icar.gov.in/jspui/handle/123456789/81595.

Naskar, S., Biswas, G., Kumar, P., De, D., Das, S., Sawant, P.B., Chadha, N.K. and Behera, P., 2023. The green seaweed Enteromorpha intestinalis: an efficient inorganic extractive species for environmental remediation and improved performances of fed species in brackishwater integrated multi-trophic aquaculture (BIMTA) system. Aquaculture, 569, 739359. (http://krishi.icar.gov.in/jspui/handle/123456789/81991)

Panigrahi, A., Das, R.R., Sarkar, S., Aravind, R., Rekha, P.N. and Sandeep, K.P., 2023. Biofloc-based farming of Indian white shrimp, *Penaeus indicus*, in recirculating aquaculture system (RAS) enriched with rotifers as feed supplement. Aquacult. Int., 31, 657–680.

Parappurathu, S., Menon, M., Jeeva, C., Belevendran, J., Anirudhan, A., Lekshmi, P.S., Ramachandran, C., Padua, S., Aswathy, N., Ghosh, S., Damodaran, D., Megarajan, S., Rajamanickam, G., Vinuja, S.V., Ignatius, B., Raghavan, S.V., Narayanakumar, R., Gopalakrishnan, A. and **Chand, P.,** 2023. Sustainable intensification of small-scale mariculture systems: Farm-level insights from the coastal regions of India. Front. Sustain. Food Syst., 7, p.1078314.

Peter, N. R., Raja, N. R., Sunny, A., Sarkar, S., Ramesh, N., 2023. Optimizing Brackishwater Shrimp Farming with IoT-Enabled Water Quality Monitoring and Decision Support System. Thalassas. (http://krishi.icar.gov.in/jspui/handle/123456789/81619)

Peter, N.R., Raja, N.R., Jayakumar, R., Aravind, R., Ambasankar, K., Saravanan, A.K., Balasubramanian, C.P., Lal, K.K., 2023. A comprehensive study on ecological insights of *Ulva lactuca* seaweed bloom in a

lagoon along the southeast coast of India. Ocean and Coastal Management, 106964. (http://krishi.icar.gov.in/jspui/handle/123456789/81547)

Raja Raja, N., Peter, N. R., Puthiyedathu, S. K., Vasudevan, C., Sarkar, S., Sunny, A., 2023. Fuzzy analytic hierarchy process (FAHP) for identification of potential cage farming sites for aqua tourism development in Muttukadu Lagoon, Chennai, India. Aquaculture International, 1-22. (http://krishi.icar.gov.in/jspui/handle/123456789/81618)

Raja, R.A., Sridhar, R., Balachandran, C., Palanisammi, A., Ramesh, S., Nagarajan, K., Paulpandi, S., 2023. Identification of Vibrio parahaemolyticus from farmed penaeid shrimp, *Penaeus vannamei* (Boone, 1931) by multiplex PCR targeting toxR and tlh genes. Indian J. Fish., 70(4), 162-167. (http://krishi.icar.gov.in/jspui/handle/123456789/81538)

Raja, R.A., Patil, P.K., Avunje, S., Kumaran, M., Anand, P., Ambasankar, K., De, D., Jithendran, K.P., Alavandi, S.V., Vijayan, K.K., 2023. Natural infestation of an anchor worm, *Lernaea* sp. in cage culture of Asian Seabass, *Lates calcarifer* juveniles and its control using an anti-parasitic drug, emamectin benzoate. J. Parasit. Dis., 47(2), 306-318. (http://krishi.icar.gov.in/jspui/handle/123456789/76560)

Rajaram, V., Jannathulla, R., Ambasankar, K., Rajendran, R., Kalanjiam, R., Dayal, J.S., 2023. A comparative study on optimising the inclusion level of three different oilseed meals/cakes as a fishmeal substitute in the diet of *Penaeus monodon* Fabricius, 1798. Indian J. Fish., 70(1): 92-102. (https://krishi.icar.gov.in/jspui/handle/123456789/81642)

Rameshkumar, P., Balachandran, C., Vairamuthu, S., Raj, G.D., Kirubaharan, J.J., Nagarajan, K., Nazeera, B.M., Praveena, P.E. Jithendran, K.P., 2023. Co-infection of viral nervous necrosis (VNN) and bacterial infection outbreak in cage cultured cobia fingerlings. Aquaculture, 578, 740047. (http://krishi.icar.gov.in/jspui/handle/123456789/81641)

Rameshkumar, P., Thirumalaiselvan, S., Mini, R, Remya, L., Jayakumar, R., Sakthivel, M., Tamilmani, G., Sankar, M., Anikuttan, K.K., Nandini, N.M., Saravanan, R., Ravikumar, T.T., Iyyapparaja, N., Krishnaveni, N., Muniasamy, V., Batcha, S.M., Gopalakrishnan, A., 2023. Monitoring of Harmful Algal Bloom (HAB) of Noctiluca scintillans (Macartney) along the Gulf of Mannar, India using in-situ and satellite observations and its impact on wild and maricultured finfishes. Mar. Pollut. Bull., 188, 1-21. (http://krishi.icar.gov.in/jspui/handle/123456789/81539)

Sandeep, K.P., Sivaramakrishnan, T., Sudhin, S., Raymond, J.A.J., Sudheer, N.S., Raja, R.A., Kumar, S., Dayal, J.S., Balasubramanian, C.P., Sawant, P.B. and **Chadha, N.K.,** 2023. Influence of dietary microalgal concentrates on growth, survival and health status of *Penaeus vannamei*. Aquacult. Int., 31(5), 2883-2903 (https://krishi.icar.gov.in/jspui/handle/123456789/78166)

Syama Dayal, J., R. Jannathulla, K. Ambasankar, H. Imran Khan, E.P. Madhubabu, M. Muralidhar 2023. Effect of dietary soy-lecithin on growth and body composition of Indian black tiger shrimp, Penaeus monodon (Fabricius, 1798) reared at hyperosmotic stress condition. Indian J. Fish., 70(1): 85-91, 2023. https://doi.org/10.21077/ijf.2023.70.1.121096-13

Sivakumar, K., Kannappan, S., Balakrishnan, V., 2023. Docking Studies on biomolecules from marine microalga Skeletonema costatum against haemolysin protein of bioluminescence disease causing *Vibrio harveyi*. Curr. Microbiol., 80:290. (http://krishi.icar.gov.in/jspui/handle/123456789/81542)

Sivakumar, K., Kannappan, S., Balakrishnan, V., 2023. Molecular docking approaches of bio-molecules extracted from red seaweed Kapaphycus alvarezii against haemolysis protein of bio-luminescence disease causing bacteria *Vibrio harveyi*. Algal Research, 74:103207. (http://krishi.icar.gov.in/jspui/handle/123456789/81545)

Sivaramakrishnan, T., Ambasankar, K., Felix, N., Bera, A., Kamalam, B.S., Vasagam, K.K., Kailasam, M., 2023. Changes in digestive enzyme activities during the early ontogeny of milkfish, *Chanos chanos* larvae. Fish Physiol. Biochem., 49(5), 867-882. http://krishi.icar.gov.in/jspui/handle/123456789/81553

Sivaramakrishnan, T., Ambasankar, K., Sathish Kumar, T., Sandeep, K.P., Bera, A., Raja, R.A., Suresh, E., Kailasam, M., Felix, N., 2023. Effect of dietary vitamin E supplementation on growth, fatty acid composition, intestinal histology, and haemato-immune indices of milkfish, *Chanos chanos*, larvae. Journal of Applied

Aquaculture, pp.1-22. (http://krishi.icar.gov.in/jspui/handle/123456789/81601)

Sivaramakrishnan, T., Dayal, J.S., Ambasankar, K., Felix, N., Sandeep, K.P., Bera, A., Vasagam, K.P.K., Thiagarajan, G. and **Kailasam, M.,** 2023. Amino acid and fatty acid compositions of various stages of *Chanos chanos* larvae: Implications for larval feed formulation. Indian J. Fish., 70(1): 77-84. (https://krishi.icar.gov.in/jspui/handle/123456789/78169)

Sivaramakrishnan, T., Sandeep, K.P., Bera, A., Raja, R.A., Kailasam, M., Felix, N., Ambasankar, K., 2023. Effects of dietary ascorbic acid on growth, hematology, intestinal histology, and resistance to Vibrio harveyi in early life stage of milkfish. Fish. Sci., pp.1-10. (http://krishi.icar.gov.in/jspui/handle/123456789/78157)

Solanki, H. G., Sumara, M. A. K., Vanza, J. G., Kailasam, M., Mahalakshmi, P., Kumar, P., Gopal, C., Ujjania N. C., 2023. Effect of stocking density on shooter formation, growth and survival of Asian seabass *Lates calcarifer* (Bloch, 1790) during nursery rearing. Indian J. Fish., 70 (4): 157-160. (http://krishi.icar.gov.in/jspui/handle/123456789/81524)

Sowmiya, V., Kanagachidambaresan, G.R., Muralidhar, M., 2023. Tiny ML-based reconfigurable IoT platform design for brackish water aquaculture monitoring. Wireless Networks. (http://krishi.icar.gov.in/jspui/handle/123456789/81596)

Thangaraj, S.K., Nathamuni, S.P., Katneni, V.K., Jangam, A.K., Avunje, S., Thulasi, D.N., Grover, M., Angel, J.R.J. and **Shekhar, M.S.,** 2023. Microbial communities associated with Zoea-2 syndrome and White feces syndrome in P. vannamei farming. Front. Mar. Sci., 10:1120004. (https://krishi.icar.gov.in/jspui/handle/123456789/81549)

BOOKS (5)

Kumaran, M., Kumaraguru Vasagam, K.P., Lal, K.K., Patil, P.A. and **Antony, J. (Eds.),** 2023. The Advances in Brackishwater Aquaculture - A Handbook for Aquafarmers (Gujarati Version), ICAR-Central Institute of Brackishwater Aquaculture, Chennai, India, p.146. ISBN: 978-81-954486-4-7

Kumaran, M., Kumaraguru K.P. and **Lal, K.K. (Eds.),** 2023. The Advances In Brackishwater Aquaculture - A Handbook for Aquafarmers, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, p.113, ISBN: 978-81-954486-2-3

