ANNUAL REPORT 2022

भा कृ अनु प – केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

Garib Kalyan Sammelan

CIBA organized the 'Garib Kalyan Sammelan' on 31st May 2022, where the Prime Minister virtually addressed. The event had local participation, and it was physically inaugurated and addressed by Dr. L. Murugan, the Honourable Union Minister of State for Fisheries, Animal Husbandry and Dairying.

Front cover: Indian white shrimp, *Penaeus indicus*: a potential desi shrimp species considered for domestication and genetic improvement by CIBA. It could be a complementary species for exotic *Penaeus vannamei*.

Back cover: As part of the national mission on the use of drones in agriculture, by Govt. of India, demonstrations were conducted showcasing the application of drones for feeding fish/shrimp, as well as the precise dispensation of liquid inputs in aquaculture.

Annual Report
2022

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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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Preface

Sustainable development of brackishwater aquaculture sector in India is critical for global seafood availability, nutritional security and trade revenue. India is one of the major seafood producer and exporter; with shrimp as a major commodity of 8.43 lakh tons cultured in about 1.67 lakh ha area. During 2021-22, the foreign exchange earning approximates to $5.83 billion from frozen shrimp export of 7.28 lakh tons. The brackishwater aquaculture is important for livelihood of millions of people, including the ancillary industries on inputs and processing. The research and policy initiatives are required to work with synergy, more than before, to support transformation of aquaculture in line with global planning processes. Some of the emerging needs are environment friendly practices, food safety and certifications, productivity enhancements through use of domesticated and improved varieties, resilient species for diversification, smart and best aquaculture practices, efficient disease governance, efficient feeds and utilization, capacity enhancement of communities for absorbing new technologies and improving land use for horizontal expansion to potential areas etc. The validated research and science-based solutions to the emerging problems and timely adaption by stakeholders through enabling environment will be the key to future growth of the sustainable brackishwater aquaculture.

ICAR-CIBA has been working and responding to the needs of the sector and with convergence to the national policy such as Pradhan Mantri Matsya Sampada Yojana (PMMSY) and providing technical inputs to state and central departments. During 2022, research focus and major efforts were directed to indigenous species, Indian white shrimp and seabass for harnessing their market potential. The salient research includes captive broodstock development of *Penaeus indicus*, application of copefloc technology in shrimp production assessment of inland saline groundwater resources from north-western India for shrimp farming, research on Integrated Multi-trophic Aquaculture (IMTA) cages as a livelihood activity for coastal fisher folks of Sindhudurg, Maharashtra. ICAR-CIBA has put in place two important and novel initiatives, such as selective breeding program of Indian white shrimp with the support under PMMSY and developed shrimp crop insurance product in collaboration with Oriental Insurance Corporation Ltd. and Alliance Insurance Brokers.

During 2022, ICAR-CIBA successfully bred the gold-lined seabream fish (*Rhabdosargus sarba*) for the first time in India. A total of 3.8 million fish seeds (32.32 lakhs spawn and 5.63 lakhs fry and fingerlings: seabass 37.75 lakhs; milkfish 12,550 nos. and pearlspot 7,080 nos.) distributed to the farmers from Kerala, Tamil Nadu, Karnataka,

Andhra Pradesh and West Bengal and an amount of ₹17.63 lakh generated as revenue. Under Scheduled Tribe Component (STC), successful demonstrations (170 farmers), trainings (130 farmers); and awareness camps (835 farmers) in Tamil Nadu, Gujarat, Maharashtra, Odisha, and West Bengal in aquaculture an allied technologies have given livelihood upliftment and income generation for tribal communities ranging from ₹0.3 lakhs to ₹11.39 lakhs. In Scheduled Caste Sub Plan (SCSP), the institute had organized eight training programs for 420 farmers; conducted six on-farm trials involving 100 farmers. In addition, five front-line demonstrations for 94 farmers, and 14 awareness meetings in different villages involving 2,470 farners were undertaken. During the year, 50 research articles in peer reviewed journals were published and scientists have also presented papers in 83 conferences/symposium/ seminars etc.

ICAR-CIBA has bagged five awards during 2022 viz., Swachhta Pakhwada Award for Year - 2021, Ganesh Shankar Vidhyarthi Hindi Patrika Puruskar - 2021 for *Jal Tarang*, Appreciation Award for the exemplary work in 'People's Movement for Clean Cities - 2022' from the Greater Chennai Corporation (Chennai), Best of India Biz Award for special display and presentation during 19th International edition of 'Mega Goa World EXPO and Summit - 2022 and 'Best Exhibitor-Winner' Award in the Exhibition Event of 12th Indian Fisheries Aquaculture Forum.

I express my gratitude to Dr. Himanshu Pathak, Secretary, DARE and Director General, ICAR for all his valuable guidance and support. I also extend our heartfelt thanks to Dr. Trilochan Mohapatra, Former Secretary, DARE and Director General, ICAR for his support and encouragement. Our heartfelt thanks to Dr. J.K. Jena, Deputy Director General (Fisheries Science) for all his encouragements, timely advices on institute research and administration activities. Our thanks are due to Dr. Pravin Putra, Former Assistant Director General (Marine Fisheries) for all his guidance and support in institute activities. We also express our sincere gratitude to all the scientists especially, Dr. Prem Kumar and Dr. Yasmine Basade and Officials in Fisheries Division at ICAR, for their able consistent support.

I express my sincere thanks to Shri. Jatindra Nath Swain, Secretary, Department of Fisheries (DoF), Ministry of Fisheries, Animal Husbandry and Dairying for his encouragement to this institute through various programs. I express my gratefulness to the Joint Secretaries of DoF, Dr. J. Balaji and Shri. Sagar Mehra for their consistent guidance to this institute, in accomplishing various programs. The thanks are due to all the officials of DoF for their support to ICAR-CIBA.

I also appreciate and congratulate Dr. K.P. Jithendran, Principal Scientist, AAHED who was the Director in-Charge of ICAR-CIBA till October 2022 and all the Heads of the Divisions, Scientist in-Charges, Heads of Research Centres, Officer In-charges and all the scientists, administrative, technical and supporting staff for their sincere efforts for the progress of the institute. Our sincere thanks to all the farmers and farm-women, State Department Officials, all the Developmental and Institutional agencies who supported in all the possible ways for effectively undertaking our mandated activities.

"Emerging needs are environment friendly practices, food safety and certifications, productivity enhancements through use of domesticated and improved varieties, resilient species for diversification, smart and best aquaculture practices, efficient disease governance, efficient feeds and utilization, capacity enhancement of communities

Special appreciation and congratulations to the editorial board of this Annual Report 2022 for their efforts in bringing out this document.

Kuldeep K. Lal

Director

कार्यकारी सारांश

मिल्कफिश और अन्य खारा जलीय प्रत्याशी प्रजातियों के विभिन्न उत्पादन मॉडल और विपणन सम्भावनाओं का मूल्यांकन

केईएस-सीबा में 1,156 वर्ग मीटर वाले एक मिट्टी के तालाब में मिल्कफिश अंगुलिकाओं (औसत शारीरिक वजन 20 ग्राम और कुल लंबाई 11.6 से.मी.) को 1.5 नग/वर्गमीटर की दर से संग्रहीत कर सीबा द्वारा तैयार किया गया फ़ीड (मिल्कफिश ग्रो-आउट$^{प्लस}$) खिलाया गया है। पालन के 230 दिनों के बाद मछलियां 340 ग्राम और 35.43 से.मी औसत आकार की हो गई हैं। 230 दिनों पर प्राप्त बायोमास 478 किलोग्राम (4.78 टन/हेक्टेयर की उत्पादकता) और मछलियों की बिक्री से ₹65,450 प्राप्त हुआ है। पालन अवधि के दौरान लगभग 1.38 एफसीआर की गणना की गई। अस्थिहीन (डि-बोन्ड) मिल्कफिश की सम्भावनाओं का पता लगाने के लिए प्रारंभिक अध्ययन किया गया। अस्थिहीन मिल्कफिश का औसत ड्रेसिंग नुकसान केवल <20% है और फसल प्रगहण के बाद की अच्छी संभावना है। मूल्यवर्धन के रूप में डी-बोनिंग की गई मिल्कफिश संभावित रूप से सम्पूर्ण मछली की तुलना में प्रीमियम मूल्य प्राप्त कर सकती है।

एक वैकल्पिक आजीविका गतिविधि के रूप में खारे पानी की खाड़ी और तालाब में स्थापित कम आयतन वाले पिंजरों में सीबास और पर्लस्पॉट मछलियों के पालन का निरूपण

आईसीएआर-सीबा के एनजीआरसी ने गुजरात सरकार के मत्स्य विभाग के सहयोग से गुजरात के तटीय मछुआरों के लिए वैकल्पिक आजीविका गतिविधि के रूप में खारे पानी की खाड़ी और तालाबों में एशियाई सीबास और पर्लस्पॉट मछलियों की पिंजरा पालन का निरूपण कार्य प्रारम्भ किया। 4 x 4 x 2 मीटर (32 वर्ग मीटर) के आठ पिंजरों और 6 x 4 x 1.5 मीटर (36 वर्ग मीटर) आकार के 4 पिंजरों को स्थानीय रूप से बनाकर जल निकायों में स्थापित किया गया था। सीबास अंगुलिकाओं (20-25 ग्राम) और पर्लस्पॉट अंगुलिकाओं (2-3 इंच) को संग्रहीत किया गया और मछलियों को तैयार फ़ीड दे कर पालन किया गया। पालन कार्य जारी है।

इंडियन साल्मन *एलेउथेरोनेमा टेट्राडैक्टाइलम* पर नर्सरी पालन परीक्षण

वन्य रूप से एकत्रित 1.0 से 1.3 से.मी आकार के इंडियन साल्मन *एलेउथेरोनेमा टेट्राडैक्टाइलम* के 3,800 पोनों को मछलीपट्टनम, कृष्णा जिला, आंध्र प्रदेश से खरीद कर एफआरपी टैंकों में 25 पीपीटी की लवणता के अनुकूल बनाया गया। आकार के अनुसार वर्गीकृत कर संग्रहीत किया गया। पोनों को 0.8 मिमी और 1.2 मिमी आकार के फॉर्मूलेटेड फीड (क्रूड प्रोटीन 46% और क्रूड फैट 10%) दिन में तीन बार *एड लिबिटम* रूप में खिलाया गया। 30 दिनों के पालन के बाद 4.5 सेमी आकार प्राप्त किया। बहुत सक्रिय रूप से तैरने वाली अंगुलिकाओं को कृत्रिम आहार से आसानी से छुड़ाया जा सकता है।

पर्लस्पॉट *इट्रोप्लस सुराटेंसिस* की हापा आधारित नर्सरी पालन

पर्लस्पॉट के लार्वा पालन चरण की अवधि को घटाने और बाहरी नर्सरी पालन के लिए लार्वा की आदर्श आयु का मूल्यांकन करने के लिए एनजीआरसी-सीबा में प्रयोग किए गए। विभिन्न आयु वर्ग के लार्वा को दो समूहों में विभाजित किया गया था जैसे कि अगेती संग्रहण (5, 10 और 15 दिन आयु वर्ग) और पछेती संग्रहण (20, 25 और 30 दिन आयु वर्ग) को हापाओं में संग्रहीत किया गया और *आर्टेमिया* नौप्ली एवं कृत्रिम आहार दिया गया। 30 दिनों के पालन के बाद, अगेती संग्रहण समूह (19.86-37.33%) की तुलना में पछेती संग्रहण समूह की उत्तरजीविता दर (78-85%) बेहतर थी। 30 दिन आयु वाली पर्लस्पॉट लार्वा (16.2±0.12 मिमी) ने 83% उत्तरजीविता दर के साथ नायलॉन हापाओं में पालन के 40 दिनों में अंगुलियों के आकार (4.12±0.38 सेमी) को प्राप्त किया।

सिंधुदुर्ग, महाराष्ट्र के तटीय मछुआरों के लिए आजीविका गतिविधि के रूप में एकीकृत मल्टी-ट्रॉफिक एक्वाकल्चर (IMTA) पिंजरों का विकास

एशियन सीबास (700 नग), पर्लस्पॉट (400 नग), टाइगर श्रिम्प (20,000 नग), *कप्पाफाइकस* समुद्री शैवाल (20 किग्रा) और 50 हरी मसल्स (150-200 मसल्स/रस्सी) का संग्रहण किया गया और स्वयं सेवी समूह की मदद इनका परिशीलन किया गया। प्रगहण पर उन्होंने 560.5 किलोग्राम सीबास, 820.3 किलोग्राम ग्रीन मसल्स, 353.9 किलोग्राम टाइगर श्रिम्प, 720 किलोग्राम पर्लस्पॉट और 20 किलोग्राम सूखे समुद्री शैवाल की बिक्री से ₹6.25 लाख का राजस्व अर्जित किया। परिणाम बताते हैं कि एकल प्रजातियों की खेती के बजाय बहु प्रजातियों का एकीकरण अधिक और नियमित आय प्रदान करता है।

मोनोकल्चर और पॉलीकल्चर के

तहत *लिज़ा टेड* का तुलनात्मक विकास मूल्यांकन

केआरसी के मिट्टी के तालाब में मोनोकल्चर और पॉलीकल्चर पालन प्रणाली के तहत टेड मुलेट का तुलनात्मक विकास मूल्यांकन हेतु अध्ययन शुरू किया गया था। टेड अंगुलिकाओं (4.7±0.8 ग्राम; 9.5±1.1 सेमी) को मोनोकल्चर और पॉलीकल्चर तालाब में 1.42 अंगुलिकाएं/वर्ग मीटर घनत्व के साथ संग्रहण किया गया था। पॉलीकल्चर तालाब में लगभग 2,000 मिल्कफिश अंगुलिकाओं (3.9±1.8 ग्राम; 7.02±2.5 सेमी) को टेड मुलेट के साथ रखा गया था। मछलियों को फ्लोटिंग फीड (प्रोटीन 28-30%, फैट 5%) @ 2-3% शारीरिक वजन की दर से खिलाया गया। मोनोकल्चर और पॉलीकल्चर तालाब में टेड मुलेट की उत्तरजीविता क्रमशः 95 और 90% दर्ज की गई। मोनोकल्चर और पॉलीकल्चर के तहत अंतिम प्रगहण का औसत शारीरिक वजन क्रमशः 503.67±19.5 ग्राम और 210.11±9.8 ग्राम था, जबकि उपज प्राप्ति के समय मिल्कफिश का औसत शारीरिक वजन 370.95±10.11 ग्राम था। मिल्कफिश के लिए विशिष्ट वृद्धि दर (एसजीआर) 1.18 दर्ज की गई, पॉलीकल्चर में टेड मुलेट के लिए 0.97 और मोनोकल्चर में टेड मुलेट के लिए 1.27 दर्ज की गई।

हिलसा का ग्रो-आउट पालन प्रोटोकॉल

हिल्सा ग्रोआउट पालन प्रोटोकॉल को परिष्कृत करने के लिए प्रयोग किए गए। प्लैंकटन$^{प्लस}$ को तालाब में 160 किग्रा/हेक्टेयर की दर से अनुप्रयोग करने के पश्चात नर्सरी पालित हिल्सा पोनों (11.23±0.82 ग्राम/10.40±0.32 सेमी) को 14,000 नग /हेक्टेयर की दर से संग्रहीत किया गया था। पालन के दौरान, प्लवकों की आबादी को बनाए रखने के लिए तालाब में प्लैंकटन$^{प्लस}$ (30 किग्रा/हेक्टेयर) और सरसों की खली (60 किग्रा/हेक्टेयर) साप्ताहिक रूप से अनुप्रयोग किया गया। शारीरिक वजन के 10-5% की दर से फॉर्मूलेटेड स्लो-सिंकिंग ग्रो-आउट फीड (हिल्सा$^{प्लस}$) दिया गया। 184 दिनों के बाद पोनों का औसत शारीरिक वजन / औसत शारीरिक लंबाई 37.43±7.14 ग्राम/16.08±0.7 सेमी दर्ज किया गया।

झींगा उत्पादन के लिए कोपेफ्लॉक प्रौद्योगिकी

कोपेफ्लॉक झींगा उत्पादन के लिए एक आदर्श तकनीक है। कोपेफ्लॉक उत्पन्न करने के लिए *डायोइथोना रिगिडा, स्यूडोडायप्टोमस एन्नांडेलेय और इवांसुला पाइग्मिया* नामक कोपेपोड्स का उपयोग किया गया था। कोपेफ्लॉक आधारित नर्सरी ने पूरक आहार में 20% की कमी की। नर्सरी पालन के 50वें दिन झींगों का औसत आकार नियंत्रण 14.2±0.92 ग्राम की तुलना में 24.4±01.2 ग्राम पाया गया था। अध्ययन दर्शाता है कि कोपेफ्लॉक संवर्धित तरूण झींगें प्रतिपूरक विकास, महत्वपूर्ण रूप से उच्च उत्तरजीविता, निम्न एफसीआर दर्शाते हैं।

झींगा पालन के लिए फार्म आधारित फीड का मूल्यांकन

स्थानीय रूप से उपलब्ध खाद्य सामग्री का उपयोग करके आहार संरचना तैयार की गई थी। फार्म आधारित फीड के साथ उगाए गए झींगों का औसत वजन पालन के 100वें दिन 13.85 ग्राम दर्ज किया गया है। आर्थिक विश्लेषण से पता चलता है कि फीड उत्पादन की कम लागत के कारण बेहतर प्रतिफल प्राप्त हुए हैं। इससे झींगा पालन में झींगों के अनिश्चित मूल्यों में सहायता प्राप्त होती है और इस फीड में झींगा पालन क्षेत्र की स्थिरता के लिए कम लागत वाली उत्पादन विधियों की मांग को पूरा करने की क्षमता है।

मीठे जल में पाले गए *पीनियस वन्नामेय* तरूण झींगों की वृद्धि और उत्तरजीविता पर खनिजों का अनुपूरण (टीडीएस <500 पीपीएम)

मीठे पानी (FW) में पैसिफिक सफेद झींगा *पीनियस वन्नामेय* की खेती, झींगों की उल्लेखनीय ऑस्मोरगुलेटरी क्षमता को देखते हुए एक उभरता हुआ क्षेत्र है। मीठे पानी में पोटेशियम (K1, K2, K3), मैग्नीशियम (M1, M2, M3) और कैल्शियम (C1, C2, C3) आयनों के पूरण से प्रायोगिक मीडिया तैयार किया गया था, जैसे कि लक्षित आयन को 5 पीपीएम क्रमिक रूप से तीन स्तरों तक बढ़ाया जा सके। जबकि अन्य आयन स्थिर रहें। अनुपचारित मीठे जल में पालित सभी झींगे प्रयोग के अंत तक मर गए। K3 और M3 के उपचार में झींगा पालन किया गया जिसमें पोटेशियम और मैग्नीशियम क्रमशः बेसल स्तरों से 15 पीपीएम तक बढ़ाए गए, जिसके परिणामस्वरूप काफी अधिक उत्तरजीविता (80.4-87.8%) दर्ज हुई जो SW (96.25%) में पालित झींगों के समान था। अध्ययन अलग अलग आयनों के महत्व को प्रकट करता है और वाणिज्यिक संचालन के लिए न्यूनतम आयनिक आवश्यकता पर एक उचित विचार देता है।

गूगल एर्थ इंजन में मशीन लर्निंग तकनीकों का इस्तेमाल करके जलीय कृषि के लिए मिट्टी में लवणता के अलग-अलग स्तरों की पहचान करना

लवण प्रभावित भूमि (एसएएल) का आकलन दुनिया भर में एक बड़ी चुनौती है, खासकर विकासशील देशों में सीमित डेटा की उपलब्धता के कारण। रिमोट सेंसिंग (आरएस) डिजिटल उपग्रह डेटा और उनकी वर्णक्रमीय विशेषताओं का विकास मिट्टी की लवणता का आकलन करने का मार्ग प्रशस्त करता है। थूथुकुडी, तमिलनाडु की लवण-प्रभावित भूमि का लैंडसेट-8 उपग्रह चित्रों का उपयोग करके अध्ययन किया गया। अध्ययन ने विभिन्न स्थानिक संकल्पों में लवण प्रभावित भूमि का पता लगाने के लिए रिमोट सेंसिंग तकनीकों की प्रभावशीलता को दर्शाया, जो वैकल्पिक आजीविका विकल्पों के निर्माण के लिए राज्य या क्षेत्रीय स्तर पर अनुत्पादक भूमि और इसके प्रबंधन का मूल्यांकन करने में मदद कर सकता है।

उत्पादन प्रदर्शन और जल की गुणवत्ता चर के आधार पर झींगा पालन के लिए उत्तर-पश्चिमी भारत के अंतर्स्थलीय लवणीय भूजल संसाधनों की उपयुक्तता का आकलन

हरियाणा, पंजाब और राजस्थान में अंतर्स्थलीय झींगा पालन तेजी से बढ़ रहा है और खेती के संचालन की समग्र सफलता के लिए खारे भूजल की गुणवत्ता चर के आधार पर स्थान का चयन अनिवार्य है। हरियाणा, राजस्थान और पंजाब राज्यों में व्हाइट लेग श्रिम्प, पीनियस वन्नामेय उगाने वाले परिचालन फार्मों से खारे भूजल के नमूने एकत्र किए गए और पानी की गुणवत्ता चर का अनुमान लगाया गया। अध्ययन का निष्कर्ष है कि स्रोत जल की सापेक्ष कठोरता एक साइट के चयन के लिए एक प्रमुख मानदंड है और लगभग 1.5:1 का न्यूनतम Mg^{2+}/Ca^{2+} अनुपात अंतर्स्थलीय खारे भूजल में पी. वन्नामेय को पालने के लिए उपयुक्त है।

खारा जलीय समुद्री शैवाल, *ग्रेसीलेरिया सैलिकोर्निया* पालन

ग्रेसीलेरिया सैलिकोर्निया के विकास प्रदर्शन का आकलन करने के लिए विभिन्न संग्रहण घनत्व, गहराई और लवणता के साथ प्रयोग किए गए थे। अध्ययन ने समुद्री शैवाल प्रजातियों के लिए अनुकूलतम पालन विधि पर पहुंचने में मदद की, जिसमें प्रारंभिक बायोमास घनत्व 50 ग्रा.-2, लवणता 20 पीपीटी, सतह से 0.5 से 0.75 मीटर की गहराई और पालन अवधि 45 दिन हैं।

फिनफिश मत्स्य बीज उत्पादन और किसानों को आपूर्ति

कुल 3.8 मिलियन मत्स्य बीजों का उत्पादन किया गया जिनमें 32.32 लाख स्पॉन, 5.63 लाख पोना और अंगुलिकाएं (सीबास 37.75 लाख; मिल्कफिश 12,550 नग और पर्लस्पॉट 7,080 नग) हैं, जिन्हें केरल, तमिलनाडु, कर्नाटक, आंध्र प्रदेश और पश्चिम बंगाल के हैचरी संचालकों / किसानों में वितरण किया गया जिससे राजस्व के रूप में ₹ 17.63 लाख की राशि प्राप्त हुई।

पहली बार गोल्ड-लाइन्ड सीब्रीम मछली (*रबदोसार्गस सरबा*) के कैप्टिव प्रजनन और बीज उत्पादन पर सफलता

आईसीएआर-सीबा ने भारत में पहली बार गोल्ड-लाइन्ड सीब्रीम फिश (*रबदोसार्गस सरबा*) का सफलतापूर्वक प्रजनन किया। परिपक्व ब्रूडस्टॉक मछलियों (350-1,800 ग्राम) को एचसीजी और एलएचआरएचए हार्मोन से प्रेरित किया गया और सहज अंडजनन करवाया गया। हैचिंग के 25वें दिन तक कुल 1,500 सीब्रीम लार्वा उत्पन्न हुए, जिन्हें शुरू में रोटिफ़र्स तत्पश्चात आर्टीमिया नौप्ली और तैयार आहार दिया गया। बीज उत्पादन बढ़ाने का प्रयास किया जा रहा है।

मैंग्रोव रेड स्नैपर के कैप्टिव प्रजनन और बीज उत्पादन को बढ़ाना

मैंग्रोव रेड स्नैपर *लुत्जेनस अर्जेन्टिमैक्यूलेटस* की कुल नब्बे प्रजनक मछलियों को दो प्रकार की मछली संग्रहीत करने वाली प्रणालियों जैसे कि 100 टन क्षमता वाले आरसीसी टैंक (एन = 30, शरीर का वजन 3.5 से 6.2 किलोग्राम) और 600 वर्ग मीटर मिट्टी के तालाब में रखा गया था। बंध स्थितियों में प्रेरित प्रजनन परीक्षण सफल रहे और एक इंच आकार (50 दिन आयु) के 200 बीजों का उत्पादन किया गया।

दो भिन्न प्रजनकों के उपयोग से मिल्कफिश *चानोस चानोस* का कैप्टिव प्रजनन

चेन्नई और काकीनाडा समूह से कुल 38 मिल्कफिश प्रजनकों (औसत 6.2 किग्रा) को दो 100 टन आरसीसी टैंकों में समान रूप से रखा गया था। मौजूदा स्टॉक के साथ बारह नए प्रजनक मछलियां (चेन्नई, एबीडब्ल्यू 4.5 किग्रा, टीएल. 82 सेमी) जोड़े गए। मछलियों को हार्मोन पैलेट (GnRHa और 17α-मिथाइल टेस्टोस्टेरोन का संयोजन) के साथ उपचार किया गया और मार्च से सितंबर के दौरान कुल छह अंडजनन देखे गए और हैचरी में उत्पादित कुल 12,250 मिल्कफिश पोनों को किसानों में वितरित किया गया जिससे ₹52,514 का राजस्व प्राप्त हुआ।

उभरती हुई प्रत्याशी फ़िनफ़िश प्रजातियों (विशालकाय ट्रेवेली, बंगाल ब्रीम और रैबिट फिश) का कैप्टिव ब्रूडस्टॉक विकास

मिट्टी के तालाबों में कुल 75 विशालकाय ट्रेवेली *कैरेंक्स इग्नोबिलिस* का रखरखाव किया जा रहा है और मछलियां 12 महीने की अवधि में 0.5 से 1.0 किलोग्राम से 0.75 से 2.5 किलोग्राम का आकार प्राप्त किए हैं। मार्च 2023 के पहले सप्ताह के दौरान 2.0 किलोग्राम से अधिक की मछलियों में बायोप्सी जांच के माध्यम से मादा परिपक्वता देखी गई और 80-100 के बीच ओसाइट व्यास देखा गया और ब्रूडस्टॉक विकास कार्य जारी रखा जा रहा है।

दिसंबर 2022 और जनवरी 2023 के दौरान सीबा के केआरसी में विभिन्न लवण व्यवस्थाओं (5-30 पीपीटी) में बंगाल ब्रीम *एकेंथोपाग्रस डाटनिया* (नर 150-180 ग्राम और मादा 200 से 350 ग्राम) के कैप्टिव प्रजनन का प्रयास किया गया और 30 पीपीटी लवणता में मछलियों का प्रजनन कराया गया। प्रजनकों का ओसाइट व्यास 450µm से अधिक था, जिन्हें LHRHa हार्मोन @ 30 µg kg-1 शारीरिक वजन के आधार पर दिया गया और इसकी आधी खुराक नर मछलियों को इंट्रामस्क्युलर रूप से दी गई थी। मछलियों में 55-58 घंटे की प्रसुप्ति अवधि के बाद सफलतापूर्वक प्रजनन हुआ। तीन दिनों तक लगातार अंडजनन देखा गया और एक मादा से 1.0 लाख अंडे प्राप्त हुए और लार्वा को हैचिंग के 2 दिन बाद तक पाला जा सका है। आरसीसी और एचडीपीई टैंकों में कुल साठ रैबिट फिश (*सिगनस जेवस*) प्रजनकों (1.5 से 2.0 किग्रा) का रखरखाव किया जा रहा है।

पेलेट फीड का उपयोग करते हुए ग्रे मुलेट *मुगिल सेफालस* के तालाब

पारित नर्सरी पालन का विकास

एमईएस में अस्तर लगे तालाब (एसडी 500 नग @ 450 वर्ग मीटर) में ग्रे मुलेट नर्सरी पालन शुरू किया गया है, जिसमें 8 से 10 ग्राम हैचरी से उत्पादित बीजों का उपयोग किया गया है और 5 से 8% शरीर के वजन पर तैयार फ्लोटिंग नर्सरी फीड खिलाया गया है। 90 दिनों के पालन-पोषण के बाद मछलियों का आकार 40-50 ग्राम हो गया है। इसी प्रकार, परिपक्वता मूल्यांकन के लिए एनजीआरसी-सीबा, नवसारी में ग्रे मुलेट का तालाब आधारित प्रजनक विकास किया गया है।

सीबा, नवसारी, गुजरात के एनजीआरसी में एक मिट्टी के तालाब में रखे गए लगभग 300 वयस्क ग्रे मलेट (*मुगिल सेफालस*) को पेलेट फीड (सीपी: 40%, सीएफ: 10%) खिलाकर बंध स्थितियों के तहत विकास और परिपक्वता का मूल्यांकन किया गया था। सितंबर 2022 से जनवरी 2023 तक, बायोप्सी पद्धति का उपयोग करके उनकी परिपक्वता स्थिति का आकलन करने के लिए 60 यादृच्छिक रूप से चयनित मछलियों का मासिक आधार पर नमूना लिया गया था। मासिक अंतराल पर ओसाइट के व्यास में महत्वपूर्ण परिवर्तन देखा गया है जो इंगित करता है कि ग्रे मलेट खारे पानी के तालाबों में परिपक्वता प्राप्त करता है और दिसम्बर माह में परिपक्वता चरम पर होती है।

बंगाल ब्रीम, *एकेंथोपाग्रस डाटनिया* की प्रेरित प्रजनन तकनीक का परिशोधन

सीबा के केआरसी में *एकेंथोपाग्रस डाटनिया* प्रजनकों ने खारे पानी (5-7 पीपीटी) में यौन परिपक्वता प्राप्त की, और उच्च लवणता (30 पीपीटी) केवल अंतिम परिपक्वता, अंडजनन, ऊष्मायन और लार्वा पालन के लिए आवश्यक है। परिपक्व मादा (ओसाइट >350-400 माइक्रोन) और स्रावित नर को प्रजनन टैंक (8,000 ली) में स्थानांतरित कर दिया गया और लवणता धीरे-धीरे @ 5 पीपीटी/दिन से बढ़ाकर 30 पीपीटी कर दी गई। मादा मछलियों को 30 माइक्रोग्राम किग्रा-1 शारीरिक वजन की दर से LHRHa दी गई और नर मछलियों को इसकी आधी खुराक। मछली 55-58 घंटे की प्रसुप्ति अवधि के बाद सफलतापूर्वक अंडे दी है, और अंडे 22 घंटे (18°C) की ऊष्मायन अवधि के बाद बाहर निकले हैं।

खारा जलीय सजावटी मछली सिल्वर मूनी के प्रजनकों का विकास एवं नियंत्रित प्रजनन

प्रथम परीक्षण में, हैचरी में उत्पादित सिल्वर मूनी (*मोनोडैक्टीलस अर्जेन्टियस*) पोनों (30 दिन आयु) को एमईएस-एफसीडी हैचरी से माधवरम, चेन्नई के मीठे जल के सजावटी मत्स्य किसानों में वितरित किया गया। किसान ने मीठे जल में नर्सरी चरण (30 दिन) को 98% उत्तरजीविता के साथ एक इंच के आकार तक का पालन सफलतापूर्वक पूरा किया और एक अच्छा बाजार मूल्य (₹50/टुकड़ा) प्राप्त करने में सफल हुआ और हैचरी उत्पादित बीजों की उत्तरजीविता दर अधिक होने के कारण वन्य रूप से एकत्रित बीजों की तुलना में मांग अधिक रही है।

ज्वारनदमुखी गोबी फिश, नाइट गोबी के बंध प्रजनन और लार्वा पालन प्रोटोकॉल का मानकीकरण

नाइट गोबी (*स्टिग्माटोगोबियस सदानुंडियो*) भारतीय सुंदरबन में पाई जाने वाली गोबी मछलियों में से एक है, जिसके शरीर पर एक सुंदर पैटर्न होता है। नाइट गोबी (आकार: 5-7 सेमी) के वयस्क और उप-वयस्कों (एन = 235) को 4-5 महीनों के लिए बंध स्थितियों के तहत अनुकूलित किया गया था। 1:3 (मादा : नर) का लिंगानुपात मछलियों और अंडजनन के सफल युग्मन का कारण बना है। हैचलिंग्स (टीएल, 2.4-2.5 मिमी) को लार्वा पालन टैंक में 25 नग/लीटर की दर से संग्रहीत किया गया था। मुंह (90±10 माइक्रोन) खोलना दो डीपीएच पर देखा गया है। पूरी तरह से गठित पेक्टोरल पंख तीन डीपीएच पर देखे गए। चार डीपीएच लार्वा को रोमक (आकार, 30-50 सुक्ष्ममापी; घनत्व 30±5 नग/मिली) और सूक्ष्म शैवाल (घनत्व 2 X 106 नग/मिली) खिलाए गए थे।

सुंदरबन क्षेत्र के किसानों की जरूरतों को पूरा करने के लिए कम लागत वाली पिंजरा आधारित पर्लस्पॉट बीज उत्पादन तकनीक का विकास

संग्रहण काल के दौरान बीज की अनुपलब्धता पर्लस्पॉट खेती के विस्तार में बाधा बन रही है। बांस आधारित कम लागत वाले पिंजरों (12 X 12 X 8 फीट) को डिजाइन किया गया था जिन्हें बीज उत्पादन के लिए आसानी से 2-3 साल तक उपयोग किया जा सकता है। सीबा के केआरसी में, कुल पंद्रह जोड़े (1 नर : 1 मादा) को पिंजरे में रखा गया था। मई और जुलाई के दौरान सबसे अधिक बारंबारता के साथ, अंडे देने की आवृत्ति मार्च से अक्टूबर तक देखी गई। जून में सबसे ज्यादा हैचलिंग्स उत्पन्न हुए। आठ महीनों के संचालन के दौरान, पिंजरे में 15 जोड़े द्वारा कुल 1,02,247 अंडे का उत्पादन किया गया और हैचरी में 85.5% की औसत उत्तरजीविता दर के साथ 23,017 पर्लस्पॉट पोनों का उत्पादन किया गया।

सीबा-एनजीआरसी में वैकल्पिक आजीविका के रूप में या स्वयं सेवी समूहों के लिए पर्लस्पॉट (*इट्रोप्लस सुराटेंसिस*) और आरएएस प्रणाली में पिंजरा आधारित बीज उत्पादन तकनीक का विकास

पालघर, रत्नागिरी और सिंधुदुर्ग, महाराष्ट्र के जिलों में तीन पर्लस्पॉट बीज उत्पादन इकाइयां स्थापित की गईं और फ्लोटिंग नेट पिंजरों में पर्लस्पॉट प्रजनन और एक टब आधारित आरएएस प्रणाली में बीज उत्पादन का निरूपण किया गया। जनवरी और दिसंबर, 2022 में, पालघर के स्वयं सेवी समूह ने पर्लस्पॉट अंगुलिकाओं (1-2 इंच) को ₹12-20 प्रति अंगुलिका की दर से 20,200 अंगुलिकाओं की बिक्री के

माध्यम से ₹2,49,500 अर्जित किया। जबकि, रत्नागिरी और सिंधुदुर्ग के स्वयं सेवी समूहों ने पर्लस्पॉट अंगुलिकाओं (1 इंच) ₹10-12 प्रति अंगुलिका की दर से 17,934 और 19,502 अंगुलिकाओं की बिक्री के माध्यम से क्रमश: ₹1,81,296 और ₹1,87,600 अर्जित किए।

हिलसा के प्रजनकों का विकास और कैप्टिव ब्रूडस्टॉक की टैगिंग और जननांगों की परिपक्वता की निगरानी

सीबा के केआरसी में 0.15 हेक्टेयर खारा जलीय तालाब में वन्य रूप से एकत्रित हिलसा उप-वयस्कों (158.84±12.50 ग्राम / 22.85±0.72 सेमी) का संग्रहण किया गया था। प्लवकों की आबादी को बनाए रखने के लिए तालाब को प्लैंकटन$^{प्लस}$ (30 किग्रा/हेक्टेयर) और सरसों की खली (60 किग्रा/हेक्टेयर) डालकर साप्ताहिक रूप से उर्वरित किया गया था। प्रजनक तालाबों में प्लवकों की बहुतायत और विविधता से पता चला है कि कोपेपोडा, क्लैडोसेरा और माइसिडा प्रचलित जन्तु प्लवक थे। सीपी - 42.16% और वसा 15.06% के साथ तैयार फ़ीड को 5-3% की दर से दिया गया। 16 महीनों के पालन के बाद, मछलियों का औसत शारीरिक वजन/लम्बाई 480±54.09 ग्राम / 36.21±1.26 सेमी हो गया। संवेदनाहारी स्थितियों में जननांगों की उचित परिपक्वता को समझने के लिए प्रजनक मछलियों में यूएसजी परीक्षण किए गए। सितंबर के महीने में कैप्टिव ब्रूडस्टॉक (183.4 ग्राम) का जीएसआई 6.49 था। ओसाइट व्यास 427.08 ± 3.24 माइक्रोन पाया गया।