Kumaran, M., Kumaraguru Vasagam. K.P., Ananda Raja. R. and **P. Kumararaja., (Eds.),** 2023. Uvarneer Meenvalarppil Thozhilnutpa Valarchigal – Vivasayikalukkana oru kaiyedu (Advances in Brackishwater Aquaculture – A Handbook for Aquafarmers, (Tamil Language), ICAR-Central Institute of Brackishwater Aquaculture, Chennai, 122p, ISBN: 978-81-954486-3-0

De, D., Das, S., Bera, A. and **Ash, M.,** 2023. Details of Seed Production and Farming of Brackishwater Finfishes - A handbook for West Bengal Fish farmers (Nona joler machher chara utpadon ebong adhunik poddhotite chaser khutinati-Paschim bonger matsya chasider jonyo handbook), ICAR-Central Institute of Brackishwater Aquaculture, Chennai, India, p. 169. ISBN: 978-81-966350-5-3

Dineshbabu, A.P., Thomas, S., Kizhakudan, S.J., Zacharia, P.U., Ghosh, S., Dash, G., Vivekanandan, E., George, G., Sivadas, M., Chellappan, A., Najmudeen, T.M., Muktha, M., Sreenath, K.R., Mohammed, K.K., Ratheesh, K.R., Indira, D., Swatipriyanka, S., Akhilesh, K.V., Rajesh, K.M., Subal, K.R., Ajay, D.N., Santosh, N.B., Rajesh, P., Geetha, R., Yousuf, K.S.S.M., Bala, M., Roshen, G.N., Shanthi, M., Swapnil, T., Ajith, S., Sathishkumar, M., Nanda, K., Rahul, R., Prabhakar, M., Gopalakrishnan, A. and **Jena, J.K.** Carbon Footprint of Marine Fisheries in India, CMFRI Special Publication No.148, ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi.

BOOK CHAPTER (16)

Balasubramanian, C. P., Anand, P.S.S., Aravind, R., Panigrahi, A., Kumaran, M., 2023. Shrimp farming in India- the present status and prospects. In: The Advances in Brackishwater Aquaculture-A Hand book for Aqua Farmers. (Eds). **M. Kumaran, Kumaraguru Vasagam, K.P., Kuldeep K. Lal.** ISBN: 978-81-954486-2-3

Balasubramanian, C. P., Anand, P. S. S., Jose Antony, Biju, I. F., Aravind, R., Sudheer, N. S., Kannappan, S., Partha Sarathy, P., 2023. Mud crab aquaculture in India: Status and way forward. In: The Advances in Brackishwater Aquaculture-A Hand book for Aqua Farmers. (Eds). M. Kumaran, Kumaraguru Vasagam, K.P., Kuldeep K. Lal. ISBN: 978-81-954486-2-3

Ishwarya, R., Tamilmani, G., Jayakumar, R., 2023.

Biological activities of vitellogenins and its mechanism. In: **B. Vaseeharan and V. Rapeepun (Eds.)** Vitellogenin in fishes: Diversification, biological properties and future perspectives (Springer) ISBN: 978-981-99-5339-4

Jayanthi, M., 2023. Spatial Planning for Sustainable Resource Use with a Special Reference to Aquaculture Development. In: **Jayaraju, N., Sreenivasulu, G., Madakka, M., Manjulatha, M. (Eds) Coasts, Estuaries** and **Lakes. Springer,** ISBN: 978-3-031-21643-5 https://doi.org/10.1007/978-3-031-21644-2_23

Kannappan, S., Poornima, M., 2023. Application of indigenous technical knowledge (ITK) practices in farmed brackishwater aqua species for health management: conceptual view point. In: V K Ahuja and Jupi Gogoi (Eds.). Protection of Traditional Knowledge and Geographical Indications with Special Reference to North-East India. pp.105-118, Satyam Books Pvt. Ltd. New Delhi. ISBN: 978-81-19121-03-8

Mahalakshmi, P., Debasis De and Sandeep, K.P., 2023. Recycling of fish waste to Plankton^{Plus} and Horti^{Plus} production technology, a viable option for doubling the coastal communities income: A Sustainable Livelihood Model, In: Prospects and challenges of environment and biological sciences in food production system for livelihood security of farmers (ICFPLS–2023), **Chaudhary, V.P., Sundar J., Verma, N., Nirmal, Bohra, P., Singh, P.K., Kumar Vijay, Kumari Sweeti, Katiyar Hari Om and Prasad, G. (Eds.).,** September 18-20, 2023, Port Blair, Andaman & Nicobar Islands, India,150p.

Mahalakshmi.P. and Ashok Kumar, J., 2023. Artificial Intelligence Based Optimal Location Model for Aquaculture Development, In: Souvenir cum Conference book: International Conference on Current Advances in Agriculture, Animal Husbandry and Allied Science (CAAAAS-2023), **Suheel Ahmad, Sheeraz Saleem Bhat, Nazim Hamid Mir, Rayees Ahmad Shah, Nuhu Yusuf, Adil Ahmad, Manpreet Kour, Bilal Ahmad Wani (Eds.).** July 10 -11, 2023, Katra, India, pp. 64-74.

Muralidhar M., Mahalakshmi, P., Kumaraguru Vasagam, K.P., Ashok Kumar, J., Kanagachibaresan, G., Kumararaja, P., Saraswathy, R., 2023. Smart farming and real-time based shrimp farm management: present status and its scope for immediate future. In: **M. Kumaran, K.P. Kumaraguru Vasagam, R. Ananda Raja and P. Kumararaja (Eds.).** The Advances in Brackishwater Aquaculture-A Hand book for Aqua Farmers. (Tamil). Pp. 38-47. ISBN: 978-81-954486-3-0.

Otta, S.K., Swain, S., 2023. Antimicrobial Resistance in Brackishwater Aquaculture. In: **Mothadaka, M.P., Vaiyapuri, M., Rao Badireddy, M., Nagarajrao Ravishankar, C., Bhatia, R., Jena, J. (eds.)** Handbook on Antimicrobial Resistance. Springer, Singapore. https://doi.org/10.1007/978-981-16-9723-4_8-1

Ravisankar. T., Geetha, R. and Sairam, C. V., 2023. The economics of shrimp crop insurance in India: farmers & insurers perception and product gap analysis, In: The advances in Brackishwaster Aquaculture-A handbook for Aquafarmers. **M. Kumaran, K.P. Kumaraguru Vasagam, Kuldeep K. Lal (eds.).** ISBN. 978-81-954486-2-3, ICAR-Central Institute of Brackishwater Aquaculture, Chennai, pp 88-98.

Ravisankar.T, Geetha, R., Sairam, C. V., 2023. Indiyavil Iral payir copeetin porulatharam: Vivasayeegal matrum Copeetalargal karuthugal matrum idaiveli paguppaivu, In : Uvar Neer Valarppil Thozhilnutpa Valarchigal: Vivasayeegalukkana Oru Kaiyedu, **M. Kumaran, K.P. Kumaraguru Vasagam, R. Ananda Raja and P. Kumararaja (eds.).** ISBN: 978-81-954486-3-0., ICAR-Central Institute of Brackishwater Aquaculture, Chennai, pp 94-105.

Saraswathy, R., Muralidhar, M., Jose Antony, Kumararaja, P., 2023. Water quality management in shrimp aquaculture. In: **M. Kumaran, K.P. Kumaraguru Vasagam and Kuldeep K. Lal (Eds.).** The Advances in Brackishwater Aquaculture-A Hand book for Aqua Farmers. pp. 23-31. ISBN: 978-81-954486-2-3.

Saraswathy, R., Muralidhar, M., Jose Antony, Kumararaja, P., 2023. Water quality management in shrimp aquaculture. In: **M. Kumaran, K.P. Kumaraguru Vasagam, R. Ananda Raja and P. Kumararaja (Eds.).** The Advances in Brackishwater Aquaculture-A Hand book for Aqua Farmers. (Tamil). pp. 19-28. ISBN: 978-81-954486-3-0.

Sathish Kumar, T., Ananda Raja, R., Jithendran, K.P., 2023. Shrimp diseases: present status with special reference to hepatopancreatic microsporidiosis (HPM) and white fecal syndrome (WFS) and mitigative measures. In:

M.Kumaran, K.P.Kumaraguru Vasagam, R.Ananda Raja, and P.Kumararaja (Eds.). The advances in brackishwater aquaculture – A handbook for aquafarmers (ICAR-Central Institute of Brackishwater Aquaculture, Chennai). pp.29-37 (In Tamil). ISBN 978-81-954486-3-0

Sathish Kumar, T., Ananda Raja, R., Jithendran, K.P., 2023. Shrimp diseases: present status with special reference to *hepatopancreatic microsporidiosis* (HPM) and white fecal syndrome (WFS) and mitigative measures. In: **M. Kumaran, K.P. Kumaraguru Vasagam,** and **Kuldeep K. Lal (Eds.).** The advances in brackishwater aquaculture – A handbook for aquafarmers (ICAR-Central Institute of Brackishwater Aquaculture, Chennai). pp. 32-39. ISBN 978-81-954486-2-3

Vimala, D.D., Jayapavithran, C., Rekha, P.N., and Senthilmurugan, T., 2023. Orunginaintha pannadukku uvarneermeen valarppu thozhilnutpam – oru arimukam (Tamil). In: Meenvalarppil puthiya thozhilnutpa anukumuraikal, KVK, TNJFU, Sikkal, Tamil Nadu. pp. 21-32. ISBN: 978-81-941996-3-2

TRAINING MANUAL (7)

Hands on Training Program on Molecular Techniques for Fish and Shrimp Diseases (TM Series 2023 - No.33)

Seed production and farming technology of brackishwater finfishes (TM Series 2023-No.35)

Training manual on Recent developments in brackishwater aquaculture technologies for farmers of Ramanathapuram district, Tamil Nadu (TM series 2023-No.36)

Training manual on Mud crab box culture and finfish nursery culture in brackishwater ponds and creeks (TM series 2023 – No. 37)

Training Manual on Breeding and farming techniques of finfishes for sustainable brackishwater aquaculture (TM Series 2023-No.44)

Training manual on Diversification of shrimp farming in India with native penaeids ISBN: 978-81-954486-8-5