हिलसा (*टेनुअलोसा इलीशा*) का कृत्रिम प्रजनन और नर्सरी पालन

पश्चिम बंगाल के गोडाखली, दक्षिण 24 परगना में हुगली मुहाने से वन्य रूप में एकत्रित प्रजनकों (मादा : 963.4-980 ग्राम / 30-47 सेमी और नर : 225-258 ग्राम / 26.5-32.5 सेमी) का उपयोग करके नाव पर ही ड्राई स्ट्रिपिंग विधि के माध्यम से हिलसा का कृत्रिम प्रजनन कराया गया था और 92±0.94 के निषेचन और 88.78±1.12% की स्फुटन दर के साथ सफलता प्राप्त किया गया है। परीक्षण से उत्पादित लार्वा को पालन के लिए हैचिंग के 5 दिनों के बाद मिट्टी के तालाब में संग्रहीत किया गया था। हिलसा हैचलिंग्स के संग्रहण से 6 दिन पहले नर्सरी तालाबों (30 वर्ग मीटर) को तीन अलग-अलग उपचारों के साथ उर्वरित किया गया था, यानी सरसों की खली @ 75 पीपीएम (टी1), प्लैंकटन$^{प्लस}$ @ 75 पीपीएम (टी2) और दोनों का संयोजन 1:1 (टी3) के अनुपात में। जन्तु प्लवकों की आबादी के बीच कोपेपोड्स, क्लैडोसेरा टी3 नर्सरी तालाब में प्रमुख जन्तु प्लवक थे। नर्सरी पालन के 90 दिनों के बाद, स्पष्ट रूप से उच्च शारीरिक वजन (15.31±0.03) और बेहतर उत्तरजीविता (27.0±1.0%) T3 नर्सरी तालाब में पाया गया जब प्लैंकटन$^{प्लस}$ (37.5 पीपीएम) और सरसों की खली (37.5 पीपीएम) के संयोजन को प्लैंकटन बूस्टर के रूप में दिया गया।

निम्न एवं उच्च लवणीय परिपक्वता प्रणाली में बंध स्थितियों में संवर्धित भारतीय सफेद झींगों के जननांगों का विकास

22 से 36 पीपीटी की अलग-अलग लवणताओं पर भारतीय सफेद झींगा के जननांग विकास ने संकेत दिया कि जननांग विकास 32 पीपीटी के बराबर देखा गया, हालांकि अंडाशय का प्रतिगमन 22 पीपीटी लवणता पर दर्ज किया गया था।

टैंक प्रणाली में पीनियस इंडिकस का कैप्टिव ब्रूडस्टॉक विकास

जीवन चक्र को पूण करने के लिए पी. *इंडिकस* ब्रूडस्टॉक का कैप्टिव पालन, प्रजनन कार्यक्रम को विकसित करने के लिए अनुसंधान के प्रमुख क्षेत्रों में से एक है। पालन के 374 दिनों के बाद टैंक-आधारित प्रणालियों में ब्रूडस्टॉक विकास ने संकेत दिया कि बंध स्थितियों में पालित मादा और नर झींगों (जी4) ने जी1 की मादा झींगों द्वारा प्राप्त 24.99 ग्राम और 25.43 ग्राम की तुलना में क्रमशः 31.5 ग्राम और 27.2 ग्राम का औसत शारीरिक वजन प्राप्त किया, यह इंगित करता है कि घरेलूकृत ब्रूडस्टॉक में पछेती परिपक्वता के साथ तेज विकास का बेहतर लाभ और एक पीढ़ी में ब्रूडस्टॉक का बड़ा के साथ परिपक्व हो गया है।

इनडोर बनाम आउटडोर टैंक में *पी. इंडिकस* का मौल्टिंग अंतराल और मेटिंग

सीमित इनडोर पालन प्रणाली ने निम्न मेटिंग दक्षता दर्शायी है। इनडोर और आउटडोर टैंकों का उपयोग करके *पी. इंडिकस* की निर्मोचन (मौल्टिंग) और संभोग (मेटिंग) दक्षता पर किए गए अध्ययन से पता चला है कि अपघर्षित स्टॉक की तुलना में पृथककरण ने अंडशावक में निर्मोचन अंतराल और निर्मोचन आवृत्ति में वृद्धि की।

मेटापीनियस मोनोसेरोस हैचरी उत्पादन का प्रदर्शन

वन्य रूप से एकत्रित *एम. मोनोसेरोस* (53 झींगों) के प्रजनकों ने संकेत दिए कि मादा प्रजनक के शरीर का वजन 19.5 और 49.2 ग्राम के बीच था, और कुल लंबाई 124 मिमी से 190 मिमी के बीच। परीक्षण के लिए लगभग 55,000 पोस्ट लार्वा का उत्पादन किया गया।

मड क्रैब के हैचरी उत्पादन के लिए उन्नत प्रोटोकॉल

कीचड़ केकड़ों के हैचरी उत्पादन के लिए फीडिंग शेड्यूल और प्रोटोकॉल का अनुकूलन समृद्ध रोटिफ़र के साथ किया गया था चूंकि फ़ीड सूक्ष्म शैवाल को फीडिंग शेड्यूल से पूरी तरह से हटा दिया गया था, और फीडिंग के छठे दिन या जब पचास प्रतिशत Z2 से Z3 में परिवर्तित हो जाती है, रोटिफ़र देना बंद कर दिया गया है। लार्वाकल्चर (Z1 से मेगालोपा (तीसरा दिन) 18 दिनों के भीतर पूरा हो गया था जो बेहतर उत्तरजीविता का संकेत देता है।

मुगिल सेफालस की प्रोटीन और लिपिड आवश्यकता का अनुकूलन

इनडोर प्रयोग में *मुगिल सेफालस* की हैचरी-प्रजनित अंगुलिकाओं की अनुकूलतम प्रोटीन और लिपिड आवश्यकता को कच्चे प्रोटीन (20, 25, 30, 35, 40 और 45%) और लिपिड (4, 6, 8, 10, 12 और 14%) के विभिन्न स्तरों के साथ व्यावहारिक आहार का उपयोग करके पता लगाया गया था और प्रोटीन और लिपिड की अनुकूलतम आवश्यकता क्रमशः 30% और 8% पाई गई।

हिल्सा के लिए ब्रूडस्टॉक फीड

हिलसा के ब्रूडस्टॉक पालन के लिए सूत्रबद्ध आहार (सीपी 42.16% और ईई 15.06%) का तालाब में परीक्षण किया गया है। विशेष रूप से डिज़ाइन किया गया यह फ़ीड और कुछ आवश्यक अमीनो एसिड जैसे लाइसिन, ल्यूसीन, थ्रेओनाइन आदि पीयूएफए से भरपूर था और इसका उपयोग प्रजनन के मौसम की शुरुआत से दो महीने पहले किया गया था। ब्रूडस्टॉक फीड को खिलाने के बाद, 80% मछलियाँ परिपक्वता के विभिन्न चरणों में पाई गईं। सूत्रबद्ध आहार दी गई कैप्टिव हिल्सा के जननांग में समान गोनाडो-सोमैटिक इंडेक्स वाली वन्य हिल्सा की तुलना में बेहतर अमीनो एसिड प्रोफाइल पाया गया। पूरी तरह से परिपक्व (चल रहे चरण) वन्य हिल्सा अंडाशय के साथ कैप्टिव हिल्सा अंडाशय की जैव रासायनिक संरचना की तुलना की गई, ब्रूडस्टॉक फीड को परिशोधित किया गया था।

आदर्श आहार घटक के रूप में फूलों का अपशिष्ट

फूलों के अपशिष्ट की पोषक संरचना से पता चला कि इसमें 3% लिपिड सामग्री के साथ 17% क्रूड प्रोटीन है। *पीनियस वन्नामेय* के 90 दिवसीय आहार परीक्षण से पता चला है कि विकास प्रदर्शन और उत्तरजीविता को प्रभावित किए बिना फूलों के अपशिष्टों को आहार में 7.5% तक शामिल किया जा सकता है।

मिस्टस गुलियो के आहार में नैनो जिंक अनुपूरण का प्रभाव

जिंक (Zn), दूसरा महत्वपूर्ण सूक्ष्म तत्व, कोशिका विभाजन, सह-कारक प्रजनन, प्रतिरक्षात्मक प्रतिक्रिया और एंटीऑक्सीडेंट रक्षा जैसे कई प्रकार के कार्य करता है। आंतों के स्तर पर कई अंतःक्रियात्मक पोषक तत्वों की उपस्थिति के कारण जिंक की उपलब्धता अक्सर एक समस्या होती है। वर्तमान प्रयोग से पता चला है कि एम. गुलियो पोनों में 40 पीपीएम @ नैनो जिंक पूरक, विकास प्रदर्शन में सुधार एवं तनाव को कम कर सकता है और साथ ही अस्तित्व में सुधार कर सकता है।

मिस्टस गुलियो के आहार में बिनौला (कच्चा और किण्वित) फ़ीड घटक के रूप में

कॉटन सीड मील (CSM), कपास रेशा और बिनौला तेल उद्योग का एक उप-उत्पाद है, जो दुनिया भर में वजन के हिसाब से तीसरा प्रमुख प्लांट प्रोटीन है और अपेक्षाकृत कम कीमत पर उपलब्ध है। *एम. गुलियो* पोनों के आहार में कच्चे और किण्वित सीएसएम के समावेशन स्तर हेतु किए गए 6 सप्ताह के अध्ययन से पता चला है कि सीएसएम (कच्चा) और सीएसएम (किण्वित) को उत्पादन प्रदर्शन से समझौता किए बिना *एम. गुलियो* आहार में 5% स्तर और 10% तक शामिल किया जा सकता है।

शून्य फिशमील या शून्य फिश ऑयल डाइट दी गई तरूण मिल्कफिश *चानोस चानोस* मछलियों का निष्पादन

एक इनडोर आरएएस प्रणाली में हैचरी से उत्पादित मिल्कफिश तरूण मछलियों पर 60 दिनों के फीडिंग प्रयोग में जीरो फिशमील आहार का परीक्षण किया गया था। मिल्कफिश चानोस चानोस में फिशमील या मछली के तेल का कुल प्रतिस्थापन, ने स्पष्ट रूप से दर्शाया कि शून्य फिशमील आहार ने विकास दर को नकारात्मक रूप से प्रभावित किया और तरूण मिल्कफिश की पाचन क्षमता को कम कर दिया। यह भी देखा गया कि मिल्कफिश आवश्यक फैटी एसिड को संरक्षित करती है जब भी आहारीय आवश्यक फैटी एसिड कम होती है, लिनोलेइक एसिड, अल्फा-लिनोलेनिक एसिड और एराकिडोनिक एसिड चयापचय को कम करता है।

वन्य रूप से एकत्रित एवं पालित वयस्क *सिगानस जावस* के तुलनात्मक फैटी एसिड प्रोफाइल

सफल परिपक्वता और अंडजनन के लिए कार्यात्मक प्रजनक आहार विकसित करने के लिए, वयस्क सिगानस जावस मछलियों को वन्य एवं पालित दोनों स्रोतों से एकत्र किया गया और इनके पोषक प्रोफाइल का विश्लेषण किया गया। पालित मछलियों के मांसपेशियों और यकृत में इकोसापैनटोइनिक एसिड और डोकोसैक्सिनोइक (क्रमशः 133.07, 81.53; 323.4, 331.24 मिलीग्राम/ 100 ग्राम) की तुलना में वन्य वयस्क मछलियों के मांसपेशियों में (161.9 और 136.2 मिलीग्राम/100 ग्राम) और यकृत में (387.1 और 543.5 मिलीग्राम/100 ग्राम) उच्चतर फैटी एसिड प्रोफाइल देखी गई। वन्य वयस्क मछलियों (176.28 और 183.5 मिलीग्राम/100 ग्राम) की तुलना में पालित वयस्क मछलियों के अंडाशय में उच्च ईपीए और डीएचए (245.9, 207.6 मिलीग्राम/100 ग्राम) देखा गया है।

किण्वन के दौरान एस्परगिलस नाइगर वृद्धि की निगरानी

एस्परगिलस नाइगर (फ़ीड संघटक का 1%) का उपयोग करके पादप प्रोटीन की ठोस अवस्था किण्वन को एक पायलट स्केल किण्वक में मानकीकृत किया गया था। *एस्परगिलस नाइगर* के विकास की मात्रा निर्धारण के लिए, रोज बंगाल के साथ डाइक्लोरन और डाइक्लोरन ग्लिसरॉल माध्यम का उपयोग किया गया। परिणामों से पता चलता है कि ऊष्मायन के 24 घंटे बाद *ए. नाइगर* बीजाणुओं का अंकुरण शुरू हो गया, जो 1 लॉग आबादी के कम मूल्य से परिलक्षित होता है। 48 घंटे और 72 घंटे तक, *ए नाइगर*

की गिनती क्रमशः 6 और 7 लॉग तक बढ़ गई। डाइक्लोरन रोज़ बंगाल और डाइक्लोरन ग्लिसरॉल मीडियम दोनों ही *ए. नाइगर* क्वांटिफिकेशन के लिए प्रभावी पाए गए।

सूक्ष्म शैवाल की पोषक रूपरेखा

मुत्तुकाडु ज्वारनदमुखी परितंत्र से सूक्ष्म शैवाल नामतः *थैलासियोसिरा वीसफ्लोगी, चेटोसेरोस ग्रैसिलिस, टेट्रासेलमिस एसपी., आइसोक्राइसिस गैलबाना, नन्नोक्लोरोप्सिस ओकुलाटा, क्लोरेला मरीना* और *आर्थ्रोस्पिरा एसपी* अलग किया गया और न्यूट्रास्युटिकल गुणों के लिए जांच की गई और खारा जलीय कृषि में उनके अनुप्रयोग का मूल्यांकन किया गया। पहली बार तमिलनाडु तट से पृथक किए गए *आर्थ्रोस्पिरा मैक्सिमा* में 62.46±3.45% क्रूड प्रोटीन पाया गया, जिसके बाद का स्थान *क्लोरेला मरीना* (49.48±3.8) और टी. वीसफ्लोगी (43.07±1.78) का था। गौरतलब है कि *आई. गैलबाना* (33.08±2.18) में उच्च (पी <0.05) लिपिड सामग्री (%) देखी गई, इसके बाद *टी. वीसफ्लोगी* (20.11±1.02) और *एन. ओकुलाटा* (18.35±1.02) का स्थान रहा। *आर्थ्रोस्पिरा मैक्सिमा* में अन्य शैवाल की तुलना में पॉलीअनसैचुरेटेड फैटी एसिड (PUFA) का उच्चतम प्रतिशत (69.51% फैटी एसिड) पाया गया।

सूक्ष्म शैवाल के जीवाणुरोधी गुण

विभिन्न सूक्ष्म शैवाल के अर्क के जीवाणुरोधी गुणों का अध्ययन किया गया। सीपीसी (सी-फाइकोसाइनिन) द्वारा सभी तीन बैक्टीरिया, वी. हार्वेई (20.52 ± 0.35 मिमी), *वी. कैंपबेली* (18.32 ± 0.52 मिमी) और *वी. पैराहेमोलिटिकस* (19.48 ± 0.84 मिमी) के खिलाफ अवरोध का उच्चतम क्षेत्र प्रदर्शित किया गया था। सीपीसी द्वारा *वी. हार्वेई, वी. कैम्पबेली* और *वी. पैराहेमोलिटिकस* के खिलाफ अन्य सभी सूक्ष्म शैवाल के अर्क की तुलना में उच्चतम जीवाणुरोधी गतिविधि दर्शायी गई।

पीनियस वन्नामेय के आहार में सूक्ष्मजीवीय सान्द्रों का समावेश

वृद्धि और उत्तरजीविता पर उनके प्रभाव के लिए समुद्री सूक्ष्म शैवाल (*थलासियोसिरा वेस्फ़्लोगी* और *टेट्रासेलमिस एसपी।*) सान्द्र पूरक आहारों का 42 दिनों के फीडिंग परीक्षण में *पीनियस वन्नामेय* पोस्ट लार्वा (पीएल 18, औसत वजनः 19.714±1.62 मिलीग्राम) पर परीक्षण किया गया था। *थैलासियोसिरा वीसफ्लोगी* और *टेट्रासेलमिस एसपी* की पोषक संरचना से स्पष्ट हुआ है कि इनमें प्रोटीन की मात्रा 43.07±1.78%, 42.11±2.55% थी; और क्रमशः 20.11 ± 1.02%, 10.56 ± 0.27% की क्रूड लिपिड सामग्री। परिणाम से पता चला कि विकास पर लाभकारी प्रभाव था और सामान्य रोगजनक सूक्ष्म जीव के खिलाफ प्रतिरोध करने के लिए बेहतर रोगाणुरोधी गुण था और इस प्रकार झींगा पोस्ट लार्वा के प्रारंभिक जीवन चरणों में लाभकारी प्रभाव का संकेत मिलता है जब सूक्ष्म शैवाल सान्द्र को आहार को 0.5 से 1.5 ग्राम किलो-1 की दर से पूरक किया गया था। . इन संभावित सूक्ष्म शैवाल युक्त फ़ीड झींगा के प्रारंभिक चरणों के दौरान पोषण और स्वास्थ्य लाभ प्रदान कर सकता है और रोग की घटनाओं को कम कर सकता है और झींगा के प्रारंभिक जीवन चरणों में कार्यात्मक फ़ीड के रूप में नए मार्ग प्रशस्त कर सकता है।

मिल्कफिश लार्वा में आहारीय टॉरिन पूरकता का प्रभाव

मिल्कफिश लार्वा के आहार में टॉरिन पूरकता के अलग-अलग स्तर के साथ 45 दिनों के फीडिंग परीक्षण से टॉरिन पूरक आहार में अधिक वजन बढ़ने, विशिष्ट विकास दर, उत्तरजीविता और निम्न फ़ीड रूपांतरण अनुपात का पता चला है। टॉरिन अनुपूरण ने मिल्कफिश लार्वा में पाचन एंजाइम गतिविधियों को बढ़ाने में मदद की है। 0.5 और 1.0% टॉरिन पूरक समूहों में आंतों के विली की उच्चतर लंबाई, मोटाई और विली के बीच कम अंतर देखा गया। परिणामों ने संकेत दिया कि 0.52% टॉरिन पूरकता *सी. चानोस* के प्रारंभिक जीवन चरणों के आहार में अनुकूलतम पाया गया।

मिल्कफिश लार्वा में ग्रोथ प्रमोटर के रूप में स्किड प्रोटीन हाइड्रोलाइज़ेट

मिल्कफिश लार्वा के विकास और उत्तरजीविता पर स्किड प्रोटीन हाइड्रोलाइजेट (एसपीएच) अनुपूरण के प्रभाव का अध्ययन करने के लिए छह सप्ताह का आहारीय परीक्षण किया गया। *सी. चानोस* को 1.0% एसपीएच पूरक देने पर महत्वपूर्ण रूप से (पी <0.05) उच्चतर वजन, विशिष्ट विकास दर, उत्तरजीविता और बेहतर फ़ीड रूपांतरण अनुपात देखा गया।

डाइजेस्टिव एंजाइम के ओंटोजनी पर विचार करते हुए मिल्कफिश लार्वा में वीनिंग विंडो का निर्धारण

मिल्कफिश, *सी. चानोस* (0, 3, 6, 9, 12, 15, 18, 21, 0, 3, 6, 9, 12, 15, 18, 21, हैचिंग के 25 और 30 दिन बाद) के प्रारम्भिक ओंटोजनी के दौरान महत्वपूर्ण पाचन एंजाइमों के प्रोफाइल का मूल्यांकन किया गया। अधिकांश एंजाइमों में हैचिंग के 15 से 21 दिनों के दौरान चरम गतिविधियां देखी गईं, और मिल्कफिश हैचरी में लार्वा को जीवंत आहार से कृत्रिम आहार की ओर करने के लिए विकासात्मक विंडो के रूप में माना जा सकता है।

पीनियस मोनोडॉन तरूण झींगों के आहार में सोया मील के स्थान पर पादप प्रोटीन स्रोतों का प्रतिस्थापन

झींगा उद्योग चारे की लागत कम करने के लिए सोया मील के विकल्प की तलाश कर रहा था। विशिष्ट रोगज़नक़ मुक्त (एसपीएफ़) पीनियस मोनोडॉन तरूण झींगों में सोया मील के स्थान पर विभिन्न पौधों के प्रोटीन स्रोतों (पीपीएस) के संयोजनों के प्रतिस्थापन के प्रभाव का अध्ययन करने के लिए 8 सप्ताहों का फीडिंग परीक्षण किया गया था। अध्ययन से पता चला कि 75% सोया मील के

स्थान पर आहारीय पादप प्रोटीन स्रोतों को 265 ग्राम किलो-1 तक शामिल किया जा सकता है। वर्तमान अध्ययन के परिणाम टाइगर झींगों के लिए वैकल्पिक पादप प्रोटीन स्रोत के साथ लागत प्रभावी फ़ीड तैयार करने के लिए आधारभूत वैज्ञानिक जानकारी प्रदान करता है।

खारे पानी के जलीय कृषि फार्मों में रोग निगरानी

वर्ष 2022 के दौरान झींगा फार्मों (N:94) में रोग निगरानी की गई, WSD का प्रसार 3.22%, हेपाटिक माइक्रोस्पोरिडिओसिस 25.8%, IMN 10.75% पाया गया, जबकि अन्य OIE सूचीबद्ध रोगों की रिपोर्ट नहीं की गई थी।

स्काइला सेर्राटा रेओ वायरस (SsRV) का पता लगाने के लिए आणविक निदान का मानकीकरण

कीचड़ केकड़े की खेती में उभरते वायरल रोगज़नक़ SsRV का पता लगाने के लिए कस्टम डिज़ाइन किए गए प्राइमरों के साथ RT-PCR प्रोटोकॉल (एकल चरण और नेस्टेड) के दो सेट मानकीकृत किए गए थे। जैव सुरक्षा उपायों के एक भाग के रूप में स्क्रीनिंग के लिए एसएसआरवी हेतु नियमित रोग निदान उपकरण के रूप में इस तकनीक का उपयोग किया जा सकता है।

SsRV पर *इन विवो ट्रांसमिशन* अध्ययन

कीचड़ केकड़ों में इंजेक्शन, मौखिक और कोहैबिटेशन मार्गों के माध्यम से चुनौतीपूर्ण प्रयोग किए गए। संचरण पद्धति के आधार पर विभिन्न नैदानिक संकेत और मृत्यु दर देखी गई। SsRV संक्रमित केकड़े के ऊतकों के साथ झींगों के प्रायोगिक अध्ययन में इंजेक्ट किए गए झींगों में आंतरायिक मृत्यु दर देखी गई जब कि मौखिक चुनौती से कोई मृत्यु नहीं हुई। बिना किसी स्पष्ट सकल परिवर्तन के पोस्ट चुनौती वाले जीवों में वाहक स्थिति का पता चला था।

खारा जलीय सजावटी मत्स्य रोगों की एटियोलॉजी और पैथोबायोलॉजी

सजावटी मछलियों को प्रभावित करने वाले रोगों पर एक अध्ययन किया गया। पहचाने गए सामान्य रोगों में *मोनोडैक्टाइलस अरजेंटियस* में वाइब्रोसिस, *इट्रोप्लस सुराटेंसिस* में वायरल नर्वस नेक्रोसिस और *आर्गुलस* एसपीपी और *कैलीगस* एसपीपी, *स्कैटोफैगस आर्गस* में परजीवी संक्रमण शामिल थे।

झींगों के सफेद मल/आंत सिंड्रोम (WFS/WGS) की जांच

यह WFS/WGS प्रभावित तालाबों में सफेद आंत और बड़े पैमाने पर आकार भिन्नता के साथ विशिष्ट नैदानिक लक्षण देखे गए। इस तरह के झींगों को ईएचपी के लिए सकारात्मकता पायी गयी जबकि 60-70% बिना लक्षण वाले झींगों में भी ईएचपी के लिए सकारात्मकता पायी गयी। हिस्टोपैथोलॉजी विश्लेषण ने हेपाटोपैंक्रियास में ईएचपी बीजाणुओं और समावेशन निकायों की उपस्थिति दर्शायी। आरएनए अनुक्रमण ने दर्शाया कि सभी नमूनों में पिकोर्नावायरस सीक्वेंस (वानजाउ श्रिम्प वायरस 8, डब्ल्यूजेडवी8 के समान) शामिल हैं, और, डब्ल्यूएफएस से प्रभावित नमूनों में पिकोर्नावायरस (और सभी रीड्स के अनुपात के रूप में) का प्रतिनिधित्व करने वाले रीड्स की कुल संख्या अधिक थी। 16s एम्प्लिकॉन सीक्वेंसिंग ने दर्शाया कि WFS झींगा के लिए अल्फा विविधता स्वस्थ झींगा की तुलना में कम थी, यह सुझाव प्राप्त हुआ है कि WFS के लक्षणों वाली झींगों के हेपाटोपैन्क्रियास में बैक्टीरिया प्रजातियों की बहुलता कम हो गई थी।

ईएचपी नियंत्रण के लिए चिकित्सावधान का विकास

एंटी-माइक्रोस्पोरिडियन गतिविधि के लिए अल्बेंडाजोल, निफेडिपिन, वेरापामिल, मेट्रोनिडाजोल, टिनिडाजोल, केटाकोनाजोल और प्राकृतिक पौध व्युत्पत्तियां कार्वोक्रोल और नारिनजेनिन जैसी विभिन्न रासायनिक दवाओं का मूल्यांकन किया गया था। प्राकृतिक व्युत्पत्ति नारिनजेनिन ने ईएचपी भार को काफी कम कर दिया और संक्रमित झींगों के विकास और उत्तरजीविता में सुधार किया। इस प्रकार, ईएचपी के उपचार और नियंत्रण के लिए प्राकृतिक व्युत्पत्ति नारिनजेनिन का चिकित्सीय/ न्यूट्रास्यूटिकल के रूप में उपयोग किया जा सकता है।

झींगा फार्मों में एंटेरोसाइटोज़ून हेपाटोपेनाई के रोगवाहकों और वाहकों की जांच

अध्ययन में गेरिड एसपी, *बेलोस्टोमा* एसपी देखा गया और जलीय कीटों, मसल्स, क्लैम और माइसिड श्रिम्प के बीच ईएचपी के संभावित वाहक के रूप में माइसिड श्रिम्प की जांच की गई।

सीबास से उपयुक्त इन विट्रो कोशिका संवर्धन प्रणाली की पहचान

भ्रूण संबंधी गोजातीय सीरम पूरक के साथ L-15 मीडियम में मांसपेशियों, मस्तिष्क, हेड किडनी, प्लीहा, यकृत और गुर्दे के ऊतकों की सीबास प्राइमरी एक्सप्लांट कल्चर अलग-अलग किया गया था। मांसपेशियों और मस्तिष्क के ऊतकों ने तीन सप्ताह में 100% संगम के साथ एक फाइब्रोब्लास्टिक मोनोलेयर में स्थापित की। मांसपेशियों और मस्तिष्क की कोशिकाओं की प्राथमिक सेल कल्चर को 1:2 के अनुपात में पांच दिनों तक सब-कल्चर करने पर अनुगामी फाइब्रोब्लास्टिक कोशिकाओं के संगम मोनोलेयर में चार पासेज स्मर तक विकसित किया गया था। हेड किडनी के एक्सप्लांट कल्चर को पक्षपाती और गैर-पक्षपाती दोनों के विषम कोशिकाओं के प्रसार के साथ विकसित की गई, दोनों रंजित और गैर-रंजित, उपकला गोल, फाइब्रोब्लास्टिक कोशिकाएं दो सप्ताह में और चार सप्ताह में 100% संगम के साथ फाइब्रोब्लास्ट मोनोलेयर में विकसित अनुवर्ती कोशिकाएं दिखाई दीं।

झींगा पालन में एक एंटागोनिस्टिक *विब्रियो स्ट्रेप्टोमाइसेस* ग्रिसियोरूबेंस

CIBA-NS1 स्ट्रेन की पहचान

स्ट्रेप्टोमाइसेस ग्रिसियोरूबेंस CIBA-NS1 स्ट्रेन को जैव रासायनिक और रूपात्मक विशेषताओं के साथ-साथ 16SrDNA अनुक्रमण के आधार पर पृथक कर इसकी पहचान की गई। प्रजातियों का उपयोग जीवाणुरोधी गतिविधि के लक्षण वर्णन हेतु किया गया, जिससे सूचित हुआ है कि *विब्रियो कैम्पबेली* के खिलाफ आशाजनक विरोधी गतिविधि का संकेत है।

एनएनवी संक्रमित एशियन सीबास प्राइमरी ब्रेन सेल कल्चर की *इन विट्रो* ट्रांसक्रिप्टोम प्रोफाइलिंग

एशियन सीबास प्राइमरी ब्रेन सेल कल्चर स्थापित किया गया था और प्रयोगात्मक रूप से एनएनवी से संक्रमित किया गया था। 0 दिन (संक्रमण से पहले) और संक्रमण के 1 और 3 दिनों पर एकत्र किए गए नमूनों को 40 मिलियन रीड्स के लिए नोवासेक 6,000 प्लेटफॉर्म (2X150 बीपी) द्वारा आरएनए अनुक्रमण किया गया था। एनोटेटेड एशियन सीबास ट्रांसक्रिप्टोम में साफ किए गए रीड्स का मैपिंग प्रतिशत 67.2 से 69.1 के बीच था। यह असंक्रमित कोशिकाओं की तुलना में 1 और 3 डीपीआई की ब्रेन सेल में भिन्न रूप से अभिव्यक्त (डीई) जीन में भिन्नता देखी गई थी। KEGG पाथवे विश्लेषण ने MAPK सिग्नलिंग पाथवे में प्रमुख रूप से शामिल दोनों समूहों के DE जीन की पहचान की। परिणामों ने एशियन सीबास-एनएनवी इंटरेक्शन में शामिल उपयुक्त जीन और उनके आणविक व्यवस्था की महत्वपूर्ण जानकारी दी।

नर्वस नेक्रोसिस वायरस (एनएनवी) से संक्रमित एशियन सीबास (*लेट्स कैलकेरिफर*) और मिल्कफिश (*चानोस चानोस*) में प्रतिरक्षा संबंधी जीन की अभिव्यक्ति प्रोफ़ाइल का तुलनात्मक मूल्यांकन

एशियाई सीबास और मिल्कफिश में प्रयोगात्मक एनएनवी संक्रमण के 1, 3, और 5 दिनों के बाद एकत्रित मस्तिष्क, यकृत, प्लीहा और गुर्दे के ऊतकों में प्रतिरक्षा जीन अभिव्यक्ति का मूल्यांकन किया गया। प्रतिरक्षा जीन जैसे Tol3, IL1, IL13, MHC, और CXC की अभिव्यक्ति प्रोफ़ाइल ने एशियाई सीबास के अन्य अंगों की तुलना में गुर्दे में उच्चतर अभिव्यक्ति प्रदर्शित की। इसी तरह, मिल्कफिश के गुर्दे में IL1, IL13 और MHC में एक उच्च अभिव्यक्ति पैटर्न देखा गया, जबकि Tol3 और CXC मस्तिष्क में अत्यधिक अभिव्यक्त हुए। हालांकि, मिल्कफिश की तुलना में एशियाई सीबास में विभिन्न जीनों की अभिव्यक्ति अधिक थी, जो एनएनवी के लिए सीबास की उच्च संवेदनशीलता से संबंधित हो सकती है।

हरे और स्वच्छ जल पालन प्रणालियों में पालित पर्लस्पॉट (*इट्रोप्लस सुराटेंसिस*) लार्वा से जुड़े लार्वल माइक्रोबायोम

हरे (*क्लोरेला* एसपीपी और आर्टेमिया) और साफ जलीय (*आर्टेमिया*) प्रणाली में पाली गई पर्लस्पॉट (*इट्रोप्लस सुराटेंसिस*) लार्वा के माइक्रोबायोम से पता चला है कि प्रोटीयोबैक्टीरिया, प्लैंकटोमाइसेट्स, बैक्टीरियोडेट्स, फर्मिक्यूट्स और एक्टिनोबैक्टीरिया अलग-अलग अनुपात में मौजूद थे, हालांकि उनके सापेक्ष योगदान दोनों पालन प्रणालियों में अलग-अलग अनुपात में मौजूद थे। यह दोनों प्रणालियों में *आर्टेमिया* खिलाने के बावजूद हरे पानी में पालित लार्वा (F. Vibrionaceae - <1%) की तुलना में साफ पानी में पालित लार्वा में F. Vibrionaceae (27%) की बहुलता देखी गयी थी। पर्लस्पॉट लार्वा में कोर बैक्टीरियल आबादी फर्मिक्यूट्स, बैक्टीरियोडेट्स और एक्टिनोबैक्टीरिया अलग अलग अनुपातों में थी, जो कुल बैक्टीरिया आबादी का लगभग 40% हिस्सा है।

जलीय कृषि में रोगजनक विब्रियोस की विषक्तता और निदान का विकास

एशियन सीबास को विब्रियो हार्वेई एसबी1 से चुनौती दी गई जो अत्यधिक विषैला पाया गया। खुराक के आधार पर मृत्यु दर 50 से 100% तक थी। इंजेक्शन स्थान पर गंभीर मांसपेशियों की विकृति देखी गई। आठ बैक्टीरियल आइसोलेट्स अर्थात *वी. कैंपबेली, वी. हार्वेई* और वी. *पैराहामोलिटिकस* का पैकबियो और इल्लुमाइन प्लेटफॉर्म पर अनुक्रमित किया गया। सभी उपभेदों (स्ट्रैन) में गुणसूत्र स्तर की जीनोम असेंबली थी। *वी. हार्वेई* स्ट्रेन SB1 में रोगजनकता के साथ प्लाज्मिड पाया गया। रोगजनक *वी. कैंपबेली* उपभेदों में लाइसोजेनिक फेज पाए गए हैं। *वी. हार्वेई, वी. कैम्पबेली, वी. ओवेंसी* और *वी. रोटिफेरियन्स* के निदान के लिए मात्रात्मक रियल टाइम पीसीआर को मानकीकृत किया गया था।

खारा जलीय प्रत्याशी प्रजातियों में परजीवीय संक्रमण का पृथककरण एवं पहचान

तमिलनाडु, पुडुचेरी, केरल और आंध्र प्रदेश में वन्य एवं पालित मत्स्य प्रजातियों में परजीवीय संक्रमण किया गया। *आर्गुलस एसपीपी., कैलीगस एसपीपी., लर्निया एसपीपी., साइमोथोआ एसपीपी., लर्नान्थ्रोपिस एसपीपी., एमिलोडिनियम* एसपीपी., *एंसिरोसेफालिड, ज़ेलेनिकोब्डेला* एसपीपी., *अनीसाकिस* एसपी., *एपिस्टीलिस* एसपीपी., *जूथैम्नियम* एसपीपी., *माइक्रोस्पोरिडियम* एसपीपी और *आक्टोलासमिस* एसपीपी जैसे तेरह प्रमुख परजीवी संक्रमणों का रूपात्मक रूप से पहचान की गई। एशियाई सीबास, *एल कैल्केरिफ़र* और *इट्रोप्लस सुराटेंसिस* में 28S rDNA और 18S rDNA अंशों के आधार पर क्रमश: *लर्निया* एसपी और *कैलिगस मिनिमस* में की आणविक पहचान की गई थी।

मछली में एंटी-पैरासिटाइड के रूप में लुफेनुरॉन (एलएफ) की जैव सुरक्षा, वापसी और प्रभावकारिता

विभिन्न खुराकों में मौखिक रूप से खिलाकर सुरक्षा के लिए मूल्यांकन किए गए एशियाई सीबास अंगुलिकाओं के फार्माकोडायनामिक अध्ययन से पता चला है कि LF जैविक रूप से

अनुशंसित चिकित्सीय खुराक के 10 गुना और उपचार की अवधि के तीन गुना तक सुरक्षित था। फार्माकोकाइनेटिक अध्ययनों से पता चला है कि यकृत, गंर्दा और मांसपेशियों में LF का स्तर 0.01 पीपीएम की क्वांटिफिकेशन (एलओक्यू) की सीमा की न्यूनतम स्तर तक 28वें दिन पहुंच गया। ग्वार गम और एग एल्ब्यूमिन कोटेड फीड में एलएफ लीचिंग की दर में कोई महत्वपूर्ण अंतर नहीं देखा गया। इसलिए, LF को एशियाई सीबास में पैरासिटिसाइड के रूप में सुरक्षित और प्रभावी ढंग से इस्तेमाल किया जा सकता है।

झींगा पालन प्रणाली में *स्ट्रेप्टोमाइसेस ग्रिसियोरूबेंस* CIBA-NS1 स्ट्रेन, एक एंटागोनिसटिक विब्रियो की पहचान

स्ट्रेप्टोमाइसेस ग्रिसियोरूबेंस CIBA-NS1 स्ट्रेन को जैव रासायनिक और रूपात्मक विशेषताओं के साथ-साथ 16SrDNA अनुक्रमण के आधार पर पृथक और पहचाना गया था। जीवाणुरोधी गतिविधि के लक्षण वर्णन हेतु किए गए अध्ययन ने *विब्रियो कैंपबेली* के खिलाफ आशाजनक एंटागोनिसटिक गतिविधि का संकेत दिया।

अंतर्स्थलीय लवणीय भूजल की जलीय गुणवत्ता प्राचल एवं आयनिक प्रोफाइल

हरियाणा, पंजाब और राजस्थान के अंतर्स्थलीय लवणीय भूजल (ISG) के नमूनों के विश्लेषण से पता चला है कि राजस्थान के नमूनों का अधिक प्रतिशत पोटेशियम को छोड़कर विभिन्न आयनिक और पानी की गुणवत्ता के मापदंडों के अनुकूलतम सीमा के भीतर आता है, आगे के अंतर्स्थलीय झींगा पालन विस्तार के लिए खनिज पूरकता की आवश्यकता का संकेत देता है।

कुल क्षारीयता को कम करने के लिए सोडियम बाइसल्फेट का प्रभाव : जलीय गुणवत्ता, जीव विकास, प्रतिरक्षा एवं जैव रासायनिक मापदंडों की जांच