Training Manual on Seed production and farming of candidate brackishwater finfishes of West Bengal (TM series 2023-No.45)

POPULAR ARTICLES (2)

Rekha, P.N., R. Nishan Raja, Albin Sunny, Soumyabrata Sarkar, Balasubramanian, C.P., 2023. Coastal Watershed-Based Surface and Sub-Surface Salinity Mapping and Modelling of Tiruvallur and Chengalpattu District, Tamil Nadu for Sustainable Brackishwater Aquaculture - A Research Study. NABARD Research Chronicle October 2023, Pp 37-49

Sandeep, K.P., Sivaramakrishnan, T., Sudhin, S., Raymond Jani Angel, J., Kumaraguru Vasagam, K.P., Syama Dayal, J., Ambasankar, K., 2023. Spirulina: jaleey krshi utpaadakata badhaane ke lie ek sambhaavit nutrasutikal. Jaltarang 2023, Pp 55-56

TECHNICAL/EXTENSION BULLETINS/ PAMPHLETS

CIBA EXTENSION SERIES (9)

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)

Orunginaintha pannadukku uvarneermeen valarppu kadalora meenavarkalin vazhvathara vaippu, (CIBA Extension Series No.89, Tamil)

Farming technology of brackishwater catfish Mystus gulio (CIBA extension series No. 90)

Aquaculture Insurance for shrimp farmers (CIBA Extension series No 91)

Coastal and tribal women in Aquaculture sector and success Stories (CIBA Extension Series No. 92)

Integrated multitrophic aquaculture in brackishwater for the betterment of livelihood (CIBA extension series No.94)

Vazhvatharam membada pannadukku uvarneer meenvalarppu. (CIBA Extension Series No.94A, Tamil).

Indian white shrimp, Penaeus indicus: A native penaeid for sustainable diversification in shrimp farming

Culture technology for nursery rearing of Indian white shrimp, P. indicus

CONFERENCE / SYMPOSIA / WORKSHOP PRESENTATIONS (39)

Abraham, T.J., Karmokar, S., Dash, G., Das, S., 2023. Surveillance of Tilapia lake virus (TiLV) in different aquaculture systems of Indian Sundarban and adjoining regions. 3rd International Conference on Aquatic Animal Epidemiology, 29 November -1 December 2023, Lucknow.

Allie, N.U., Swain, S., Praveena, P.E., Bhuvaneswari, T., Panigrahi, A., Otta, S.K., 2023. Effect of inulin on the growth and

disease resistance status of Pacific white shrimp, Penaeus vannamei, XVI Agricultural Science Congress & ASC expo., ICAR-Central Marine Fisheries Research Institute, 10-13 October 2023, Kochi, Kerala.

Ananda Raja, R., 2023. Biosafety, withdrawal and efficacy of anti-parasitic drugs in aquaculture – An overview. Regulatory Compliance in Preclinical Research of Agrochemicals, Pharmaceuticals and Medical Devices, 3-4 October 2023, Chennai.

Ananda Raja, R., Otta, S.K., Ezhil Praveena, P., Poornima, M., Kumar, S., Bhuvaneswari, T., Sathish Kumar, T., Joseph Sahayarajan, J., Shashi Shekhar, M., 2023. Asymptomatic prevalence of white spot syndrome virus (WSSV) in wild and cultured shrimps of economic importance: A comprehensive analysis. VIROCON-2023 Advancement in Global Virus Research Towards One Health, 1-3 December 2023, Tiruchirappalli.

Antony, J., Saraswathy, R., Muralidhar, M., Jayanthi, M., Patil, P.K., Jithendran, K.P., 2023. Suitability Assessment of Inland Saline Groundwater Resources from North-Western India for Shrimp Farming Based on the Production Performance and Water Quality Variables. Indian Ecological Society Conference IESFAC 2023, 22-24 February 2023, Ludhiana.

Aravind, R., Shyne Anand, P. S., Balasubramanian, C. P., Bhuvaneswari, T., Panigrahi, A., Vidhu Rajan, R., Rajamanickam, S., 2023. High density nursery and grow-out farming of *Penaeus vannamei* using copefloc technology. XVI Agricultural Science Congress & Expo, 10-13 October 2023, Kochi.

Balagopal, K.B., Bhuvaneswari, T., Praveena, P.E., Otta, S.K., 2023. Virulence gene analysis in Vibrio spp from diseased Penaeus vannamei culture ponds. AquaEpi III, 3rd international conference on aquatic animal epidemiology, 29 November -1 December 2023, ICAR-NBFGR, Lucknow.

Bhuvaneswari, T., Balagopal, K.B., Ezhil Praveena, P., Vidya Rajendran and **Otta, S.K.** Vibrio associated with mortality of nursery reared Asian seabass in backwaters at Chengalpattu district of Tamil Nadu. 3rd International Conference on Aquatic Animal Epidemiology, 29 November - 1 December 2023, ICAR-NBFGR, Lucknow.

Das, S., Priyadarsani, L., Sudheer, N.S., Kumar, P., Biju, I.F. and **De, D.,** 2023. Investigation of 'Red gut disease' in *Penaeus vannamei* farms of Purba Medinipur, West Bengal. 3rd International Conference on Aquatic Animal Epidemiology, 29 November -1 December 2023, Lucknow.

Hauton, C., Marsh, R., Ambasankar, K., Shekhar, M.S., Katneni, V.K., Angel, J.R.J., Sandeep, K.P, Sivaramakrishnan, T., 2023. Diversification of potential crop species in brackishwater aquaculture, adaptation for climate resilience. 3rd International Conference on Aquatic Animal Epidemiology, 29 November-01 December 2023, Lucknow

Jayakumar, R., Kailasam, M., Bhuvaneswari, T., Geetha, R., Subburaj, R., Thiagarajan, G., Dhavaselvam, A., 2023. Brackishwater cage farming of Asian Seabass Lates calcarifer as an additional income generation activity by fisher women SHG's. 16th Agricultural Science Congress, 10-13 October 2023, Kochi.

Kannan, S., Kumar, T.S., Otta, S.K., Praveena, P.E., Raja, A.R., 2023. Prevalence of *hepatopancreatic microsporidiosis* in Penaeus vannamei shrimp farms in Thiruvallur district of Tamil Nadu. AquaEpi III, 3rd international conference on aquatic animal epidemiology, 29 November - 1 December, 2023, ICAR-NBFGR, Lucknow.

Kathirkaman, V., Otta, S.K., Praveena, P.E., Poornima, M., 2023. Infectious myonecrosis virus – its prevalence in *Penaeus vannamei* shrimp farms in India. AquaEpi III, 3rd international conference on aquatic animal epidemiology, 29 November to 1 December, 2023, ICAR-NBFGR, Lucknow.

Kumar, S., Nishanthini, B., Robinson, A., Kumar, T.S., Makesh, M., Shekhar, M.S., 2023. Pathogenomic epidemiology of shrimp pathogen Vibrio campbelli. 3rd International Conference on Aquatic Animal Epidemiology, 29 November-01 December 2023, Lucknow.

Lalitha, N., Ambasankar, K., Sivaramkrishnan, T., Tomy, S., Raja R. A., 2023. Effect of Dietary Supplementation of *Lactiplantibacillus plantarum* Probiotics as Functional Additives In Pacific White Shrimp (*Peneaus Vannamei*). National conference on Sustainable wellness through Noni, Medicinal plants, Microbes and Bio-molecules SWNMPMB-2023, School of Biological Sciences, 27-28 November 2023, Madurai Kamaraj University.

Lalitha, N., Ambasankar, K., Sivaramkrishnan, T., Tomy, S., Kumar, S., 2023. Effect of Lactiplantibacillus

plantarum Supplementation on The Immune Response And Disease Resistance of Whiteleg Shrimp *Penaeus vannamei* Against Vibrio campbellii. National conference on Sustainable wellness through Noni, Medicinal plants, Microbes and Bio-molecules SWNMPMB-2023, School of Biological Sciences, 27-28 November 2023, Madurai Kamaraj University.

Lalitha, N., Ambasankar, K., Sivaramkrishnan, T., Suganya. P. N., 2023. Insight Into the Bacterial Gut Microbiome of *Penaeus vannamei* Fed with Functional Feed Additives *Lactiplantibacillus plantarum* by Amplicon Sequencing. Indian Conference on Bioinformatics 2023 - Inbix'23, Theme: Application of Bioinformatics in Healthcare, School of Bio Sciences and Technology, Vellore Institute of Technology, Vellore.

Makesh, M., 2023. Management of Viral Nervous Necrosis in Finfish Hatcheries. 'VIROCON-2023: Advancement in Global Virus Research Towards One Health'. 1-3 December 2023, Tiruchirappalli.

Mandal, B., De, D., Das, S., Biju, I.F., Lal, K.K., 2023. Effect of salinity on embryonic development and hatching of knight goby (*Stigmatogobius sadanundio*): a brackishwater aquaculture fish of Indian Sundarbans. International Conference on Aquatic Resources and Sustainable Management (ICARSM), 30-3 August 2023, Barrackpore.

Mandal, B., Ghoshal, T.K., De, D., Mahalakshmi, P., Das, S., Biju, I.F., Sudheer, N.S., 2023. Sustainable livelihood generation through brackishwater ornamental fish production in homestead ponds by coastal tribal farmers of Mousuni Islands, Sundarban. 2nd International Conference on Prospects and challenges of environmental biological sciences in food production system for livelihood security of farmers (ICFPLS- 2023), 18-20 September 2023, Port Blair, Andaman and Nicobar Islands.

Naveen, R, Sathish Kumar, T., Jithendran, K.P., Megha, K. Bedekar, Jeena, K., Sanath Kumar, H. Rajendran, K.V. 2023. Prevalence of shrimp microsporidian, Enterocytozoon hepatopenaei (EHP) in farmed tiger shrimp, Penaeus monodon in India. XVI Agricultural Science Congress and ASC Expo, Transformation of Agri-food systems for achieving sustainable development goals. National Academy of Agricultural Sciences, New Delhi and ICAR-Central Marine Fisheries Research Institute, Kochi, 10-13 October 2023, Kochi, India.