कुल क्षारीयता (TA) को कम करने के लिए, सोडियम बाइसल्फेट सबसे अच्छा विकल्प है, लगभग 1.3 और 1.6 पीपीएम क्रमशः 2 और 25 पीपीटी लवणता के तहत कुल क्षारीयता के 1 पीपीएम को कम करता है। सोडियम बाइसल्फेट के प्रयोग से जीवों के जीवित रहने, जलीय गुणवत्ता और जैव रासायनिक मापदंडों पर कोई प्रभाव नहीं पड़ा और नियंत्रण (उच्च टीए) उपचारों की तुलना में विकास दर अधिक थी।

अलग-अलग संग्रहण घनत्वों (SD) के साथ पीनियस वन्नामेय पालन में कार्बन बजटिंग

निम्न और मध्यम संग्रहण घनत्वों में मृदा का कार्बन इनपुट अधिकतम होता है, जबकि उच्च संग्रहण घनत्व में उच्चतम कार्बन इनपुट के लिए फ़ीड दायी है। कार्बन आउटपुट के संदर्भ में, संग्रहण घनत्व के किसी भी स्तर के बावजूद मृदा, उच्चतम अंश के लिए जिम्मेदार है। बेहिसाब कार्बन आउटपुट कम संग्रहण घनत्व में सबसे अधिक और उच्च संग्रहण घनत्व में सबसे कम पाए गए। कार्बन बजटिंग पर ये अध्ययन ग्लोबल वार्मिंग में झींगा पालन के योगदान को समझने में मदद करते हैं।

सल्फाइड और अमोनिया के बायोरेमेडिएशन के लिए माइक्रोबियल एनरिचमेंट्स का विकास

अमोनिया का एक पीपीएम से अधिक का स्तर पता लगाने योग्य हाइड्रोजन सल्फाइड का स्तर विषाक्त माना जाता है और संवर्धित झींगों के लिए तनाव का कारण बनता है। सल्फाइड विषाक्तता के शमन के लिए अलग किए गए जीवाणुवीय एनरिचमेंट्स सल्फाइड और अमोनिया हटाने में प्रभावकारी पाए गए। खारा जलीय वातावरण में सल्फाइड और अमोनिया मेटाबोलाइट्स के प्रभावी बायोरेमेडिएशन के लिए केमोआटोट्रॉफ़िक और हेटरोट्रॉफ़िक बैक्टीरियल कंसोर्टिया के एनरिचमेंट्स के संयोजन को एक प्रोबायोटिक के रूप में विकसित किया जा सकता है।

संभावित गट (आंत) एवं पर्यावरणीय प्रोबायोटिक के रूप में लैक्टिक एसिड बैक्टीरिया का विशेषीकरण

5 से 25 पीपीटी तक की लवणता वाले पी. वन्नामेय पालन तालाबों से अलग किए गए लैक्टिक एसिड बैक्टीरियल आइसोलेट्स में झींगा रोगजनकों के विरूद्ध जीवाणुरोधी गतिविधि, उत्कृष्ट ऑटो-एग्रीगेटिव गतिविधि और हाइड्रोफोबिसिटी के गुणों को प्रदर्शित करने की गट प्रोबायोटिक क्षमता होती है, इसके अलावा, मृदा एवं जल के बायोरेमेडिएशन की भी क्षमता होती है। आइसोलेट्स के बीच कोई एंटागोनिस्टिक गतिविधियां न होने के कारण जलीय कृषि उत्पादन प्रणालियों में संभावित मल्टीपल कॉकटेल गट और पर्यावरणीय प्रोबायोटिक के रूप में इसके उपयोग का सुझाव देती है।

अमोनिया और नाइट्राइट ऑक्सीडाइजिंग बैक्टीरिया का अलगाव

अमोनिया ऑक्सीडाइजिंग बैक्टीरिया (एओबी) और नाइट्राइट ऑक्सीडाइजिंग बैक्टीरिया (एनओबी) को फ्रेंच बीन (*फेजियोलस वल्गेरिस*) की जड़ से अलग किया गया था, जिसे 16S rRNA जीन अनुक्रमण *स्फिंगोबैक्टीरियम* एसपी के रूप में पहचाना गया और *स्फिंगोबैक्टीरियम* एसपी एसडीकेआरसी-13 के रूप में नामित किया गया। आइसोलेट लवण-सहिष्णु पाया गया और अनुक्रम को एनसीबीआई को परिग्रहण संख्या OQ396674 के तहत प्रस्तुत किया गया। अमोनिया और नाइट्राइट को कम करने में *स्फिंगोबैक्टीरियम* एसपी SDKRC-13 के प्रभाव का पता लगाने के लिए तरूण *पी. वन्नामेय* झींगों पर एक परीक्षण अध्ययन किया गया जो पालन के 15 और 35 दिनों पर में नाइट्राइट के स्तर में महत्वपूर्ण कमी दर्शाया है और 35

डीओसी पर कुल अमोनिया नाइट्रोजन (TAN) के स्तर में काफी कमी देखी गई। इस अध्ययन के आधार पर, यह कहा जा सकता है कि विशेष रूप से आइसोलेट स्फिंगोबैक्टीरियम एसपी। SDKRC-13 जल प्रोबायोटिक्स के निर्माण में एक अच्छे उम्मीदवार के रूप में कार्य कर सकता है, जो अमोनिया और नाइट्राइट जैसी जहरीली गैसों के स्तर को कम कर सकता है।

पश्चिम बंगाल के खारा जलीय क्षेत्रों में स्रोत जल और तालाब की मिट्टी का गुण चित्रण

दक्षिण-24 परगना जिला, पश्चिम बंगाल में स्रोत जल और तालाब की मिट्टी की विशेषता ने संकेत दिया कि अधिकांश मिट्टी की बनावट दोमट और चिकनी मिट्टी की है, जिसका अनुकूलतम पीएच 7.5-8.5 है। मिट्टी की बड़ी संख्या में जैविक कार्बन, उपलब्ध नाइट्रोजन और उपलब्ध फास्फोरस की कमी है। अधिकांश जलीय नमूनों में लवणता स्तर 10 पीपीटी से कम है। कुल मिलाकर, सभी क्षेत्र खारा जलीय कृषि के लिए उपयुक्त हैं, जिनमें उर्वरता की स्थिति को बढ़ाने के लिए वर्ष में एक बार मिट्टी में खाद डालने की सिफारिश की गई है।

पिंजरा पालन के लिए मुत्तुकाडु मुहाना और अडयार क्रीक की उपयुक्तता

मुत्तुकाडु मुहाना और अडयार क्रीक की जलीय गुणवत्ता ऋतुओं से प्रभावित होती है। वर्ष भर की जलीय गुणवत्ता निगरानी, समुदायों द्वारा पर्यावरणीय स्थिरता को प्रभावित किए बिना अपनी आजीविका में सुधार करने के लिए खाड़ी में और आसपास के क्षेत्र में पिंजरा/पेन पालन शुरू करने के लिए एक उपयुक्त मौसम का सुझाव देती है।

मिल्कफिश के जीवन चरणों की तापीय सहनशीलता

मिल्कफिश के जीवन चरणों की तापीय सहिष्णुता सीमाओं के अध्ययन हेतु किए गए 30 दिनों के लंबे तापमान अनुकूलन परीक्षण के अंत में पता चला कि ऑक्सीजन की खपत के लिए न्यूनतम तापमान गुणांक (Q10) मूल्यों और लार्वा, पोनों, अंगुलिकाओं और स्टंटेड इयरलिंग्स की अनुकूलन प्रतिक्रिया अनुपात (एआरआर) के आधार पसंदीदा तापमान क्रमशः 280, 300, 30-320, और 340 से. हैं।

खारा जलीय कैटफ़िश, *मिस्टस गुलियो*, एक जलवायु-लचीली मछली की परिपक्वता, प्रजनन और लार्वा पालन के लिए आदर्श लवणता

मिस्टस गुलियो (हैम.), खारा जलीय कृषि के लिए व्यावसायिक रूप से महत्वपूर्ण जलवायु-लचीली प्रजाति है। प्रयोग के परिणामों से पता चला कि यद्यपि *एम. गुलियो* ने 0-20 पीपीटी की लवणता के बीच यौन परिपक्वता प्राप्त की और इनमें अंडजनन भी हुए, परन्तु प्रजनकों के विकास, प्रजनन और लार्वा पालन के लिए आदर्श लवणता 0-10 पीपीटी के बीच है।

झींगा, *पीनियस वन्नामेय* में तापमान तनाव में सुधार में लिपिड स्तर का प्रभाव

तापमान तनाव को कम करने के लिए, पी. वन्नामेय के तरूण झींगों पर 45 दिनों तक एक प्रयोग किया गया था जिसमें झींगों को तीन अलग अलग जलीय तापमानों में पाला गया और दो अलग अलग स्तरों की लिपिड सामग्री वाले आहार खिलाया गया। विभेदक जीन अभिव्यक्ति विश्लेषण और बायोइंफॉर्मेटिक्स टूल्स द्वारा मेटाबॉलिक पाथवे दर्शाया है कि प्रायोगिक स्थितियों के तहत उच्च लिपिड उपचार पाइरूवेट मेटाबॉलिज्म, टीसीए चक्र और एएमपीके सिग्नलिंग पाथवे जैसे एनर्जी मेटाबॉलिज्म में शामिल मेटाबॉलिज्म पाथवे को अप-रेगुलेट कर सकता है और संभावित रूप से तापमान तनाव को कम कर सकता है।

झींगे, *पीनियस वन्नामेय* में ईएचपी लोड पर लवणता में आकस्मिक बदलाव का प्रभाव

झींगों के हेपाटोपेंक्रियास में *एंटेरोसाइटोजून हेपाटोपेनाई* (ईएचपी) लोड पर लवणता का 25 से 5 और 15 पीपीटी तक में आकस्मिक बदलाव के प्रभाव के अध्ययन से पता चला है कि आकस्मिक बदलाव के 48 घंटे और 2 सप्ताह के बाद ईएचपी प्रतिलिपि संख्या में उल्लेखनीय वृद्धि हुई थी।

झींगा उपज वर्गीकरण मॉडल का निर्माण

जलीय कृषि प्रक्षेत्रों को निम्न, मध्यम और उच्च उपज वाले प्रक्षेत्रों (फार्मों) में वर्गीकृत करने के लिए विभिन्न मशीन लर्निंग मॉडल जैसे लॉजिस्टिक रिग्रेशन, मल्टीलेयर परसेप्ट्रॉन, सपोर्ट वेक्टर मशीन, डिसीजन ट्री और रैंडम फ़ॉरेस्ट को लागू किया गया था, जो दस गुना क्रॉस-वैलिडेशन मॉडल और मॉडल आउटपुट पैरामीटर के माध्यम से प्राप्त सटीकता के आधार पर रैनडम फॉरेस्ट मॉडल को प्रक्षेत्रों (फार्मों) के वर्गीकरण करने के लिए सबसे उपयुक्त पाया गया।

ग्लोबल वार्मिंग सम्भावनाओं में झींगा पालन का योगदान : जीवन चक्र मूल्यांकन (एलसीए) दृष्टिकोण

हैचरी, फीड मिल और खेती की प्रणालीगत सीमाओं के साथ भारत में *पी. वन्नामेय* खेती से जुड़े पर्यावरणीय प्रभावों की मात्रा और तुलना करने के लिए जीवन चक्र मूल्यांकन का उपयोग किया गया था। झींगा हैचरी, फीड मिल और झींगा खेती की ग्लोबल वार्मिंग सम्भावनाएं (GWP) क्रमशः 331, 704 और 3,230 किलोग्राम CO_2eq थी, जो दर्शाता है कि खेती प्रमुख चरण है, जो GHG उत्सर्जन में महत्वपूर्ण योगदान देती है। GWP में योगदान देने वाला प्रमुख हॉटस्पॉट बिजली और डीजल के संदर्भ में ऊर्जा का उपयोग है।

झींगा फ़ीड मिल से ग्लोबल वार्मिंग की सम्भावनाओं को कम करने के लिए वैकल्पिक मॉडल

फिश मील की अनुपलब्धता और उच्च लागत के कारण फिश मील के विकल्प के रूप में पादप प्रोटीन स्रोतों के साथ वैकल्पिक फ़ीड सूत्रण विकसित किए जा

रहे हैं। इन विकसित आहारों का झींगा विकास प्राचलों पर प्रभावकारिता परीक्षण के अलावा ग्लोबल वार्मिंग सम्भावनाओं के आकलन हेतु इनका जीवन चक्र मूल्यांकन किया गया। FR-0, FR-50, FR-60, और FR-70 के साथ GWP क्रमशः 704, 660, 651 और 642 किग्रा CO_2eq था, जो फिश मील के विकल्प के रूप में प्रतिस्थापित फ़ीड की स्थिरता को दर्शाता है।

झींगा किसानों की तकनीकी दक्षता को प्रभावित करने वाले जलवायु परिवर्तन की घटनाओं के अनुकूलन के उपाय

यह समझने के लिए कि क्या जलवायु परिवर्तन (सीसी) के नकारात्मक प्रभावों को दूर करने के लिए किसानों द्वारा अपनाई जाने वाली अनुकूलन रणनीतियों से उनकी दक्षता में सुधार करने में मदद मिल सकती है, झींगा पालन पर सीसी घटनाओं की संभावना, परिणाम और जोखिम रेटिंग पर किसानों की (एन = 250, नेल्लोर जिला, आन्ध्र प्रदेश) धारणा के साथ साथ सामाजिक-आर्थिक स्थिति और अपनाई गई अनुकूलन रणनीतियां पिछले 10 वर्षों का एकत्रित किया गया था। जलवायु और सामाजिक-आर्थिक स्थिति को प्रभावित करने वाले घटनाओं को शामिल करके गणना की गई किसानों की तकनीकी और आर्थिक दक्षताओं ने संकेत दिया कि जिन किसानों ने चक्रवात और बाढ़ के नकारात्मक प्रभाव को सफलतापूर्वक दूर कर लिया है, उनके दक्षता स्तर में वृद्धि हुई है।

मैंग्रोव रेड स्नैपर का संपूर्ण जीनोम अनुक्रमण

लुत्जनस अर्जेन्टिमाकुलैटस, जलीय कृषि एक्वाकल्चर के लिए एक संभावित प्रत्याशी प्रजाति है क्योंकि यह एक यूरीहैलाइन मछली है, जो मीठे, खारे और समुद्री आवासों में बढ़ने में सक्षम है और इसे बंद परिस्थितियों में आसानी से पाला जा सकता है। संपूर्ण जीनोम सूचना डेटा, एल. अर्जेंटिमाकुलैटस के जीनोमिक्स के लिए एक नया दृष्टिकोण प्रदान करेगा। इस मछली के जीनोम असेंबली का इस प्रजाति के संरक्षण और प्रबंधन में संभावित अनुप्रयोग होगा, जो भविष्य में चयनात्मक प्रजनन कार्यक्रमों में मदद करेगा। *लुत्जेनस अर्जेन्टिमाकुलैटस* की ड्राफ्ट जीनोम असेंबली ने 699 नंबर के साथ 1.04 जीबी की जीनोम लंबाई का खुलासा किया जिसमें 12 एमबी की N50 लंबाई वाले कॉन्टिग्स हैं।

मुगिल सेफालस में ओवेरियन स्टेरॉयडोजेनिक एंजाइम जीन अभिव्यक्ति

अपरिपक्व मादाओं की तुलना में ओवेरियन स्टेरॉइडोजेनिक एंजाइम जीन के जीन ट्रांसक्रिप्ट्स् विटेलोजेनिक मादाओं में अधिक थे और ग्रे मलेट्स में परिपक्वता के दौरान प्लाज्मा एस्ट्रोजन के स्तर के साथ एक सकारात्मक सहसंबंध प्रदर्शित किया।

पीनियस इंडिकस में अत्यधिक लवणता और तापमान तनाव से जुड़े मेटाबोलिक पाथवेस

अत्यधिक लवणता और तापमान तनाव के कारण *पी. इंडिकस* में पाथवे स्तर को समझने के लिए प्रयोग ने लिपिड चयापचय, तनाव प्रतिक्रियाओं और फॉस्फोमिथाइलथेनॉलमाइन, 6-फॉस्फोग्लुकोनेट डिहाइड्रोजनेज, सेल ग्रोथ-रेगुलेटिंग न्यूक्लियर प्रोटीन, साइटोक्रोम P450 और विकास प्रोटीन के अवरोधक जैसे नियामक तंत्र के लिए जीन एन्कोडिंग की भूमिका पर प्रकाश डाला गया।

पीनियस वन्नामेय में स्वदेशी माइक्रोबियल बायोमार्कर

इन सिलिको मेटा-विश्लेषण के माध्यम से, *एसिनेटोबैक्टर* और *अल्टेरोमोनास* को क्रमशः पी. वन्नामेय के लिए स्वास्थ्य और रोग की अवस्था के लिए संभावित माइक्रोबियल बायोमार्कर के रूप में पहचाना गया। झींगा स्वास्थ्य के लिए सुक्रोज पर्यावरण और पीढ़ी के लाभकारी सूक्ष्म जीवों की भूमिका, *एसिनेटोबैक्टर, बिफीडोबैक्टीरियम, ब्रेवुंडिमोनस* और *ल्यूटिबैक्टर* का प्रलेखन किया गया है।

पर्लस्पॉट फुल-सिब परिवार और उनका विकास प्रदर्शन : चयनात्मक प्रजनन पर एक पहल

छह पर्लस्पॉट फुल-सिब परिवारों को एमईएस तालाब के पिंजरों में रखा गया था और 360 दिनों के बाद उनके विकास का प्रदर्शन देखा गया था। 360 डीपीएच के बाद परिवारों का औसत वजन 85 से 125 ग्राम के बीच पाया गया था। उत्तरजीविता दर 77 से 95% तक थी।

पीनियस इंडिकस में तनाव संबंधी जीन अभिव्यक्ति

तीन सप्ताह की अवधि के लिए कम लवणता तनाव (5 पीपीटी) पर qRT-PCR द्वारा कार्बोनिक एनहाइड्रेज (CA), सोडियम पोटेशियम ATPase (Na+/K+-ATPase), क्रस्टिन, प्रो फिनोल ऑक्सीडेज (PPO), पेरोक्सीनेक्टिन, बीटा ग्लूकेन बाइंडिंग प्रोटीन (BGBP), सुपर ऑक्साइड डिसम्यूटेज (SOD) और हेमोसायनिन की जीन अभिव्यक्ति को मापा गया था। CA, Na+/K+-ATPase, PPO और BGBP के एक्सप्रेशन लेवल को अप-रेगुलेटेड देखा गया।

पर्लस्पॉट के लिए क्रोमोजोम-स्तरीय जीनोम असेंबली

पर्लस्पॉट के लिए 344 स्कैफोल्ड्स में 1.275 जीबी की असेंबली लंबाई और 50.27 एमबी के एन50 मीट्रिक के साथ एक क्रोमोजोम-स्तरीय जीनोम असेंबली तैयार की गई थी। असेंबली में 98.9% BUSCO पूर्णता है।

सामाजिक विज्ञान एवं विकास

झींगें की खेती में रोग प्रमुख जोखिम है और 45% तक उत्पादन हानि के साथ *एंटेरोसाइटोज़ून हेपाटोपेनाई* (ईएचपी) के कारण होने वाला हेपाटोपैंक्रिएटिक माइक्रोस्पोरिडिओसिस (एचपीएम) एक प्रमुख उत्पादन जोखिम है। यह अनुमान लगाया गया है कि झींगा पालन 4% प्रीमियम के साथ प्रति वर्ष ₹750 करोड़