Otta, S.K., Praveena, P.E., Swain, S., Allie, N.U., Janakiraman, R.B., 2023. Evaluating pathogen association with shrimp white gut syndrome by Polymerase Chain Reaction and histopathology. AquaEpi III, 3rd international conference on aquatic animal epidemiology, 29 November - 1 December, 2023, ICAR-NBFGR, Lucknow.

Otta, S.K., Saravanan, P., Arul Raj, R., Praveena, P.E., Bhuvaneswari, T., 2023. White spot syndrome virus (WSSV) – A long standing problem for shrimp aquaculture industry. VIROCON 23, Advances in Global Virus Towards One Health, 1 December - 3 December 2023, ICAR-NRCB, Tiruchirapalli, Tamil Nadu.

Panigrahi, A., Reshmi Das, Balasubramnian C. P., 2023. Biofloc technology (BFT) based maturation and breeding of Indian white shrimp, Penaeus indicus along with eyestalk ablation in captive condition. XVI Agricultural Congress, 10 to 13 October 2023. Kochi.

Patil P.A., Hussain T., Mahalakshmi P., Kailasam M., Antony, J., Ambasankar, A., Vijayan, K.K., Lal, K. K., 2023. Integrating culture of finfish, shellfish, livestock, poultry, and horticulture crops in brackishwater farming system as a livelihood activity for coastal communities of Gujarat. 8th International Conference on "Recent Advances in Agriculture, Animal Husbandry, Sciences & Technology for Sustainable Entrepreneurship", 26-28 March, 2023, Gwalior.

Patil, P.A., Hussain, T., Kailasam, M., Sairam, C.V., Vijayan, K.K., Sanaye, S.V., 2023. Nursery rearing of Pearlspot, Etroplus suratensis (Bloch, 1790) in hapa as a livelihood activity by the self-Help group of Sindhudurg district, Maharashtra. 8th International Conference on "Recent Advances in Agriculture, Animal Husbandry, Sciences & Technology for Sustainable Entrepreneurship", 26-28 March, 2023, Gwalior.

Poornima, M., Nalayeni, K., Ezhil Praveena, P., Vidya Rajendran, Rajan, J.J.S., Otta, S.K., 2023. Occurrence of multiple pathogen infections in farmed shrimp, Penaeus vannamei in India one microbe one disease paradigm shift. 3rd International Conference on Aquatic Animal Epidemiology (AquaEpi III), 29 November - 01 December, Lucknow

Praveena, P.E., Otta, S.K., Bhuvaneswari, T.,

Jithendran, K.P., Rajan, J.J.S., 2023. Disease surveillance in Penaeus vannamei cultured shrimp farms in India. AquaEpi III, 3rd international conference on aquatic animal epidemiology, 29 November - 1 December, 2023, ICAR-NBFGR, Lucknow.

Rajesh, R., Saraswathy, R., Satheesha Avunje., Patil, P. K., 2023. Degradation kinetics of potassium permanganate in tropical aquaculture environments. 16th Agricultural Science Congress, 10-13 October 2023, Kochi, Kerala.

Sandeep, K.P., Debasis De., Sivaramakrishnan, T., Sudhin, S., Raymond, J.A.J., Mahalakshmi, P., and Ambasankar, K., 2023. Exploring the impact of fish waste hydrolysate on growth enhancement in Penaeus vannamei during nursery phase. 16th Agricultural Science Congress-2023, 10-13 October 2023, Kochi.

Shekhar, M.S., 2023. Molecular diagnostic techniques for white spot syndrome virus: An overview. VIROCON 2023, 1-3 December, 2023, Tiruchirappalli.

Shekhar, M.S., Katneni, Jangam, A.K., Angel, J.R.J., Kumaravel, J., 2023. Development of molecular markers for WSSV genotyping. 3rd International Conference on Aquatic Animal Epidemiology, 29 November - 01 December 2023, Lucknow.

Shekhar, M.S., Vinaya Kumar, K., Ashok Kumar, J., Raymond Jani Angel J., 2023. Challenges and approach in unravelling of complex shrimp whole genome: potential application in genetic improvement programmes. Genomics India Conference, 2-3 February 2023.

Sherly Tomy, Ezhil, P., Aritra Bera., Dani Thomas., Thiagarajan, G., Kailasam, M., 2023. Differential expression of steroidogenic enzyme genes during ovarian development of grey mullet *Mugil cephalus*. 16th Agricultural Science Congress, 10-13 October 2023, Kochi.

Subburaj, R., Kailasam, M., Makesh, M., Jayakumar, R., Thiagarajan, G., Aritra Bera., Dani Thomas., 2023. Innovative approaches on procurement, transportation and development of captive broodstock of Asian seabass Lates calcarifer (Bloch). 16th Agricultural Science Congress-2023, 10-13 October 2023, Kochi.

Subburaj, R., Kailasam, M., Makesh, M., Jayakumar, R., Thiagarajan, G., Aritra Bera., Dani Thomas., 2023. Recent advances in finfish seed production. National workshop on innovative approaches for sustainable Indian fisheries and aquaculture, Trichy, 12-13 September 2023, Fisheries Technocrats Forum and Department of Marine Sciences, Bharathidasan University, Trichy.

Sudheer N. S., Biju I. F., Aravind R, Shyne Anand P. S., Balasubramanian C. P., 2023. Antagonistic bacteria from shrimp larval rearing system. National Seminar on Recent Trends in Aquaculture, 09-10 March, 2023, Kochi.

Sudheer N.S., Shyne Anand P.S., Panigrahi A, and **Balasubramanian C.P.,** 2023. Modification of algal culture media of Chlorella sp. for increased production. International conference on Current advances in agriculture, animal husbandry and allied sciences" (CAAAAS 2023), 10-11 July, Katra.

Swain, S., Bhuvaneswari, T., Praveena, P.E., Vidya, R., Otta, S.K., 2023. Prevalence and virulence analysis of Vibrio parahaemolyticus from grow-out shrimp culture farms along ethe east coast region of India. AquaEpi III, 3rd international conference on aquatic animal epidemiology, 29 November to 1 December, 2023, ICAR-NBFGR, Lucknow.

PARTICIPATION IN CONFERENCES, MEETINGS, WORKSHOPS AND SYMPOSIA

Dr Kuldeep K. Lal, Director

Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.Sci.), ICAR on virtual mode at SMD (Fisheries) ICAR, New Delhi on 5th January 2023.

12th Meeting of Puducherry Union Territory Wetland Authority (PUTWA) under the Chairmanship of Chief Secretary, organized by Directorate of Forests and Wildlife, Govt. of Puducherry at Chief Secretariat, Puducherry on 11th January 2023.

Trainers Training (ToT) program on "The Fundamentals of Artificial reefs for improving Marine Fisheries in India" at MRC of CMFRI, Chennai on 18th January 2023.

National Consultative meet on "Roapmap for Dissemination of Genetically Improved Varieties of Fish and Shellfish" organized by Central Institute of Freshwater Aquacutlure (CIFA), Bhubaneswar at CIFA, Bhubaneswar during 27-28 January 2023.

Inaugural programme of the Winter School on "Mariculture Technologies for Income Multiplication, Employment, Livelihood and Empowerment", organized by Central Marine Fisheries Research Institute (CMFRI), Kochi at CMFRI, Kochi on 7th February 2023.

Fisheries Seminar in Krushi Odisha 2023, organized by Department of Agriculture & FE in collaboration with Fisheries & ARD Department, Govt. of Odisha at Baramunda, Bhubaneswar on 18th February 2023.

Safe and Sustainable Aquatic Food Workshop, organized by Centre for Environment, Fisheries and Aquaculture Science (Cefas) at Kochi during 20-21 February 2023.

Annual Conference of Vice-Chancellors (VCs) of Agricultural Universities & Directors Conference of ICAR at NASC Complex, New Delhi during 4-5 March 2023.

ICAR-Industry Stakeholders Consultation Meet, organized by Agrinnovate India Limited, New Delhi at NASC Complex, New Delhi at 6th March 2023.

Seventy Third Meeting of the Coastal Aquaculture Authority on hybrid mode (virtual mode) at Coastal Aquaculture Authority, Chennai on 14th March 2023.

26th Meeting of Scientific Panel on Fish & Fishery Products (SP-10) at FSSAI, New Delhi on 16th March 2023.

International Conference on "Enhancing Productivity and Value Addition in Millets", organized by the Ministry of Agriculture and Farmers' Welfare, Govt. of India at National Agricultural Science Complex, IARI, New Delhi on 18th March 2023.

11th Meeting of the Central Apex Committee of PMMSY, organized by Department of Fisheries, Govt. of India at Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India, New Delhi on 27th March 2023.

28th Extension Council Meeting of ICAR-CIFE, in hybrid mode (virtual mode) at CIFE, Mumbai on 27th March 2023

Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.), ICAR, on virtual mode at SMD (Fisheries) ICAR, New Delhi on 28th March 2023.

2nd Audit Committee Meeting of Tamil Nadu Fisheries Development Corporation Limited at Secretariat Chennai – 9 on 28th March 2023.

238th Board Meeting of Tamil Nadu Fisheries Development Corporation Limited at Integrated Office Complex for Animal Husbandry, Fisheries and Fishermen Welfare Chennai – 35 on 29th March 2023.

National Workshop on "Sustainable Fisheries and Coastal Aquaculture" at Sathyabama Institute of Science and Technology, Chennai on 30th March 2023.

Meeting to review the progress made under CRP on Agrobiodiversity during 2021-22, organized by NBPGR, New Delhi, on virtual Mode at NBPGR, New Delhi on 5th April 2023.

Combined Interaction of Department of Fisheries, Govt. of Maharashtra and Guardian Minister, MPs, MLAs to discuss the problems/issues and further development in Marine sector, Co-chaired by Hon'ble Minister, Department of Forest, Culture Affairs, Fisheries, Maharashtra (Physical mode) at Sahyadri Guest House, Malabar Hill, Mumbai on 5th April 2023.

Meeting with the Hon'ble Minister, Department of

Forest, Culture Affairs, Fisheries, Maharashtra to discuss regarding development of aquaculture in the State of Maharashtra (Physical mode) at Sahyadri Guest House, Malabar Hill, Mumbai on 12th April 2023.