की फसल बीमा व्यवसाय सम्भावनाएं प्रदान करता है। इसी तरह, झींगा पालन के लिए सूक्ष्म ऋण की आवश्यकता प्रति वर्ष ₹13,000 करोड़ होने का अनुमान लगाया गया था, जो वर्तमान में उच्च ब्याज दरों पर अनौपचारिक लेनदारों द्वारा पूरा किया जा रहा है।

नर्सरी, प्री-ग्रो आउट और ग्रो-आउट चरणों के साथ-साथ पिंजरों में एशियाई सीबास मछली पालन के आर्थिक विश्लेषण पर काम किया गया और दोनों प्रणालियों में लाभदायक पाया गया। सीबास केज फार्मिंग की औसत तकनीकी दक्षता 0.91 थी जो यह दर्शाता है कि किसान दिए गए इनपुट के साथ अधिकतम संभावित उत्पादन का 91% उत्पादन करने में सक्षम थे।

तटीय गांवों में प्रचलित मत्स्य पालन और जलीय कृषि आधारित आजीविका को उजागर करने के लिए पीआरए अभ्यासों का उपयोग करते हुए कृषि प्रणाली के आरेख तैयार किए गए थे।

झींगा किसानों द्वारा अपनाए जा रहे विभिन्न नर्सरी मॉडल के तकनीकी-आर्थिक मूल्यांकन ने संकेत दिया कि वे ग्रो-आउट उत्पादन के लिए गुणवत्तापूर्ण बीज प्रदान करने, एक वर्ष में दो से अधिक फसलों के साथ उच्च उत्पादन, जोखिम न्यूनीकरण और लाभदायक झींगा खेती के मामले में कुशल थे।

पिंजरा जलीय कृषि के लिए वायरलेस सेनर नेटवर्क आधारित आर्टिफिशियल इंटेलिजेंस मॉनिटरिंग सिस्टम के विकास के लिए मशीन लर्निंग आधारित सुगेनो डेटा एग्रीगेशन मॉडल उपयुक्त पाया गया।

जलीय कृषि के किसानों, उनकी उत्पादन प्रणालियों और खेती के तरीकों के बारे में जानकारी को संग्रहीत करने और पुनः प्राप्त करने के लिए एक्वाकल्चर इंफॉर्मेशन सिस्टम (एआईएस), एक वेब आधारित एप्लिकेशन सॉफ्टवेयर विकसित किया गया था।

सस्टेनेबल लाइवलीहुड फ्रेमवर्क विश्लेषण से पता चला है कि फिश वेस्ट टू वेल्थ तकनीक को अपनाने से तटीय परिवारों की आजीविका की स्थिति पर सकारात्मक प्रभाव (26%) पड़ा है।

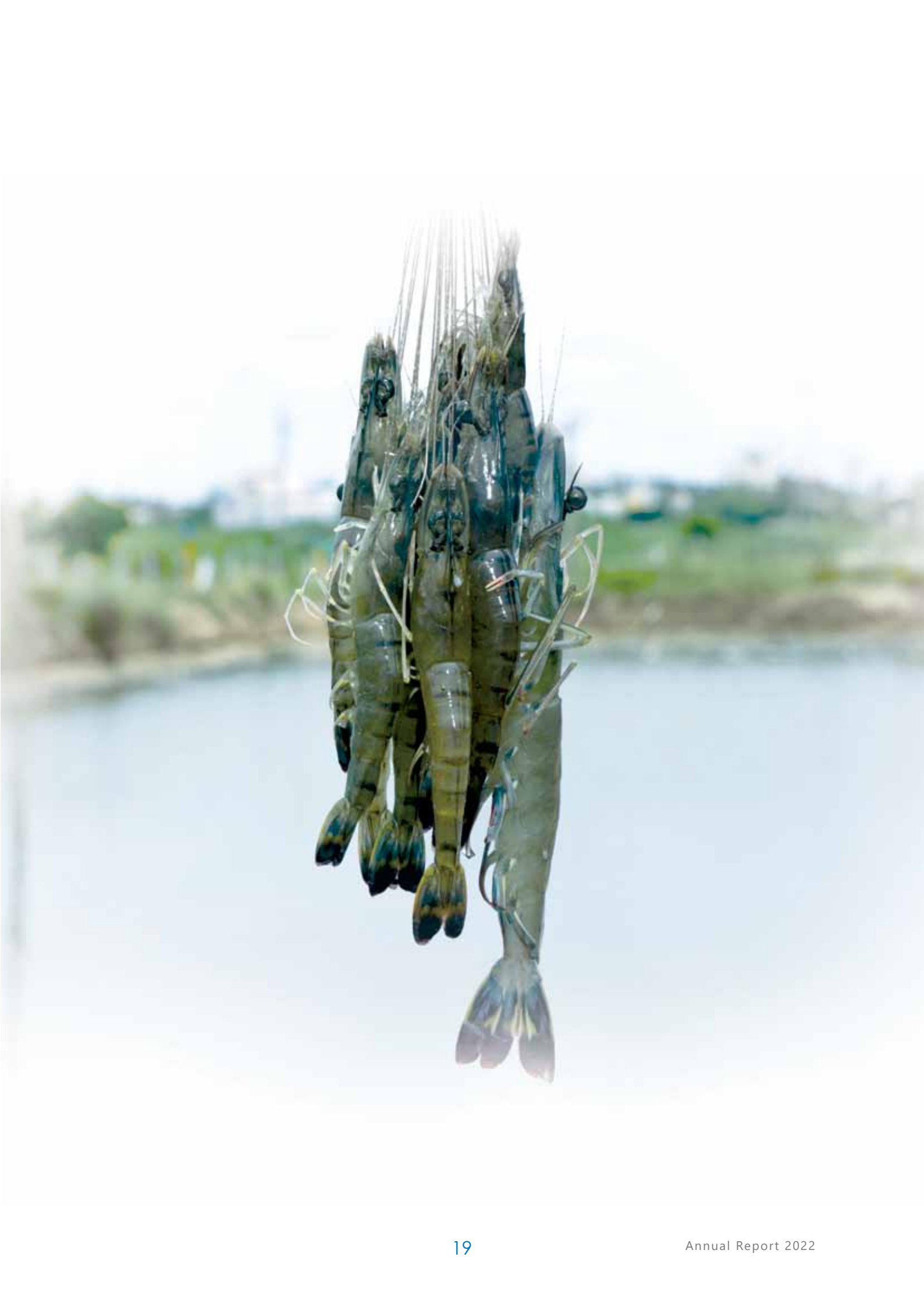
तटीय ग्रामीणों को रोजगार और आय प्रदान करने के लिए वैकल्पिक आजीविका विकल्प के रूप में उपलब्ध प्राकृतिक जल संसाधनों का उपयोग करने वाली एकीकृत मल्टी-ट्रॉफिक एक्वाकल्चर (IMTA) की पहचान की गई थी।

अनुसूचित जाति उप योजना

अनुसूचित जाति उप योजना के तहत, संस्थान ने आंध्र प्रदेश, गुजरात, तमिलनाडु और पश्चिम बंगाल राज्यों के सात अलग-अलग स्थानों में 3098 अनुसूचित जाति के लाभार्थियों के कल्याण के लिए व्यवहार्य खारा जल कृषि प्रौद्योगिकियों पर जागरूकता अभियान, किसान बैठकें, व्यावहारिक प्रशिक्षण और प्रदर्शन आयोजित किए। इस कार्यक्रम के तहत 420 लाभार्थियों के लिए आठ प्रशिक्षण कार्यक्रम; 100 लाभार्थियों के लिए बीज, चारा, बाड़ सामग्री, पिंजरों आदि जैसे कृषि आदानों के वितरण के साथ छह ऑन-फार्म परीक्षण; 94 लाभार्थियों के लिए पांच अग्रपंक्ति निरूपण और विभिन्न गांवों के 2,470 लाभार्थियों को शामिल करने वाले 14 जागरूकता बैठकों का आयोजन किया गया।

जनजातीय उप योजना

अनुसूचित जनजाति घटक (एसटीसी) के तहत, ऑन-फ़ार्म/ऑन-साइट प्रदर्शन (170 लाभार्थी), व्यावहारिक प्रशिक्षण (130 लाभार्थी) और तमिलनाडु, गुजरात, महाराष्ट्र, ओडिशा और पश्चिम बंगाल राज्यों में जलीय कृषि और संबद्ध प्रौद्योगिकियों पर जागरूकता शिविर (835 लाभार्थी) आयोजित किए गए। इन विकासात्मक हस्तक्षेपों से प्रति क्लस्टर ₹0.3 लाख से ₹11.39 लाख की सीमा में आदिवासी समुदायों के लिए आजीविका उत्थान और आय सृजन प्राप्त हुआ।



Executive Summary

EVALUATION OF DIFFERENT PRODUCTION MODELS AND MARKET POTENTIAL OF MILKFISH AND OTHER BRACKISHWATER CANDIDATE SPECIES

Milkfish fingerlings (20 g abw, 11.6 cm total length) stocked @ 1.5 numbers/ m^2 in 1,156 m^2 earthen pond at KES-CIBA and fed with CIBA formulated feed (milkfish Grow-Out^{Plus}). After 230 DOC fishes has grown to average size of 340 g and 35.43 cm. Harvested biomass is 478 kg (4.78 t/ha productivity) till 230 DOC and ₹65,450 generated from sale of fishes. FCR calculated around 1.38 during culture period. Initial studies conducted to explore potential of deboned milkfish. Average dressing loss of de-boned milkfish is < 20% only and there is good post-harvest possibility. Milkfish with de-boning as value addition, can potentially fetch premium value compared to whole fish.

DEMONSTRATION OF LOW VOLUME CAGE CULTURE OF SEABASS AND PEARLSPOT IN BRACKISHWATER CREEKS AND POND AS AN ALTERNATIVE LIVELIHOOD ACTIVITY

The NGRC of ICAR-CIBA, in collaboration with the Department of Fisheries, Govt. of Gujarat, has initiated demonstration of cage culture of Asian seabass and pearlspot in brackishwater creeks and ponds as an alternative livelihood activity for coastal fishermen in Gujarat. Eight cages of 4 x 4 x 2 m (32 m^2) and 4 cages of size 6 x 4 x 1.5 m (36 m^2) were fabricated locally and deployed. Seabass fingerlings (20–25 g) and pearlspot fingerlings (2–3 inches) were stocked and reared on formulated feed. The culture is in progress.

NURSERY REARING TRIALS ON INDIAN SALMON *ELEUTHERONEMA TETRADACTYLUM*

Wild collected Indian salmon *Eleutheronema tetradactylum* fry of 1.0 to 1.3 cm size 3,800 numbers were procured from Machilipatnam, Krishna Dt., Andhra Pradesh and acclimatized to the salinity of 25 ppt in FRP tanks. Graded and stocked according to the size. The fry were fed with formulated feeds (crude protein 46% and crude fat 10%) of 0.8 mm and 1.2 mm size at ad libitum thrice a day. After 30 days of rearing attained 4.5 cm size. Very actively swimming fingerlings could be easily weaned to artificial diets.

HAPA BASED NURSERY REARING OF *PEARLSPOT ETROPLUS SURATENSIS*

Experiments carried out at NGRC-CIBA to shorten the larval rearing phase of pearlspot and to evaluate ideal age of larvae for outdoor nursery rearing. Different age groups of larvae were divided into two groups such as early stocking (5, 10 and 15 day old) and late stocking (20, 25 & 30 day old) were stocked in the hapas and fed with *Artemia* nauplii and artificial diet. After 30 days rearing, late stocking group had better survival rate (78–85%), as compared to early stocking groups (19.86-37.33%). 30 day old pearlspot larvae (16.2±0.12 mm) attained fingerling size (4.12±0.38 cm) in 40 days of rearing in nylon hapas with 83% survival rate.

DEVELOPMENT OF INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) CAGES AS A LIVELIHOOD ACTIVITY FOR COASTAL FISHER FOLKS OF SINDHUDURG, MAHARASHTRA

Asian seabass (700 no.), pearlspot (400 no.), tiger shrimp (20,000 no.), *Kappaphycus* seaweed (20 kg) and 50 green mussels (150–200 mussels/rope) were stocked and read with the help of SHGs. On harvest they generated revenue of ₹6.25 lakhs through the sales from the harvest of 560.5 kg of seabass, 820.3 kg of green mussels, 353.9 kg of tiger shrimp, 720 kg of pearlspot and 20 kg of dry seaweed. Results

suggest that integration of multi species provides more and regular income rather than single species farming.

COMPARATIVE GROWTH ASSESSMENT OF *LIZA TADE* UNDER MONOCULTURE AND POLYCULTURE

A comparative growth assessment study of tade mullet under monoculture and polyculture farming system was initiated in earthen pond of KRC. Tade fingerling (4.7±0.8 g; 9.5±1.1 cm) was stocked with a density 1.42 fingerling/m^2 in monoculture and polyculture pond. About 2,000 milkfish fingerling (3.9±1.8 g; 7.02±2.5 cm) was stocked with tade mullet in polyculture pond. Fishes were fed with floating feed (Protein 28- 30%, Fat 5%) @ 2-3% of body weight. Survival of the tade mullet was recorded 95 and 90% in monoculture and polyculture pond, respectively. The final harvested average body weight under monoculture and polyculture was 503.67±19.5 g and 210.11±9.8 g, respectively, whereas the average body weight of milkfish was 370.95±10.11 g at the harvest. Specific growth rate (SGR) was recorded at 1.18 for milkfish, 0.97 for tade mullet in polyculture, and 1.27 for tade mullet in monoculture.

GROW-OUT REARING PROTOCOL OF HILSA

Experiments were carried out to refine the growout rearing protocols for hilsa. Plankton^{Plus} was applied @ 160 kg/ha in the pond and nursery reared hilsa fry (11.23±0.82 g/ 10.40±0.32 cm) were stocked @ 14,000/ha. During culture, pond was fertilized weekly with Plankton^{Plus} (30 kg/ha) and mustard oil cake (60 kg/ha) to maintain the plankton population. Formulated slow-sinking grow-out feed (Hilsa^{Plus}) was offered @ 10-5% body weight. After 184 days, fry gained av. body weight/av. body length of 37.43±7.14 g/16.08± 0.7 cm.

COPEFLOC TECHNOLOGY FOR SHRIMP PRODUCTION

Copefloc is a novel technology for shrimp production. Copepods namely Dioithona rigida, *Pseudodiaptomus annandalei* and Evansula pygmea were used to generate copefloc. Copefloc based nursery reduced 20% of supplementary feed. Average size of the harvested shrimp was 24.4±01.2 g compared to control of 14.2±0.92 g on 50th day post nursery rearing. The study show that copefloc reared juvenile shrimp shows compensatory growth, significantly higher survival, lower FCR.

EVALUATION OF FARM BASED FEED FOR SHRIMP FARMING

A feed composition was formulated using locally available feed ingredients. The shrimps grown with farm based feed has arttained 13.85 g at 100 DOC. Economic analysis shows that better returns was realized due to the lower cost of feed production. This has potential to support against uncertain shrimp price and fill the demand for low-cost prodcution methods for sustainabiliy of shrimp farming sector.

MINERAL SUPPLEMENTATION ON THE GROWTH AND SURVIVAL OF *PENAEUS VANNAMEI* JUVENILES REARED IN FRESHWATER (TDS <500 PPM)

Farming of pacific white shrimp Penaeus vannamei in freshwater (FW) is an emerging area of interest given the remarkable osmoregulatory ability of the shrimp. Experimental media were prepared by supplementing FW with potassium (K1, K2, K3), magnesium (M1, M2, M3) and calcium (C1, C2, C3) ions, such that the targeted ion was raised by 5 ppm sequentially to three levels while the other ions remain constant. All the shrimp reared in raw FW died by the end of the experiment. Shrimp reared in treatments K3 and M3 wherein potassium and magnesium were increased by 15 ppm from basal levels respectively, resulted in significantly higher survival (80.4-87.8%) and were similar to shrimp reared in SW (96.25%). The study reveals the importance of individual ions and gives a fair idea on minimal ionic requirement for commercial operations.

IDENTIFYING THE DIFFERENT LEVELS OF SOIL SALINIZATION FOR AQUACULTURE USING MACHINE LEARNING TECHNIQUES IN GOOGLE EARTH ENGINE

Assessing salt-affected land (SAL) remains a major challenge worldwide, especially in developing countries due to limited data availability. The development of remote sensing (RS) digital satellite data and their spectral characteristics pave the way to assess soil salinity. Salt-affected land of Thoothukudi, Tamil Nadu was studied using Landsat-8 satellite images. The study showed the effectiveness of RS techniques to detect the SALs in different spatial resolutions, which can help to evaluate unproductive land and its management at the state or regional level for the creation of alternative livelihood options.

SUITABILITY ASSESSMENT

OF INLAND SALINE GROUNDWATER RESOURCES FROM NORTH-WESTERN INDIA FOR SHRIMP FARMING BASED ON THE PRODUCTION PERFORMANCE AND WATER QUALITY VARIABLES

Inland shrimp farming in Haryana, Punjab and Rajasthan is growing rapidly and site selection based on water quality variables of saline groundwater is imperative for the overall success of the farming operation. Saline groundwater samples from operational farms growing whiteleg shrimp, *Penaeus vannamei* in the states of Haryana, Rajasthan and Punjab were collected and water quality variables were estimated. The study concludes that the relative hardness of the source water is a principal criterion for the selection of a site and a minimum Mg^{2+}/Ca^{2+} ratio of approximately 1.5:1 to be suitable for rearing
P. vannamei in inland saline ground waters.

BRACKISHWATER SEAWEED, *GRACILARIA SALICORNIA* CULTURE

Experiments were done with different stocking density, depth and salinity to assess the growth performance of *Gracilaria salicornia*. The study helped to arrive at optimum culture practice for the seaweed species with initial biomass density is 50 gm^{-2}, salinity 20 ppt, at depth of culture 0.5 to 0.75 m from surface and the days of culture is 45 days.

FINFISH SEED PRODUCTION AND SUPPLY TO THE FARMERS

A total of 3.8 million fish seeds consisting 32.32 lakhs spawn and 5.63 lakhs fry and fingerlings were (seabass 37.75 lakhs; milkfish 12,550 nos and pearlspot 7,080 nos) produced and distributed to the hatchery operators / farmers from Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and West Bengal and an amount of ₹17.63 lakh was generated as revenue.

BREAKTHROUGH ON THE CAPTIVE BREEDING AND SEED PRODUCTION OF GOLD-LINED SEABREAM FISH (*RHABDOSARGUS SARBA*) FOR THE FIRST TIME

ICAR-CIBA successfully bred the gold-lined seabream fish (Rhabdosargus sarba) for the first time in India. Matured broodstock fishes (350-1,800 g) were induced with hCG and LHRHa hormones and effected spontaneous spawning. A total of 1,500 seabream larvae produced up to 25th day post hatch by feeding with rotifers initially followed by Artemia nauplii and formulated diet. Seed production upscale is being attempted.

UPSCALING THE CAPTIVE BREEDING AND SEED PRODUCTION OF MANGROVE RED SNAPPER

A total of ninety broodstock fishes of mangrove red snapper *Lutjanus argentimacultus* were maintained in two types of fish holding systems such as 100 t capacity RCC tank (n=30, body weight 3.5 to 6.2 kg) and 600 m^2 earthen pond. Induced breeding trials successful under captivity and 200 numbers of one inch size (50 days old) seed produced.

CAPTIVE BREEDING OF MILKFISH *CHANOS CHANOS* USING TWO DIFFERENT STOCKS

A total 38 milkfish broodstock (average 6.2 kg) from Chennai and Kakinada group were maintained equally in two 100 t RCC tanks. Twelve new stock fishes (Chennai, ABW 4.5 kg, tl. 82 cm) were added with the existing stock. Fishes were treated with hormone pellet (combination of GnRHa and 17 α-Methyl Testosterone) and a total of six spawning were observed during March to September and a total 12,250 hatchery produced milkfish fry were distributed to the farmers and revenue of ₹52,514 was generated.

CAPTIVE BROODSTOCK DEVELOPMENT OF EMERGING CANDIDATE FINFISH SPECIES (GIANT TREVALLY, BENGAL BREAM AND RABBIT FISH)

A total of 75 giant trevally *Caranx ignobilis* are being maintained in earthen ponds and they attained the size range of 0.75 to 2.5 kg from 0.5 to 1.0 kg size in 12 months period. Female maturity observed through biopsy examination from the fishes of above 2.0 kg during first week of March 2023 and oocyte diameter observed between 80-100 and broodstock development is being continued.

Captive breeding of Bengal bream *Acanthopagrus datnia* (male 150-180 g and female 200 to 350 g) attempted in different salinity regime (5-30 ppt) at KRC of CIBA during December 2022 and January 2023 and the fish bred in 30 ppt salinity. Brooders had oocyte diameter of above 450µm were administered with LHRHa hormone @ 30 µg kg^{-1} body weight and half the dose to male intramuscularly. Fish spawned successfully after latency period of 55-58 h. spawning noticed continuously for three days and 1.0 lakh egg from single female and larvae could be reared up to 2 day post hatch. A total of sixty numbers of rabbitfish (*Siganus javus*) broodstock (1.5 to 2.0 kg) are being maintained in RCC and HDPE tanks.

DEVELOPMENT OF POND PASSED NURSERY REARING OF GREY MULLET *MUGIL CEPHALUS* USING PELLET FEED

Grey mullet nursery rearing has been initiated in lined pond (SD 500 nos @ 450 m^2) at MES using the hatchery produced seeds @ 8 to 10g and fed with formulated floating nursery feed @ 5 to 8% body weight. After 90 days rearing the fishes attained the size range of 40-50 g.

Similarly, pond based broodstock development of grey mullet at NGRC-CIBA, Navsari, for maturity assessment is taken up. A total of around 300 adult grey mullet (*Mugil cephalus*) maintained in an earthen pond at NGRC of CIBA, Navsari, Gujarat by feeding with pellet feed (CP: 40%, CF: 10%) were assessed for growth and maturity under captivity. From September 2022 to January 2023, 60 randomly selected fishes were sampled monthly basis to assess their maturity status using the biopsy method. Significant changes in oocyte diameters at monthly intervals and indicates that grey mullet attains maturity in brackishwater ponds with a peak in December.

REFINEMENT OF INDUCED BREEDING TECHNIQUE OF BENGAL BREAM, *ACANTHOPAGRUS DATNIA*

Acanthopagrus datnia broodstock, maintained at KRC of CIBA, attained sexual maturity in brackishwater (5-7 ppt), and high salinity (30 ppt) required only for final maturation, spawning, incubation and larval rearing. Mature female (oocyte >350-400 µm) and oozing male was shifted to breeding tank (8,000 L) and salinity was gradually increased @ 5 ppt/day to 30 ppt. LHRHa administered @ 30 µg kg^{-1} body weights to female and half the dose to male. Fish spawn successfully after latency period of 55-58 h, and eggs hatched out after an incubation period of 22 h (18°C).

BROODSTOCK DEVELOPMENT AND CONTROLLED BREEDING OF BRACKISHWATER ORNAMENTAL FISH SILVER MOONY

In the first trial, hatchery produced silver moony (*Monodactylus argenteus*) fry (30 days old) were distributed from the MES-FCD hatchery to the freshwater ornamental farmer from Madhavaram, Chennai. Farmer successfully completed the nursery phase (30 days) in fresh water with 98% survival to rear to one inch size and was able to fetch a good market price (₹50/piece) and demand is high compared to wild collected stock due to higher survival rate of hatchery produced seeds.

STANDARDIZATION OF CAPTIVE BREEDING AND LARVAL REARING PROTOCOLS OF ESTUARINE GOBY FISH, KNIGHT GOBY

Knight goby (*Stigmatogobius sadanundio*) is one of the goby fish occurring in Indian Sundarbans, having a beautiful pattern over its body. Adults and sub adults (n=235) of knight goby (size: 5-7 cm) were domesticated in captivity for 4-5 months. Sex ratio of 1:3 (female: male) lead to the successful pairing of fishes and spawning. Hatchlings (TL, 2.4-2.5 mm) were stocked @ 25 no/L in the larval rearing tank. Mouth (90±10 µm) opening is observed on two dph. Completely formed pectoral fins were observed on 3 dph. Four dph larvae were fed with ciliates (size, 30-50 µm; density 30±5 no/ml) and microalgae (density 2 X 10^6 no/ml).

DEVELOPMENT OF LOW-COST CAGE-BASED SEED PRODUCTION TECHNOLOGY OF PEARLSPOT TO CATER TO THE NEED OF FARMERS OF THE SUNDARBANS REGION

Non-availability of seed during stocking season is hindering the expansion of pearlspot farming. Bamboo-based low-cost cages (12 X 12 X 8 ft) were designed which can be operational for 2–3 years easily for seed production. At KRC of CIBA, a total of fifteen pairs (1 male: 1 female) were stocked in the cage. Spawning was observed from March to October, with the highest spawning frequency during May and July. The highest number of hatchlings was produced in June. During eight months of operation, a total of 1,02,247 eggs were produced by 15 pairs in the cage and 23,017 pearlspot fry were produced with an average survival rate of 85.5% in the hatchery.

DEVELOPMENT OF CAGE BASED SEED PRODUCTION TECHNOLOGY FOR PEARLSPOT (*ETROPLUS SURATENSIS*) AND IN RAS SYSTEM AS AN ALTERNATIVE LIVELIHOOD OR SHGS AT CIBA-NGRC

Three pearlspot seed production units were established in the Palghar, Ratnagiri and Sindhudurg, districts of Maharashtra and demonstrated pearlspot breeding in floating net cages and seed production in a tub based RAS system.) In January and December, 2022, Palghar site SHGs earned ₹2,49,500 through the sale of 20,200 nos. pearlspot fingerlings (1-2 inches) @ ₹12-20 per fingerling. Whereas, Ratnagiri and Sindhudurg SHGs earned ₹1,81,296 and ₹1,87,600 through the sale of 17,934 nos. and 19,502 nos. pearlspot fingerlings (1 inch) @ ₹10-12 per fingerling, respectively.

BROODSTOCK DEVELOPMENT OF HILSA AND TAGGING OF CAPTIVE BROODSTOCK AND MONITORING OF GONADAL MATURATION

Wild collected hilsa sub-adults (158.84±12.50 g / 22.85±0.72 cm) were stocked in 0.15 ha brackishwater pond at KRC of CIBA. Pond was fertilized weekly with Plankton^{Plus} (30 kg/ha) and mustard oil cake (60 kg/ha) to maintain the plankton population. The plankton abundance and diversity in broodstock ponds revealed that copepoda, cladocera and mysida were the prevalent zooplankton. A formulated feed with CP- 42.16% and fat 15.06% was offered @ 5-3%. After 16 months of culture, fish attained av. body weight/length of 480±54.09 g / 36.21±1.26 cm. USG tests were carried out in brood-stock fishes to understand the proper gonadal maturation status in anaesthetic conditions. GSI of captive broodstock (183.4 g) was 6.49 in the month of September. Oocyte diameter was found to be 427.08±3.24 µm.

ARTIFICIAL BREEDING AND NURSERY REARING OF HILSA (*TENUALOSA ILISHA*)

Artificial breeding of hilsa was conducted on-boat using wild collected broodstock (female; 963.4-980 g / 30-47 cm and male; 225-258 g / 26.5-32.5 cm) from Hooghly estuary at Godakhali, South 24 Parganas, West Bengal through dry stripping method and could get success with fertilization of 92±0.94 and hatching rate of 88.78±1.12%. Larvae produced from the trial were stocked in the earthen pond after 5 days of hatching for rearing. Nursery ponds (30 sq m) were fertilized with three different treatments i.e., mustard oil cake @ 75 ppm (T1), Plankton^{Plus} @ 75 ppm (T2) and a combination of both at the ratio of 1:1 (T3) six days prior to stocking of hilsa hatchling. Among the zooplankton population copepod, cladocera were dominant zooplankton in the T3 nursery pond. After 90 days of nursery rearing, apparently higher body weight (15.31±0.03) and better survival (27.0±1.0%) was found in the T3 nursery pond when the combination of Plankton^{Plus} (37.5 ppm) and Mustard cake (37.5 ppm) was supplemented as plankton booster.

GONAD DEVELOPMENT OF CAPTIVE-REARED INDIAN WHITE SHRIMP IN LOW AND HIGH SALINE MATURATION SYSTEM

Gonad development of Indian white shrimp at varying salinities from 22 to 36 ppt indicated that gonad development was noticed on par with 32 ppt, however regression of ovaries was recorded at 22 ppt salinity.

CAPTIVE BROODSTOCK DEVELOPMENT OF *PENAEUS INDICUS* IN TANK SYSTEM

Captive rearing of *P. indicus* broodstock to close the life cycle is one of the major thrust areas of research to develop the breeding program. Broodstock development in tank-based systems with 374 DOC indicated that female and male captive-reared stocks (G4) attained mean weight of 31.5 g and 27.2 g, respectively, compared to 24.99 g and 25.43 g attained by the female of G1. This indicates domesticated broodstock has later maturity with a better advantage on faster growth rate and bigger broodstock size over a generation.

MOULTING INTERVAL AND MATING OF *P. INDICUS* IN INDOOR VS OUTDOOR TANK

The confined indoor rearing system has given the poor mating efficiency. The study on moulting and mating efficiency of *P.indicus* using the indoor and outdoor tanks revealed that ablation increased moulting interval and moulting frequency in broodstock compared to un-ablated stock.

HATCHERY PRODUCTION PERFORMANCE OF *METAPENAEUS MONOCEROS*

The wild caught broodstock of *M. monoceros* (53 shrimps) indicated that the body weight of female broodstock ranged between 19.5 and 49.2 g), and total length has varied from 124 mm to 190 mm. About 55,000 PL were produced for the trial.

IMPROVED PROTOCOL FOR HATCHERY PRODUCTION OF MUD CRAB

The optimization of the feeding schedule and protocol for the hatchery production of mud crab was carried out with enriched rotifer as feed microalgae were completely removed from the feeding schedule, and feeding of rotifer stopped by the sixth day or when fifty percentage of Z2 are converted to Z3. Larviculture (from Z1 to megalopa (3rd day) was completed within 18 days indicating better survival.

OPTIMIZATION OF PROTEIN AND LIPID REQUIREMENT OF *MUGIL CEPHALUS*

Optimal protein and lipid requirement of hatchery-bred fingerling of *Mugil cephalus* was ascertained using practical diets with different levels of crude protein (20, 25, 30, 35, 40 and 45%) and lipid (4, 6, 8, 10, 12 and 14%) in indoor experiment and optimum protein and lipid requirement were found to be 30% and 8%, respectively.

BROODSTOCK FEED FOR HILSA

Formulated feed (CP 42.16% & EE 15.06%) for broodstock rearing of hilsa has been developed tested in pond. This specially designed feed was rich in PUFA and some essential amino acids like lysine, leucine, threonine etc. were used for two months before the onset of breeding season. After feeding of the broodstock feed, 80% of fish were found to be in different stages of maturity. Gonads of captive hilsa reared with formulated were found to have better amino acid profile compared to that of wild hilsa with similar gonado-somatic index. Comparing the biochemical composition of captive hilsa ovary with that of fully matured (running phase) wild hilsa ovary, broodstock feed was fine-tuned.

FLOWER WASTE AS NOVEL FEED INGREDIENT

The nutrient composition of flower waste revealed that it had 17% crude protein with 3% lipid content. A 90-day feeding trial in *Penaeus vannamei* showed that flower waste can be incorporated up to 7.5% level in diet without affecting the growth performance and survival.

EFFECT OF NANO ZINC SUPPLEMENTATION IN DIET OF *MYSTUS GULIO*

Zinc (Zn), the second important microelement, performs a variety of functions such as cell division, co-factor reproduction, immunological response, and antioxidant defence. The availability of zinc is often an issue due to presence of several interacting nutrients at gut level. Present experiment revealed that nano zinc supplementation @ 40 ppm can improve growth performance and reduce the stress and improve survival of *M. gulio* fry.

COTTONSEED MEAL (RAW AND FERMENTED) AS FEED INGREDIENT IN THE DIET OF *MYSTUS GULIO*

Cottonseed meal (CSM), a by-product of the cotton fibre and cottonseed oil industries is the third leading plant protein by weight used worldwide and is available at relatively lower cost. A 6-weeks study on inclusion level of raw and fermented CSM in the diet of *M. gulio* fry revealed that that CSM (raw) and CSM (fermented) can be included up to 5% level and10% in *M. gulio* diet without compromising production performance.

PERFORMANCE OF MILKFISH, *CHANOS CHANOS* JUVENILES FED ZERO FISHMEAL OR ZERO FISH OIL DIET

Zero fishmeal diet was tested in a 60-day feeding experiment in an indoor RAS system using hatchery produced juveniles of milkfish. Total replacement of fishmeal or fish oil in milkfish, *Chanos chanos* clearly showed that zero fishmeal diet negatively affected growth rate and reduced the digestive capability of the juvenile milkfish. It was also observed that milkfish conserved the essential fatty acids whenever the dietary essential fatty acids are lower by lowering the linoleic acid, Alpha-linolenic acid and arachidonic acid metabolisms.

COMPARATIVE FATTY ACID PROFILES OF ADULT *SIGANUS JAVUS* COLLECTED FROM WILD AND CULTURED

In order to develop the functional broodstock diet for successful maturation and spawning, adult *Siganus javus* fishes were collected from both wild and cultured sources and its nutrient profiles are analysed. Wild fishes have higher fatty acid profiles of eicosapentaenoic acid and docosahexaenoic acids in muscle (161.9 and 136.2 mg/100 g) and liver (387.1 and 543.5 mg/100 g) compared to muscle and liver (133.07, 81.53; 323.4, 331.24 mg/100 g, respectively) of cultured fish. The ovary of cultured adults showed higher EPA and DHA (245.9, 207.6 mg/100 g) contents compared to wild adult (176.28 and 183.5 mg/100 g), respectively.

MONITORING OF *ASPERGILLUS NIGER* GROWTH DURING FERMENTATION

Solid state fermentation of plant proteins using *Aspergillus niger* (1% of the feed ingredient) was standardized in a pilot scale fermenter. For quantification of growth of *Aspergillus niger*, Dichloran with Rose Bengal and Dichloran Glycerol Medium were used. The results suggest that *A. niger* spores started germinating from 24 h post incubation reflected by a lower value of 1 log population. By 48 h and 72 h, *A. niger* count increased to 6 and 7 log, respectively. Both, Dichloran Rose Bengal and Dichloran Glycerol Medium were found effective for *A. niger* quantification

NUTRIENT PROFILING OF MICROALGAE

Microalgae namely, Thalassiosira weissflogii, Chaetoceros gracilis, Tetraselmis sp., Isochrysis galbana, Nannochloropsis oculata, Chlorella marina and *Arthrospira* sp. were isolated from Muttukadu estuarine ecosystem and screened for nutraceutical properties and evaluated their application in brackishwater aquaculture. *Arthrospira maxima* isolated from Tamil Nadu coast for the first time was found to contain crude protein of 62.46±3.45% followed by *Chlorella marina* (49.48±3.8) and *T. weissflogii* (43.07±1.78).

Significantly, higher (P <0.05) lipid content (%) was observed in I. galbana (33.08±2.18) followed by *T. weissflogii* (20.11±1.02) and *N. oculata* (18.35±1.02). Arthrospira maxima were found to contain highest percentage (69.51% of fatty acids) of polyunsaturated fatty acids (PUFA) compared to other algae.

ANTIBACTERIAL PROPERTIES OF MICROALGAE

The antibacterial properties of various microalgae extracts were studied. The highest zone of inhibition was exhibited by CPC (C-Phycocyanin) against all three bacteria, *V. harveyi* (20.52±0.35 mm), *V. campbellii* (18.32±0.52 mm) and *V. parahaemolyticus* (19.48±0.84 mm). Highest antibacterial activity was shown by CPC against *V. harveyi, V. campbellii* and *V. parahaemolyticus* compared to all other microalgal extracts.

INCLUSION OF MICROALGAL CONCENTRATES IN DIET OF *PENAEUS VANNAMEI*

Marine microalgae (*Thalassiosira weissflogii* and *Tetraselmis* sp.) concentrates supplemented diets were tested in a 42 days feeding trial in *Penaeus vannamei* post larvae (PL 18, mean weight: 19.714±1.62 mg) for their effect on the growth and survival. The nutrient composition of *Thalassiosira weissflogii* and *Tetraselmis* sp. revealed that it had protein content of 43.07±1.78%, 42.11±2.55%; and crude lipid content of 20.11±1.02%, 10.56±0.27%, respectively. Result revealed that there was beneficial effect on growth and better antimicrobial property to withstand against the common pathogenic microbe and thus indicating the beneficial effect in the early life stages of shrimp post larvae when microalgae concentrate was supplemented @ 0.5 to 1.5 g kg^{-1} of diet. The feed containing these potential microalgae can provide nutrition and health benefits during the early stages of shrimp and can reduce the disease incidence and opens the new avenues as functional feeds in the early life stages of shrimp.

EFFECT OF DIETARY TAURINE SUPPLEMENTATION IN MILKFISH LARVAE

A 45 days feeding trial with varying level of taurine supplementation in diet of milkfish larvae revealed higher weight gain, specific growth rate, survival and lower feed conversion ratio in taurine supplemented diet. Taurine supplementation helped to increase digestive enzyme activities in the milkfish larvae. Higher intestinal villi length, thickness and reduced gap between the villi were observed at 0.5 and 1.0% taurine supplemented groups. The results indicated that 0.52% taurine supplementation was found to be optimum in diet of *C. chanos* early life stages.