Meeting of Agriculture Chief Scientists of G-20 countries and showcasing the exhibits (Exhibition Stall) pertaining to Fisheries Research Institutes, on behalf of SMD (Fisheries), ICAR, as Nodal Officer at Hotel Taj Ganges, Varanasi during 17-19 April 2023.

Mid-term Review Meeting of ICAR Regional Committee for Zone VIII, organized by CMFRI, Kochi, on virtual mode at CMFRI, Kochi on 25th April 2023.

Review Meeting of eHRMS, under the Chairmanship of Additional Secretary, DARE and Secretary, ICAR, on virtual mode at ICAR, New Delhi on 12th May 2023.

Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.), ICAR, on virtual mode at SMD (Fisheries) ICAR, New Delhi on 23rd May 2023.

Meeting with DDG (Fy.), ICAR with regard to CRISPER Cas Technology, on virtual mode at SMD (Fisheries)ICAR, New Delhi on 25th May 2023.

Consultative Workshop with State Governments, organized by The Marine Products Export Development Authority,Kochi at ITC Fortune Resort Benaulim, South Goa during 15-16 June 2023.

Seventy Fourth Meeting of Coastal Aquaculture Authority, under the Chairmanship of Chairperson, CAA (Virtual Mode) at CAA, Chennai on 22nd June 2023.

64th Council Meeting of Asian Fisheries Society organized by Asian Fisheries Council (AFS) at Bogar, Indonesia during 26-28 June 2023.

Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.), ICAR, on virutual mode at SMD (Fisheries)ICAR, New Delhi on 5th July 2023.

Fisheries Summer Meet 2023 organized by the Department of Fisheries, MoFAHD, GOI, as a part of outreach activity under PMMSY on the occasion of National Fish Farmers Day at Kaldan Samudhra Resorts, Mahabalipuram, T.N. during 10-11 July 2023.

Second Consultation Workshop on Aquaculture Transformation hosted by Network of Aquaculture Centres in Asia-Pacific (NACA) in collaboration with the FAO Regional Office for Asia and the Pacific (FAORAP) at Bangkok, Thailand during 11-12 July 2023.

95th Foundation Day-cum-Technology Day of ICAR at NASC Complex,New Delhi during 16-18 July 2023.

Fisheries Startup Meeting for Encouraging Start-ups and Innovation in the Fisheries Sector on virtual mode at Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, GOI on 27th July 2023.

International Conference on "Mighty Millets for Food, Nutritional and Health Security" organized by M.S.Swaminathan Research Foundation (MSSRF) at MSSRF, Chennai on 6th August 2023.

Meeting organized by the Deputy Director General (Fy.), ICAR, regarding G20 meeting on virtual mode at SMD (Fisheries), ICAR, New Delhi on 20th August 2023 (12.30 hrs.).

3rd Audit Committee Meeting of Tamil Nadu Fisheries Development Corporation Limited at Office of Deputy Secretary to Govt. Finance Department, Secretariat, Chennai at 30th August 2023.

Meeting to discuss on the relevant amendments for drafting of Rules/Regulations and Guidelines for 'The Coastal Aquaculture Authority (Amendment) Act, 2023', under the Chairmanship of Joint Secretary (Marine Fisheries), Department of Fisheries, GOI (Virtual mode) at Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, GOI on 5th September 2023.

Meeting for Aquaculture Crop Insurance Scheme for Shrimp Farming and Pilot Project on Crop Aquaculture Scheme, under the Chairmanship of Union Secretary (Fisheries), Department of Fisheries, GOI (Virtual mode) at Department of Fisheries Ministry of Fisheries, Animal Husbandry and Dairying, GOI on 12th September 2023.

Seminar titled "Sustainable Aquaculture – India's Potential to be the Global Leaders" organized by Kings Infra Ventures Pvt. Ltd., Kochi & launch of SISTA360 abd Signing of MoU between ICAR-CIBA and Kings Infra Ventures Pvt. Ltd. for collaboration and propoagation of sustainable coastal aquaculture at India Habitat Centre, New Delhi on 25th September 2023.

27th Meeting of Scientific Panel on Fish and Fisheries Products (SP-10), organized by Food Safety and Standards Authority of India (FSSAI), New Delhi at FSSAI, New Delhi on 26th September 2023.

Inaugural Programme of the Hands-on Training on "Basic Molecular Diagnostic Techniques (BMDT-2023)" under DST-SERB-TARE Project, organized by Ethiraj College for Women, Chennai, during 5-6 October 2023 at Ethiraj College on 5th October 2023.

XVI Agricultural Science Congress & ASC Expo, organized by National Academy of Agricultural Sciences, New Delhi and hosted by Central Marine Fisheries Research Institute, Kochi at Hotel Le Meridien, Kochi during 10-13 October 2023.

International Conclave on Mainstreaming Climate Change into International Fisheries Governance and Strengthening of Fisheries Management Measures in the Indo-Pacific Region, hosted by The Department of Fisheries, Government of India and co-organized by BOBP-IGO and National Fisheries Development Board (NFDB) at Welcom hotel by ITC Hotels, Mahabalipuram on 17 October 2023.

Meeting with Seafood Exporters and other Stakeholders on setting up of Nucleus Breeding Centre (NBCs) in India and other issues, organized under the Chairmanship of Secretary, Department of Fisheries, Govt. of India at Krishi Bhavan, New Delhi on 20th October 2023.

Visit to the BMC facility of M/s. Kona Bay India Private Limited for inspection as Chairman of the Technical and Inspection Committee, constituted by the Department of Fisheries, MFAHD, Govt. of India at Kotapalem Ranastalam, Srikakulam District AP on 28th October 2023.

Meeting to review the progress of projects approved under Central Sector Scheme Component of Pradhan Mantri Matsya Sampada Yojana (PMMSY), under the Chairmanship of Secretary (Fisheries), DoF, Govt. of India at Department of Fisheries Ministry of Fisheries, Animal Husbandry and Dairying, GOI on 23rd November 2023

75th Meeting of Coastal Aquaculture Authority on virtual mode at Coastal Aquaculture Authority, Chennai on 28th November 2023.

49th Meeting of the Board of Management of Central Institute of Fisheries Education, Mumbai at Central Institute of Fisheries Education Mumbai on 29th November 2023.

VIROCON – 2023, jointly organized by National Research Centre for Banana, Tiruchirappalli, T.N. and Indian Virological Society (IVS), New Delhi at Hotel Courtyard by Marriot, Tiruchirappalli during 2-3 December 2023.

Brainstorming meeting on Institutional convergence for efficient fish cage culture, organized by National Institute of Ocean Technology (NIOT), Chennai at NIOT, Chennai on 12th December 2023.

Meeting to review the progress of projects approved under Central Sector Scheme Component of Pradhan Mantri Matsya Sampada Yojana (PMMSY) on virtual mode at Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, GOI on 14th December 2023.

Expenditure Review Meeting organized by Joint Secretary (Finance), ICAR, on virtual mode at ICAR, New Delhi on 19th December 2023.

SCIENTISTS

14th Scientific Advisory Committee Meeting of KVK, Villupuram on 5 January 2023 - **Dr C V Sairam**

37th National Committee Meeting on Exotic Species – Department of Fisheries, Govt. of India, 2 January 2023 - **Dr S.K.Otta**

Advisory committee meeting of Hilsa project. Captive breeding of hilsa *Tenualosa ilisha*- phase II, organized by CIFRI Barrackpore and KRC of ICAR-CIBA, 6 January, 2023- **Dr Debasis De**

Attended the IAEC meeting at Post-Graduate Research Institute in Animal Sciences, Kattupakkam, Potheri, TANUVAS as CCSEA nominee, 7 January 2023 - **Dr R. Ananda Raja**

Organized and attended Information, Education and Entertainment (IEE) program, 4 January 2023- **Dr R. Ananda Raja**

Served as NABL observer at Captain Srinivasa Murti Regional Ayurveda Drug Development Institute, Central Council for Research in Ayurvedic Science, Ministry of Ayush, Government of India, Arignar Anna Government Hospital Campus, Arumbakkam, Chennai, Tamil Nadu-600106, 21-22 January 2023 - **Dr R. Ananda Raja**

Served as NABL observer at Translational Research Platform for Veterinary Biologicals (TRPVB), TANUVAS on 28-29th January, 2023 – **Dr R. Ananda Raja**

Panelist in the program on interactive Session on SPS_TBT Issues with respect to Export of Fish & Fishery Products, jointly by EIA-Chennai and SEAI on 06 February 2023 at CIBA Chennai - **Dr K. Ambasankar**

International symposium on innovations in fishing

technologies for sustainable and resilient fisheries, organised by the BoBP, Chennai at Kochi, Kerala, 13-17 February 2023- **Dr M. Kailasam**

Aqua Nutrition workshop organized by USSEC at Hyderabad during 21-22 February 2023 - **Dr K. Ambasankar, Dr J. Syama Dayal**

XII Biennial Conference (ANACON-2023) organized by Animal Nutrition Association (ANA), in collaboration with College of Veterinary Science, DUVASU, Mathura, 16-18 February 2023 - **Dr K. Ambasankar**

Participated in Indian Ecological Society Conference, IESFAC 2023, organized by GADVASU during 22-24 February, 2023, Ludhiana – **Mr Jose Antony**

Meeting conveyed by CAA to discuss for further steps on EHP detection in AQF facility, 28th February 2023 – **Dr S.K.Otta**

25th Scientific Advisory Committee Meeting of KVK Kancheepuram on 11 March 2023- **Dr C V Sairam**

3rd Advisory Committee meeting on NASF. Captive breeding of hilsa *Tenualosa ilisha*- phase II, organized by CIFRI Barrackpore and KRC of ICAR-CIBA, 28 – 29 March, 2023- **Dr Debasis De**

3rd Advisory Committee meeting on NASF. Captive breeding of hilsa *Tenualosa ilisha*- phase II Organized by CIFRI Barrackpore and KRC of ICAR-CIBA, 28- 29 March, 2023 - **Dr Babita Mandal**

Participated in national conference "FISHTECH, 2023", organized by The Maharashtra Economic Development Council (MEDC), Maharashtra, at Navi Mumbai, Maharashtra on 2-3 March, 2023 - **Mr Pankaj Amrut Patil**

Acted as Co-Chairperson of technical session of "Recent advances in Animal Husbandry, Fishery and Allied sciences" during the 8th international conference on "Recent Advances in Agriculture, Animal Husbandry, Sciences & Technology for Sustainable Entrepreneurship" organised by Agro Environmental Development Society, Rampur during 26-28 March, 2023, Gwalior - **Mr Pankaj Amrut Patil**

Attended the IAEC meeting of BCG Vaccine Laboratory (BCGVL), Chennai under the Directorate General of Health Services (DGHS), Ministry of Health and Family Welfare, Government of India, 25 March 2023 – **Dr R. Ananda Raja**

Attended the selection committee meeting as an eternal expert for engagement to the position of Project Associate-I/II through walk-in interview in CSIR-CLRI, 28 March 2023 – **Dr R. Ananda Raja**

International Symposium on Healthy Mangroves and Sustainable Fisheries for Climate Resilient Coastal Community in South Asia organized by Khulna University, Bangladesh, 1-6 March, 2023- **Dr Debasis De**

Meeting conveyed by CAA regarding representation by prawn farmers federation of India, 1st March 2023 - **Dr S.K.Otta**

Participated in the workshop on genome editing in farm animals for improved productivity and health organized by ICAR-NDRI, Karnal on 3 March 2023 – **Dr T.Bhuvaneswari**

National seminar on Recent trends in aquaculture organized by CUSAT, Kochi, Kerala, 09-10March, 2023- **Dr N.S Sudheer**

Organized and attended two Institutional Animal Ethics Committee (IAEC) meetings as Member Secretary during 2023 – **Dr R. Ananda Raja**

Participated in 8th International Conference on "Recent Advances in Agriculture, Animal Husbandry, Sciences & Technology for Sustainable Entrepreneurship" organized by Agro Environmental Development Society, Rampur during 26-28 March, 2023, Gwalior - **Mr Pankaj Amrut Patil**

State level interaction meeting in Mumbai with officials of the Department of Fisheries, Govt. of Maharashtra to discuss various issues and development of brackishwater aquaculture sector for the state of Maharashtra, 5 April 2023- **Dr M. Kailasam**

Member of the selection committee for recruitment to the post of Technician in CSIR-Central Leather Research Institute (CLRI), 4-5 March, 2023 - **Dr R. Ananda Raja**

42nd Governing Body meeting of Agency for Development of Aquaculture, Kerala (ADAK) held on 12th April 2023 at Thiruvananthapuram - **Dr K. Ambasankar**

Attended review meeting of Mangrove Cell and Fisheries Department, Maharashtra at Malabar Hill, Mumbai on 12 April 2023 - **Mr Pankaj Amrut Patil**

Knowledge-sharing workshop on "Use of GM Crops and their Derivatives for Aqua Sector" on 20 April, 2023 at CMFRI, Kochi, organised by ICAR-Central Marine Fisheries Research Institute (CMFRI)

and Biotech Consortium India Limited - **Dr K. Ambasankar**

Meeting on allowing the import of SPF broodstock of crustaceans from South East Asian Countries, constituting the Expert Committee to develop Standard Operating Procedures, CAA, 17 April 2023 - **Dr S.K.Otta**

Project inception workshop of Atlas of Climate Adaptation in South Asian Agriculture (ACASA) project NASC, New Delhi during 25-27 April, 2023 - **Dr J. Ashok Kumar**

17th meeting of FAD 12 on 29 May, 2023 at Manak Bhawan, BIS Headquarters, New Delhi - **Dr K. Ambasankar**

7th Annual review workshop ICAR-CRP Genomics, NBFGR, Lucknow, 26-27 May 2023 - **Dr M.S.Shekhar**

Farmers interaction meet cum 5th Anniversary of Dr, Attar Aqua feed mill, Charki Dadri, Haryana established under CIBA technical guidance on 15 May 2023 - **Dr K. Ambasankar**

Inspected for registration and renewal of 31 L. vannamei, one *P. monodon* and one finfish (*L. calcarifer*, *Trachinotus blochii* and *Trachinotus mookalee*) hatcheries located at Anakapalli, Kakinada and DrB.R.Ambedkar Konaseema districts of Andhra Pradesh, 30 May to 1 June 2023 - **Dr R. Ananda Raja**

Inspected for registration and renewal of six *Litopenaeus vannamei,* two *Penaeus monodon* and one *Lates calcarifer* hatcheries located at Visakhapatnam, Vizianagaram, Anakappalli and Kakinada districts of Andhra Pradesh, 4-5 May 2023- **Dr R. Ananda Raja**

Inspected for registration and renewal of ten *L. vannamei* and one *P. monodon* hatcheries located at Puri and Ganjam districts of Odisha, 11-12 May 2023- **Dr R. Ananda Raja**

Inspected for registration and renewal of six *Litopenaeus vannamei,* two *Penaeus monodon* and one *Lates calcarifer* hatcheries located at Visakhapatnam, Vizianagaram, Anakappalli and Kakinada districts of Andhra Pradesh, 4-5 May 2023- **Dr R. Ananda Raja**

Inspected for registration and renewal of ten *L. vannamei* and one *P. monodon* hatcheries located at Puri and Ganjam districts of Odisha, 11-12 May 2023- **Dr R. Ananda Raja**

International Conference on Feminism, Literature & Social Sciences – 2023 at Scott Christian College, Nagercoil, Kanniyakumari, Tamil Nadu held during 05-06 May 2023- **DrB.Santhi**

Meeting on Allowing the import of Specific Pathogen Free (SPF) brood stocks of crustaceans from South East Asian countries under Chairmanship of Joint Secretary (Marine Fisheries), 1 May 2023 – **Dr S.K.Otta**

35th Meeting of the Academic Council (Special Meeting) of KUFOS, Kerala, 21 June 2023 - **Dr S.K.Otta**

Meeting of the board of studies in zoology as a member, the University of Madras to revise the syllabus for undergraduate degrees in the subject of Zoology, 21 June 2023- **Dr M. Kailasam**

Attended a "Hands on training programme on CRISPR/Cas9-based gene editing technologies in plants" at ICRISAT, Telangana from 12-14 June 2023 – **Dr T.Bhuvaneswari**

Expert in the research council meeting for the finalization of research programme at CoF, CAU, Lembucherra, Tripura on 13 June 2023 - **Dr K. Ambasankar**

Inspected for registration and renewal of three *L. vannamei* hatcheries located at Krishna district of Andhra Pradesh, 23 June 2023– **Dr R. Ananda Raja**

Inspected for registration and renewal of three *L. vannamei* hatcheries located at Chengalpattu and Villupuram districts of Tamil Nadu, 20 July 2023– **Dr R. Ananda Raja**

Inspected for registration and renewal of two *L. vannamei* hatcheries located at Bapatla and Sri Potti Sriramulu Nellore districts of Andhra Pradesh, 16 June 2023– **Dr R. Ananda Raja**

Meeting of the Empanelment Committee for overseas SPF broodstock suppliers, CAA, 1st June, 2023 – **Dr S.K.Otta**

Meeting with the stakeholders' associations to discuss the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) Phase – II, CAA, 21 June 2023 – **Dr S.K.Otta**

National Training Conclave organized by Capacity Building Commission, Government of India, 11 June, 2023 – **Dr R. Saraswathy**

Served as NABL assessor at BAIF Analytical Laboratories, Uruli Kanchan, Pune-412202, 24-25 June 2023 – **Dr R. Ananda Raja**

Workshop on "Linking Researchers and Resources" organised by ICAR-NBAIR and I-STEM, NBAIR, Bangalore, 14-16 June 2023- **Dr M.S.Shekhar**

Empowered committee meeting of NASF Project, organized by ICAR Headquarters, Delhi, 6 July, 2023- **Dr Debasis De**

International conference on Current advances in agriculture, animal husbandry and allied sciences (CAAAAS 2023) organized by Agricultural research council of Nigeria and National agriculture development cooperative Ltd. (NADCL), Baramulla, J &K, 10-11 July, 2023- **Dr Biju, I.F**

International conference on Current advances in agriculture, Animal Husbandry and allied dciences (CAAAAS-23) organized by Agricultural research council of Nigeria and National agriculture development cooperative Ltd. (NADCL), Baramulla, J&K, 10-11 July, 2023- **Dr N.S Sudheer**

Liaison officer for organizing "Fisheries Summer Meet 2023" at Mahabalipuram organized by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India, 10-11 July 2023 – **Dr R. Ananda Raja**

Member of the selection committee for engagement to the position of Senior Project Associate on temporary basis in CSIR-CLRI, Chennai, 13 July 2023 - **Dr R. Ananda Raja**

Workshop on "GM crops and their derivatives for the aqua sector: Opportunities and way forward" on 25 July 2023, organized by ICAR-CIBA and Biotech Consortium India Limited, New Delhi - **Dr J. Syama Dayal, Dr Sherly Tomy, Dr K. Ambasankar, Dr M.S.Shekhar.**

95th ICAR-Foundation and Technology Day at Krishi Bhavan, New Delhi and received Technology Certificate from the Honourable Minister of State for Agriculture and Farmers Welfare, Govt. of India, 16 July 2023- **Dr M. Kailasam**

Convened the Shrimp Farmers Conclave – 2023 in association with the Faculty of Marine Sciences (FMS), Annamalai University, and Tamil Nadu Coastal Aquaculture Farmers Federation (TANCAFF) at Parangipettai, Tamil Nadu, 1 August 2023 - **Dr R. Ananda Raja**

Shrimp Farmers Conclave-2023 organized by CIBA in association with the Faculty of Fisheries, Annamalai University and TANCAFF at Parangipettai, Tamil Nadu and interaction with the stakeholders on the importance of species diversification in brackishwater aquaculture with finfish species, 1 August, 2023- **Dr M Kailasm**

International conference on Aquatic Resources and Sustainable Management organized by International Academy of Science and Research Kolkata West Bengal, August 30-31 2023 – **Dr Babita Mandal**

Meeting at CAA to modify the SOP for import of SPF brooders/live feed etc from SEA countries, 22 August 2023 – Dr S.K.Otta

Meeting of NABL final onsite assessment, at ICAR-CIBA, Chennai, 26-27 August 2023 - **Dr M.S.Shekhar**

Meeting of Town Official Language Implementation Committee (TOLIC) at NIOT, Chennai, 31 August 2023 - **Dr M.S.Shekhar**

Meeting to finalise the SOP and criteria for the empanelment of suppliers for import of SPF shrimp and scampi Broodstock PPL of crustaceans along with Artemia cysts from AHPND/ EMS affected countries, CAA, 20 August, 2023 - **Dr S.K.Otta**

Meeting with member secretary, CAA at CIBA regarding CAA amendment bill, 31 August 2023 – **Dr S.K.Otta**

National training cum workshop on Trends in Genomics organized by Madras Veterinary College, TANUVAS, Chennai, 7-11 August, 2023 - **Dr N.Lalitha**

National Workshop for India of the project Atlas of Climate Adaptation in South Asian Agriculture (ACASA) held at CRIDA, Hyderabad during 21-23 August 2023 - **Dr J. Ashok Kumar**

Virtual Meeting for deciding the criteria for shrimp crop insurance, 30 August, 2023- **Dr S.K.Otta**

2nd International Conference on Prospects and Challenges of Environmental and Biological Sciences in Food production system for Livelihood Security of Farmers (ICFPLS 2023) organized by ICAR-CIARI, Port Blair, Andaman & Nicobar Islands, September 18-20 2023 – **Dr Babita Mandal**

Attended IAEC meeting of Government Kilpauk Medical College (GKMC) as CCSEA main nominee, 8 September 2023 – **Dr R. Ananda Raja**

Consultation Meeting to discuss on the for drafting of Rules/ Regulations and Guidelines for 'The Coastal Aquaculture Authority (Amendment) Act, 2023', Dept of Fisheries, Govt of India, 29 September 2023 - **Dr S.K.Otta**

Farmers conclave, NAU, Navsari, Gujarat, 14 Sept 2023 - **Dr S.K.Otta**

International Conference on Honoring the contributions and an insight into the contemporary and future perspectives of Microorganisms. 16 September, 2023 - **Dr M.Poornima**

Workshop on Innovative approaches for sustainable Indian Fisheries and Aquaculture organized by Bharathidasan University and Fisheries Technocrats Forum, 12-13 September 2023- **Dr R. Jayakumar.**

International Workshop on Diagnostics for Future: Precision Diagnostics in Aquaculture organized by ICAR-CIFE, 13 September, 2023- **Dr M.Poornima**

Meeting with ADG-NASF under NASF Project organized by CIFRI, Barrackpore, 6 September, 2023- **Dr Debasis De**

Participated in Sahakar Bharti organized "National Fisheries Convention" on at Vishnudas Bhave Natya Gruha, Vashi, Navi Mumbai, Maharashtra 6 October, 2023 -**Mr Pankaj Amrut Patil**

16th Agricultural science congress held at Kochi, Kerala during 10-13 October 2023 - **Dr J. Ashok Kumar**

16th Agricultural Science Congress organized by ICAR-CMFRI, 10-13 October 2023- **Dr R. Jayakumar, Dr Sandeep KP, Dr Sherly Tomy, Dr Dani Thomas**

36th Academic council meeting of KUFOS, Kochi, 6th October 2023 – **Dr S.K.Otta**

Attended IAEC meeting of Christian Medical College, Vellore, Tamil Nadu as CCSEA nominee, 21 October 2023 – **Dr R. Ananda Raja**

Served as NABL assessor at SRM Institute of Science and Technology – SRM DBT platform for advanced life science technologies, First floor, Sir C.V.Raman Research Park, Kattankulathur, Chengalpattu, Kanchipuram, Chennai-603203, Tamil Nadu, 7-8 October 2023 – **Dr R. Ananda Raja**

Attended IAEC meeting of M/s. Bioklone biotech Pvt. Ltd., Chennai-600061 as CCSEA nominee, 7 October 2023 – **Dr R. Ananda Raja**

Awareness program on Provisions of protection of plant varieties and Farmers Rights Act 2001 at ICAR-KVK, VCRI Namakkal on 26 October 2023 - **Dr K. Ambasankar**

International workshop on "Genetic Improvement of Performance Traits: A Genome Wide Selection Perspective" CIFA, Bhubaneswar, 28 October, 2023 - **Dr M.S.Shekhar**

Meeting of Institutional Animal Ethics Committee (IAEC) at ICAR-CIBA, Chennai, 4 October, 2023 - **Dr M.S.Shekhar**

Organized and attended the 9th IAEC meeting of ICAR-CIBA as Member Secretary, 4 October 2023 – **Dr R. Ananda Raja**

Participated in meeting cum inspection of Asangaon and Badapokhran farm/hatchery of Maharashtra fisheries department along with Officials of the Department of Fisheries and Mangrove cell, Maharashtra on 31 October, 2023- **Dr M. Jayanthi, Mr Pankaj Amrut Patil, Mr Jose Antony**

Served as NABL assessor at National Dairy Development Board Research and Development Laboratory, Indian Immunologicals Ltd. Campus, Gachibowli Post, RR. District, Hyderabad-500032, 4-5 November 2023 - **Dr R. Ananda Raja**

18th meeting of FAD 12 virtually on 20 November 2023, Organized by BIS, New Delhi - **Dr K. Ambasankar**

Participated in "The Global Fisheries Conference India 2023" organized by Department of Fisheries, Govt. of India, at Science City Ahmedabad, Gujarat, on 21-22 November, 2023 – **Dr A. Panigrahi, Dr K. Ambasankar, Dr P. K. Patil, Dr T. Ravishankar, Mr Pankaj Amrut Patil, Mr Jose Antony**

3rd International Conference on Aquatic Animal Epidemiology (AquaEpi III), 29 November - 01 December 2023 - **Dr M.Poornima**

3rd International Conference on Aquatic Animal Epidemiology organized by ICAR- NBFGR, Lucknow, 29 November - 1 December, 2023- **Dr Sanjoy Das**

Attended a meeting on CIBA work plan for livelihood development of coastal communities of Gujarat with Mr Raghavjibhai Patel, the Minister of Fisheries, Government of Gujarat organized by GHED Fishermen Farmers Producer Organization (FFPO), Mangrol at Sachivalay, Gandhi Nagar, Ahmedabad on 2 November, 2023 - **Mr Pankaj Amrut Patil**

Attended meeting on sustainable development of Brackishwater fisheries in Maharashtra organized by Fisheries, Department, Maharashtra at the Office of the Commissioner of Fisheries, Maharashtra, Mumbai, on 28 November 2023 - **Mr Pankaj Amrut Patil, Mr Jose Antony**

Attended the IAEC meeting of Ramachandra Medical College and Research Institute, Porur, Tamil Nadu as CCSEA nominee, 27 November 2023 - **Dr R. Ananda Raja**

Workshop on "Disease free shrimp farming with special reference to WSD and HPM", VIROCON-2023, Tiruchirappalli, 1-3 December, 2023 - **Dr M.S.Shekhar**

Virocon 2023, Tiruchirapalli, 1 – 3 December, 2023 – **Dr S.K.Otta**

VIROCON-2023: Advancement in Global Virus Research Towards One Health'. 1-3 December 2023, Tiruchirappalli - **Dr M.Makesh**

23rd Meeting of Technical Committee to oversee and monitor the functioning of Aquatic Quarantine Facility, 14 December 2023 – **Dr S.K.Otta**

Advisory committee meeting of Hilsa project organized by CIFRI, Barrackpore & KRC-CIBA, 26- 28 December, 2023- **Dr Debasis De**

Aquatic Animal Epidemiological Conference (AquaEpi III), Lucknow, 30 November – 1 December, 2023 – **Dr S.K.Otta**

Attended and presented an abstract in VIROCON-2023 Advancement in Global Virus Research Towards One Health", 1-3 December 2023 – **Dr R. Ananda Raja**

Attended the IAEC meeting of BCG Vaccine Laboratory (BCGVL), Chennai under the Directorate General of Health Services (DGHS), Ministry of Health and Family Welfare, Government of India, 23 December 2023 – **Dr R. Ananda Raja**

Workshop on Disease free shrimp farming with special references to WSD and HPM organized during 'VIROCON-2023. 1-3 December 2023, Tiruchirappalli - **Dr M.Makesh**

Meeting to discuss on the Arrival status report of P. vannamei Broodstock consignment in AQF, CAA, 15 Dec 2023 - **Dr S.K.Otta**

Project review workshop of Atlas of Climate Adaptation in South Asian Agriculture (ACASA) held at Kathmandu, Nepal during 12-14 December 2023 - **Dr J. Ashok Kumar**

INVITED LECTURES

Invited lecture on "Diseases of shrimp" and "Histopathology" in 14th skill development programme for the aquaculture professionals organized by the Avanti Foundation, Andhra University-Avanti Aquaculture Skill Development Centre, Andhra University campus, Vishakhapatnam, Andhra Pradesh, 24-25 January 2023 – **Dr R. Ananda Raja**

Delivered a guest lecture on 'Coastal Aquaculture & Shellfish Hatchery Management' for ICAR-JRF students. Organized by College of Fisheries, Kishanganj, Bihar during 13-14 February, 2023- **Dr Aritra Bera**

Emerging trends in the use of plant based proteins in formulating shrimp feeds in the Aqua Nutrition workshop organized by USSEC at Hyderabad during 21-22 February 2023 - **Dr K. Ambasankar**

Delivered invited lecture on "Growing Seabass in Ponds" in the Fish India 2023 organized by SAP on 25 February 2023- **Dr R. Jayakumar**

Delivered an invited talk on 'Shrimp farming' in Farmers seminar organized by Dr Attar Aqua Feed and Gentle Bio Science at Malout, Punjab, Kalanwali, Haryana and Rajgarh, Rajasthan on 1-3 March, 2023- **Mr Jose Antony**

Delivered an invited talk on "Technologies for Livelihood Up-liftment of Coastal Community" in "FISHTECH, 2023" organized by The Maharashtra Economic Development Council (MEDC), Maharashtra, at Navi Mumbai on 2 March, 2023 – **Mr Pankaj Amrut Patil**

Delivered lead lecture on Brackishwater aquaculture technologies of KRC of ICAR-CIBA for farmers of Sundarbans, 4 March 2023- **Dr Babita Mandal**

Invited lecture and training on "Major shrimp diseases and their latest updates on diagnostics" in the Department of Biotechnology, University of Madras, Guindy Campus, Chennai-600025, 6 March 2023 – **Dr R. Ananda Raja**

Delivered a guest lecture on 'Brackishwater Aquaculture' for ICAR-JRF students. Organized by College of Fisheries, CAU, Tripura during 15 -17 March, 2023- **Dr Aritra Bera**

Delivered a talk on "CIBA Proposals for development of sustainable brackishwater aquaculture expansion in Maharashtra" in the "Review meeting of Mangrove Cell and Fisheries Department, Maharashtra" orgnanized by Mangrove Cell and Fisheries, Department, Maharashtra Government, at Malabar Hill, Mumbai on 12 April, 2023 – **Mr Pankaj Amrut Patil**

Use of GM Crops and their Derivatives for Aqua Sector on 20 April, 2023 at CMFRI, Kochi, organised by ICAR-Central

Marine Fisheries Research Institute (CMFRI) and Biotech Consortium India Limited - **Dr K. Ambasankar**

Delivered an invited lead lecture at International Conference on Feminism, Literature & Social Sciences – 2023, held during 5 - 6 May, 2023 at Scott Christian College, Nagercoil, Kanniyakumari, Tamil Nadu - **DrB.Shanthi**

Recent developments in Aquaculture Nutrition at CoF, CAU, Agartala, Tripura on 14th June 2023 in the Silver jubilee lecture series celebration - **Dr K. Ambasankar**

Delivered invited lecture on "Recent advances on finfish culture" in STP in Animal Sciences (STP-2023) at University of Madras on 7 July 2023- **Dr R. Jayakumar**

Challenges and opportunities in Aquaculture feed formulations in the India International Aquafeed Formulation Database workshop and training organized by USSEC at Vijayawada on the 11 of July 2023 - **Dr K. Ambasankar**

Lead lecture on Fermented soy products as tools for sustainable shrimp feed production in the International Aquafeed Formulation Database workshop and training organized by USSEC at Vijayawada, 11-12 July 2023 - **Dr J. Syama Dayal**

An overview on Shrimp Nutrition and Feed Processing Technology International Aquafeed Formulation Database workshop organized by USSEC at Dhakka on the 14 July 2023 (2 Lecturers) – **Dr K. Ambasankar**

Delivered invited lead lecture on Species composition with scope for diversification for SAIME in Indian Sundarban in National Symposium on Mangrove conservation and building resilient coasts, 26-27 July 2023- **Dr Debasis De**

Microbial diversity in Workshop on Coastal Zones and Marine Ecosystems and its sustainable development, 27-28 July 2023, Chennai - **Dr N.Lalitha**

Delivered invited lecture on "Guidelines for brackishwater Fish farming" in USSEC -Regional Aquaculture Production Course (RAPCOS)" from the 7–12 August 2023- **Dr R. Jayakumar**

Delivered an invited talk on "Brackishwater finfish nursery and grow out farming and Integrated fish farming" during the five days refresher course on "Advanced Aquaculture Practises", organized by Centre of Excellence, Kamdhenu University, at Ukai, Gujarat on 22 August, 2023- **Mr Pankaj Amrut Patil**

Delivered an invited lead talk on Emerging shrimp diseases of brackishwater aquaculture and their management, 23 August 2023 - **DrSanjoy Das**

Invited lecture on "Fish Cell Culture Development and Isolation of Pathogens" to Post Graduate students of 2022-23 batch of Dr MGR Fisheries College and Research Institute, Ponneri, Tamil Nadu on 25 August 2023 – **Dr T.Bhuvaneswari**

Invited lecture and training on "Shrimp health monitoring" and "Common shrimp diseases and management" in the Certificate course on "Shrimp farming and better management practices" organized by the Avanti Foundation, Andhra University-Avanti Aquaculture Skill Development Centre, Andhra University campus, Vishakhapatnam, Andhra Pradesh, 10 September 2023 - **Dr R. Ananda Raja**

Delivered invited lead lecture on "Culture of brackishwater finfishes" in the FTF workshop on Innovative approaches for sustainable Indian Fisheries and Aquaculture, 12-13 September 2023- **Dr R. Jayakumar**

Delivered an invited talk on "ICAR-CIBA brackishwater aquaculture technologies for livelihood development of coastal communities" in "National Fisheries Convention" organized by Sahakar Bharti, at Vashi, Navi Mumbai, Maharashtra on 06 October, 2023 -**Mr Pankaj Amrut Patil**

Use of tuber crops in animal and aqua feed in the awareness program on Provisions of protection of plant varieties and Farmers Rights Act 2001 at ICAR-KVK, VCRI Namakkal on 26 October 2023 - **Dr K. Ambasankar**

Invited lecture on "Penaeid draft genomes: Prospects and challenges" at International workshop on "Genetic Improvement of Performance Traits: A Genome Wide Selection Perspective" ICAR-CIFA, Bhubaneswar, 28 October 2023 - **Dr M.S.Shekhar**

Delivered invited lead lecture on Domestication and genetic improvement of Indian white shrimp, *Penaeus indicus* in Aquaex India 2023, 3 November 2023 at Bhimavaram, AP-**Dr P.S. Shyne Anand**

Delivered a guest lecture on 'Vaccines and Disease control for Aquatic Animal Health Management' to students of Aquatic Biotechnology (BIY2014) at Vellore Institute of Technology by online mode, 6 November 2023- **Dr M. Makesh**

Delivered an invited talk on

'Disease management in Asian seabass and Mud crab culture' to farmers at Centre for Advanced Studies in Marine biology, Annamalai University, Parangipettai, 8 November 2023- **Dr M. Makesh**

Delivered invited lead lecture Artificial Intelligence & IoT in Aquaculture". National Workshop "PONSHRIMP' 23 on 21 Novemeber 2023 at Dr J. Jayalalithaa Fisheries University, Ponneri, Thiruvallur - **DrP. Nila Rekha**

Delivered a guest lecture on 'Disease Diagnosis and Vaccine Development in Brackishwater Aquaculture Species' at Environmental Information, Awareness, Capacity building and livelihood Programme (EIACP), Department of Zoology, University of Madras, Guindy Campus, Chennai on the occasion of World Fisheries Day, 21 November 2023- **Dr M. Makesh**

Sustainable alternatives for Fish meal: Indian Scenario, deliver an invited lecture in the Global Fisheries Conference during 21-22 November 2023 at Ahmedabad organized by MoFAH - **Dr K. Ambasankar**

Delivered invited lead lecture on Better management practices in shrimp farming emphasizing on Antimicrobial resistance, 24 November 2023- **Dr Sanjoy Das**

Invited lecture on "Molecular diagnostic techniques for white spot syndrome virus: An overview" VIROCON-2023, Tiruchirappalli, 1-3 December, 2023- **Dr M.S.Shekhar**

Delivered invited lecture on "Aquaculture development in India" in the UGC- HRDC, University of Madras on 02 December 2023- **Dr R. Jayakumar**

Delivered an invited lecture on "Millets for health and sustainable planet" during the State Women's Scientific Exhibition for cluster level attended by 8 Kendriya Vidyalaya Schools of Chennai region on 13 December 2023 at Chennai- **Dr D. Deboral Vimala**

Delivered a lecture on the topic diversification of brackishwater aquaculture with candidate finfish species during Shrimp Farmers Conclave at Navasari Agriculture University, Navasari, Gujarat, 14 September 2023- **Dr M. Kailasam**

Nutritional Management in Aquaculture in National Workshop PONSHRIMP conducted at Dr MGR Fisheries College and Research Institute, Ponneri on 21 December 2023 - **Dr K. Ambasankar**

EXHIBITION

Kakdwip Research Centre of ICAR- CIBA participated and put up exhibition stall at 30th Annual flower show-2023 organized by Kakdwip Agri-Horticulture Society at Kakdwip Bidhan Maidan. Kakdwip, South 24 Parganas, West Bengal, during 1-8 January, 2023.

Kakdwip Research Centre of ICAR- CIBA participated and put up exhibition stall at Krishi mela organised by Sasya Shyamala Krishi Vigyan Kendra, Ramkrishna Mission Vivekananda Educational and Research Institute (RKMVERI), Sonarpur, West Bengal during 14-16 February, 2023.

Kakdwip Research Centre of ICAR- CIBA participated and put up exhibition stall at 26th National Agriculture Exhibition at Central Calcutta Science & Culture Organization, Central Park Maidan, Salt Lake on 27 August, 2023.

CIBA IN MASS MEDIA

Head News TV. CIBA and All Fishermen's Association organized an awareness program on the use of fish waste as a natural pesticide for agriculture. Available at: https://www.youtube.com/watch?v=Kls2OA5lC_4

Meen kazhivukaliliruntu vivasayathirugu iyargai poochikollii marunthaga payanpaduthuvathu kurithana vilzipunarnchi nighazchi, Malai News. 23, December 2023, p3.

Meen kazhivukalai maarusuhzarchi mooulam vivasayathirugu iyargai poochikollii marunthaga payanpaduthuvathu kuritdhana vilzipunarnchi nighazchi, Manasoli 23 December 2023.

Media news-Puppet show at Kottaikadu on 31st October 2023

Commercialized ICAR-CIBA technologies

Headquarters

ICAR-Central Institute of Brackishwater Aquaculture

75, Santhome High Road, MRC Nagar, RA 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

Kakdwip, South 24 Parganas,
West Bengal - 743 347.
Telephone: +91 3210-255072
Fax: +91 3210-257030
E-mail: oic_krc.ciba@icar.gov.in
krckakdwip@gmail.com

Navsari-Gujarat Research Centre of CIBA

1st Floor, Animal Husbandry Polytechnic Building,
Navsari Agricultaral University Campus,
Eru Char Rasta, Dandi Road
Navsari - 396 450, Gujarat,
Telephone: +91 2637-283509
E-mail: oic_ngrc.ciba@icar.gov.in

www.ciba.icar.gov.in

ICAR-Central Institute of Brackishwater Aquaculture
ISO 9001 : 2015
(Indian Council of Agricultural Research)

75, Santhome High Road, MRC Nagar, RA Puram,
Chennai - 600 028, Tamil Nadu,
Telephone: +91 44 24616948, 24618817, 24610565,
Fax: +91 44 24610311
E-mail: director.ciba@icar.gov.in

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