SQUID PROTEIN HYDROLYSATE AS GROWTH PROMOTER IN MILKFISH LARVAE

A six week feeding trial was conducted to study the effect of squid protein hydrolysate (SPH) supplementation on growth and survival of the milkfish larvae. Significantly (p <0.05) higher weight gain, specific growth rate, survival and a better feed conversion ratio was observed in *C. chanos* supplemented with 1.0% SPH.

DETERMINING WEANING WINDOW IN MILKFISH LARVAE CONSIDERING ONTOGENY OF DIGESTIVE ENZYME

Profile of key digestive enzymes viz., trypsin, chymotrypsin, leucine aminopeptidase, lipase, amylase and alkaline phosphatase were assessed during the early ontogeny of milkfish, *C. chanos* (0, 3, 6, 9, 12, 15, 18, 21, 25 and 30 days post-hatch). Most of the enzymes were found to have peak activities at 15 to 21 dph, and can be considered as the developmental window for weaning larvae from live to artificial feeds in milkfish hatcheries.

SOY MEAL REPLACEMENT WITH PLANT PROTEIN SOURCES IN DIETS OF *PENAEUS MONODON* JUVENILE

Shrimp industry was searching for alternative to soy meal to bring down the feed cost. An 8-week feeding trail was conducted to study the effect of soy meal replacement with combination of different plant protein sources (PPS) in specific pathogen free (SPF) *Penaeus monodon* juvenile. The study revealed that the dietary plant protein sources can be incorporated up to 265 g kg-1 by replacing 75% soy meal. The results of the present study provide the baseline scientific information for formulation of cost-effective feeds with alternative plant protein source for tiger shrimp.

DISEASE SURVEILLANCE IN BRACKISHWATER AQUACULTURE FARMS

The disease surveillance carried out during the year 2022 in shrimp farms (N:94), the prevalence of WSD was found to be 3.22%, hepatic microsporidiosis 25.8%, IMN 10.75%, while other OIE–listed diseases were not reported.

STANDARDIZATION OF MOLECULAR DIAGNOSTICS FOR DETECTION OF *SCYLLA SERRATA* REO VIRUS (SsRV)

Two sets of RT-PCR protocol (single

step and nested) with custom designed primers for detection of emerging viral pathogen SsRV in mud crab farming were standardised. This technique can be used as routine disease diagnostic tool for SsRV for screening as a part of biosecurity measures.

IN VIVO TRANSMISSION STUDIES ON SsRV

Challenge experiments carried out in mud crabs via injection, oral and cohabitation routes. It was observed varied clinical signs and mortalities depending on mode of transmission. Experimental studies in shrimp with SsRV infected crab tissue caused intermittent mortalities in injected shrimp and no mortalities by oral challenge. The carrier state was detected in post challenge animals with no obvious gross changes.

ETIOLOGY AND PATHOBIOLOGY BRACKISHWATER ORNAMENTAL FISH DISEASES

A study on diseases affecting the ornamental fishes was carried out. The common diseases identified were vibriosis in *Monodactylus argentius*, viral nervous necrosis in *Etroplus suratensis* and *Argulus* spp. and *Caligus* spp. parasitic infestations in *Scatophagus argus*.

INVESTIGATION ON SHRIMP WHITE FAECES/GUT SYNDROME (WFS/WGS)

It was observed typical clinical symptom with white gut and large-scale size variation in WFS/WGS affected ponds. Such shrimps were found positive for EHP while 60-70% of the asymptomatic shrimps were also found EHP positive. Histopathology analysis showed presence of EHP spores and inclusion bodies in the hepatopancreas. RNA sequencing showed all samples contained picornavirus sequences (similar to Wenzhou shrimp virus 8, WZV8), and, the total number of reads representing picornavirus (and as a proportion of all reads) were higher in samples affected from WFS. 16s amplicon sequencing showed alpha diversity for WFS shrimp was lower than that of healthy shrimp, suggesting that bacterial species richness was reduced in the hepatopancreas of shrimp with symptoms of WFS.

DEVELOPMENT OF THERAPEUTICS FOR EHP CONTROL

Different chemical drugs such as albendazole, nifedipine, verapamil, metronidazole, tinidazole, ketaconazole and natural plant derivatives such as carvocrol and naringenin were evaluated for anti-microsporidian activity. The natural derivative naringenin significantly reduced the EHP load and improved the growth and survival of infected shrimp. Thus, the natural derivative naringenin can be used as therapeutic/ nutraceutical for the treatment and control of EHP.

INVESTIGATION OF VECTORS AND CARRIERS OF *ENTEROCYTOZOON HEPATOPENAEI* IN SHRIMP FARMS

The study observed *Gerrid* sp., *Belostoma* sp. and the mysid shrimp as possible carriers of EHP among aquatic insects, mussel, clam and mysid shrimps screened.

IDENTIFICATION OF SUITABLE *IN VITRO* CELL CULTURE SYSTEM FROM SEABASS

The seabass primary explant culture of muscle, brain, head kidney, spleen, liver and kidney tissue were grown separately in L-15 medium supplemented with fetal bovine serum. The explant culture of muscle and brain tissues established in to a fibroblastic monolayer with 100% confluency in three weeks. The primary cell culture of muscle and brain cells were sub cultured at a ratio of 1:2 to a confluent monolayer of adherent fibroblastic cells in five days were grown up to four passage level. The explant culture of head kidney developed with the proliferation of heterogeneous cells of adherent and non-adherent, both pigmented and non-pigmented, epithelioid round, fibroblastic cells appeared in two weeks, the adherent cells developed into fibroblast monolayer with 100% confluency in four weeks.

IDENTIFICATION OF *STREPTOMYCES GRISEORUBENS* CIBA-NS1 STRAIN, AN ANTAGONISTIC *VIBRIO* IN SHRIMP REARING SYSTEM

Streptomyces griseorubens CIBA-NS1 strain was isolated and identified based on biochemical and morphological characteristics as well as 16SrDNA sequencing. The species was used to study on characterization of antibacterial activity, indicated promising antagonistic activity against *Vibrio campbellii*.

IN VITRO TRANSCRIPTOME PROFILING OF NNV INFECTED ASIAN SEABASS PRIMARY BRAIN CELL CULTURE

Asian seabass primary brain cell culture was established and experimentally infected with NNV. The samples collected at day 0 (before infection), 1 and 3 dpi were subjected to RNA sequencing by Novaseq 6,000 platform (2X150 bp) for 40 million reads. The mapping percentage of cleaned reads to the annotated Asian seabass transcriptome ranged from 67.2 to 69.1. It was observed variance in

differentially expressed (DE) genes at 1 and 3 dpi brain cells compared to uninfected cells. KEGG pathway analysis identified the DE genes of both the groups majorly involved in MAPK signaling pathway. The results offered vital information of novel genes and their molecular mechanism involved in Asian seabass-NNV interaction.

COMPARATIVE EVALUATION OF THE EXPRESSION PROFILE OF IMMUNE-RELATED GENES IN ASIAN SEABASS (*LATES CALCARIFER*) AND MILKFISH (*CHANOS CHANOS*) INFECTED WITH NERVOUS NECROSIS VIRUS (NNV)

Immune gene expression in brain, liver, spleen and kidney tissues due to NNV infection in Asian seabass and milkfish evaluated by experimental infection collected at 1, 3, and 5 days post-infection. The expression profile of immune genes such as Tol3, IL1, IL13, MHC, and CXC exhibited higher expression in the kidney compared to other organs of Asian seabass. Similarly, a higher expression pattern was observed in IL1, IL13, and MHC in the kidney of milkfish, while Tol3 and CXC were highly expressed in the brain. However, the expression of different genes was higher in Asian seabass than milkfish, which could be related to the higher susceptibility of seabass to NNV.

LARVAL MICROBIOME ASSOCIATED WITH PEARSPOT (*ETROPLUS SURATENSIS*) LARVAE REARED IN GREEN AND CLEAR WATER REARING SYSTEMS

The microbiome of pearlspot (*Etroplus suratensis*) larvae reared in green (*Chlorella* spp and *Artemia*) and clear water (*Artemia*) system revealed that Proteobacteria, Planktomycetes, Bacteriodetes, Firmicutes, and Actinobacteria were present in varying ratios, though their relative contributions varied between the two rearing systems. It was seen dominance of F. Vibrionaceae (27%) in clear water reared larvae compared to green water reared larvae (F. Vibrionaceae - <1%) despite feeding with *Artemia* in both the systems. The core bacterial population in pearlspot larvae was distinct with varied proportion of Firmicutes, Bacteriodetes, and Actinobacteria, accounting for nearly 40% of the total bacterial population

VIRULENCE AND DEVELOPMENT OF DIAGNOSTICS AGAINST PATHOGENIC VIBRIOS IN AQUACULTURE

Asian seabass challenged with *Vibrio harveyi* SB1 was found highly virulent. The mortalities ranged 50 to 100% depending upon the dose. Severe muscular degeneration was noticed at the injection site. Eight bacterial isolates viz., *V. campbellii, V. harveyi* and *V. parahaemolyticus* sequenced at PacBio and illumine platform. All the strains had chromosome level genome assembly. *Vibrio harveyi* strain SB1 found to possess plasmid with pathogenicity. Pathogenic *V. campbellii* strains possessed lysogenic phages. Quantitative real time PCR was standardized for diagnosis of *V. harveyi, V. campbellii, V. owensii* and *V. rotiferianus*.

ISOLATION AND IDENTIFICATION OF PARASITIC INFESTATIONS IN BRACKISHWATER CANDIDATE SPECIES

Parasitic infestations in wild and farmed fish species were carried out in Tamil Nadu, Puducherry, Kerala and, Andhra Pradesh. Thirteen major parasitic infestations such as *Argulus* spp., *Caligus* spp., *Lernaea* spp., *Cymothoa* spp., *Lernanthropsis* spp., *Amyloodinium* spp., *Ancyrocephalid, Zeylanicobdella* spp., *Anisakis* sp., *Epistylis* sp., *Zoothamnium* sp., *Microsporidium* sp., and *Octolasmis* spp. were identified morphologically. *Lernaea* sp. and *Caligus minimus* were identified from Asian seabass, *L. calcarifer* and *Etroplus suratensis* by molecular identification based on 28S rDNA and 18S rDNA fragments, respectively.

BIOSAFETY, WITHDRAWAL AND EFFICACY OF LUFENURON (LF) AS AN ANTI-PARASITICIDE IN FISH

Pharmacodynamic study in Asian seabass fingerlings assessed for the safety by oral feeding at different doses revealed that LF was biologically safe up to 10 times the recommended therapeutic dose and three times the treatment duration. Pharmacokinetic studies showed that the level of LF in liver, kidney and muscle reached least by 28th day with limit of quantification (LOQ) of 0.01 ppm. No significant difference was observed in the rate of LF leaching in guar gum and egg albumin coated feeds. Hence, LF can be safely and effectively used as a parasiticide in Asian seabass.

IDENTIFICATION OF *STREPTOMYCES GRISEORUBENS* CIBA-NS1 STRAIN, AN ANTAGONISTIC *VIBRIO* IN SHRIMP REARING SYSTEM

Streptomyces griseorubens CIBA-NS1 strain was isolated and identified based on biochemical and morphological characteristics as well as 16SrDNA sequencing. The study on characterization of antibacterial activity indicated promising antagonistic activity against *Vibrio campbellii*.

WATER QUALITY PARAMETERS AND IONIC PROFILE OF INLAND

SALINE GROUNDWATER

The analysis of inland saline groundwater (ISG) samples from Haryana, Punjab and Rajasthan showed that a greater percentage of samples from Rajasthan fall within the optimal ranges for different ionic and water quality parameters, except for potassium indicating the necessity of mineral supplementation for further expansion of inland shrimp farming.

EFFECT OF SODIUM BISULPHATE TO REDUCE TOTAL ALKALINITY: INVESTIGATIONS ON WATER QUALITY, ANIMAL GROWTH, IMMUNITY AND BIOCHEMICAL PARAMETERS

To reduce total alkalinity (TA), sodium bisulphate is the best option, about 1.3 and 1.6 ppm reduces 1 ppm of TA under 2 and 25 ppt salinity, respectively. The application of sodium bisulphate didn't affect animal survival, water quality and biochemical parameters and the growth rate was high compared to control (high TA) treatments.

CARBON BUDGETING IN *PENAEUS VANNAMEI* CULTURE WITH VARYING STOCKING DENSITY (SD)

Soil accounted for the highest carbon input in low and medium SDs, whereas feed accounted for the highest carbon input in high SD. In terms of carbon output, soil accounts for the highest fraction irrespective of the SD. The unaccounted carbon outputs were highest in low SD and the lowest in high SD. These studies on carbon budgeting helps in understanding the contribution of shrimp farming to global warming.

DEVELOPMENT OF MICROBIAL ENRICHMENTS FOR BIOREMEDIATION OF SULPHIDE AND AMMONIA

The detectable level of H_2S is considered to be toxic and more than one ppm of ammonia causes stress for cultured shrimp. The bacterial enrichments isolated for mitigation of sulphide toxicity were proved to be efficient for sulphide and ammonia removal. The combination of enrichments of chemoautotrophic and heterotrophic bacterial consortia can be developed as a probiotic for effective bioremediation of sulphide and ammonia metabolites in the brackishwater environment.

CHARACTERISATION OF LACTIC ACID BACTERIA AS POTENTIAL GUT AND ENVIRONMENTAL PROBIOTIC

The lactic acid bacterial isolates from *P. vannamei* culture ponds with salinity ranging from 5 to 25 ppt have the potential of gut probiotic by exhibiting the properties of antibacterial activity against shrimp pathogens, excellent auto-aggregative activity and hydrophobicity, besides, as an environmental probiotic for soil and water bioremediation. No antagonist activities among the isolates suggest its use as the potential multiple cocktail gut and environmental probiotic in aquaculture production systems.

ISOLATION OF AMMONIA AND NITRITE OXIDIZING BACTERIA

Ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) isolated from root of French bean (*Phaseolus vulgaris*) was identified as *Sphingobacterium* sp. by 16S rRNA gene sequencing and designated as *Sphingobacterium* sp. SDKRC-13. The isolate was found to be salt-tolerant and the sequence was submitted to NCBI with Accession No. OQ396674. A trial study on juvenile *P. vannamei* shrimp conducted to ascertain the effect of *Sphingobacterium* sp. SDKRC-13 on reduction of ammonia and nitrite showed reduction of the level of nitrites significantly at DOC 15 and 35 and the level of total ammonia nitrogen (TAN) at DOC 35. Based on this study, it can be stated that the particular isolate *Sphingobacterium* sp. SDKRC-13 can act as a good candidate in formulation of water probiotics, which can reduce the level of toxic gases like ammonia and nitrites.

CHARACTERISATION OF SOURCE WATERS AND POND SOILS IN BRACKISHWATER AREAS OF WEST BENGAL

Characterisation of source waters and pond soils in South-24 Parganas district, West Bengal indicated that most of the soils are having the soil texture of clay loam and clay with the optimum pH of 7.5-8.5. A large number of soils were deficient in organic carbon, available nitrogen and available phosphorus. Most of the water samples have a salinity of less than 10 ppt. Overall, all the areas are suitable for brackishwater aquaculture with the recommendation of manuring the soils once a year to increase the fertility status.

SUITABILITY OF MUTTUKADU ESTUARY AND ADYAR CREEK FOR CAGE CULTURE

The water quality of Muttukadu estuary and Adyar creek is influenced by the seasons. The year-round monitoring of water quality suggests a suitable season to start cage/pen culture by the communities in and around the creek to improve their livelihood without affecting environmental sustainability.

THERMAL TOLERANCE OF MILKFISH LIFE STAGES

The study on the thermal tolerance limits of milkfish life stages at the end of 30 day long temperature acclimation trial revealed that based on the lowest temperature coefficient (Q10) values for oxygen consumption and acclimation response ratio (ARR) of larvae, fry, fingerling and stunted yearling, the preferred temperatures are 28°C, 30°C,
30-32°C, and 34°C, respectively.

IDEAL SALINITIES FOR MATURATION, BREEDING AND LARVAL REARING OF BRACKISHWATER CATFISH, *MYSTUS GULIO*, A CLIMATE-RESILIENT FISH

Mystus gulio (Ham.) is a commercially important climate-resilient species for brackishwater aquaculture. The experiment results revealed that though
M. gulio attained sexual maturation and spawned between a salinity of 0-20 ppt, the ideal salinity for broodstock development, breeding and larval rearing is between 0-10 ppt.

EFFECT OF LIPID LEVEL ON AMELIORATION OF TEMPERATURE STRESS IN SHRIMP, *PENAEUS VANNAMEI*

To ameliorate the temperature stress, an experiment was conducted for 45 days with juvenile *P. vannamei* reared in three water temperatures and fed with two diets varying in lipid content. Differential gene expression analysis and metabolic pathways by bioinformatics tools show that higher lipid treatment might up-regulating the metabolic pathways involved in energy metabolisms like pyruvate metabolism, TCA cycle and AMPK signalling pathways, under experimental conditions and potentially ameliorated the temperature stress.

EFFECT OF A SUDDEN SHIFT IN SALINITY ON EHP LOAD IN SHRIMP, *PENAEUS VANNAMEI*

The study on the sudden shifting of shrimp from 25 to 5 and 15 ppt to assess its impact on *Enterocytozoon hepatopenaei* (EHP) load in the hepatopancreas of shrimp revealed that there was a significant increase in EHP copy number at 48 h and 2 weeks post salinity shock in the group reared at 15 ppt compared to 5 ppt.

BUILDING SHRIMP YIELD CLASSIFICATION MODELS

Different machine learning models viz., logistic regression, multilayer perceptron, support vector machines, decision trees and Random forest were applied to classify the aqua farms into low, medium, and high-yielding farms, Based on the accuracies obtained through tenfold cross-validation models and model output parameters, the Random forest model was observed to be best suited for the classification of aqua farms.

CONTRIBUTION OF SHRIMP FARMING TO GLOBAL WARMING POTENTIAL: LIFE CYCLE ASSESSMENT (LCA) APPROACH

LCA was used to quantify and compare environmental impacts associated with *P. vannamei* farming in India, with the system boundaries of the hatchery, feed mill and farming. The global warming potential (GWP) of shrimp hatchery, feed mill and shrimp farming was 331, 704 and 3,230 kgCO_2eq, respectively indicating that farming is the key stage, significantly contributing to GHG emissions. The major hotspot contributing to GWP was the energy use in terms of electricity and diesel.

ALTERNATE MODELS TO DECREASE GLOBAL WARMING POTENTIAL FROM THE SHRIMP FEED MILL

Alternate feed formulations are being developed by replacing fish meal with plant protein sources due to the non-availability and high cost of fish meal. Besides testing these feeds efficiency on shrimp growth parameters, subjected to LCA to estimate global warming potential. The GWP was 704, 660, 651 and 642 kg CO_2eq with FR-0, FR-50, FR-60, and FR-70, respectively indicating the sustainability of feeds replaced with fish meal.

ADAPTATION MEASURES TO CLIMATE CHANGE EVENTS INFLUENCING THE TECHNICAL EFFICIENCY OF SHRIMP FARMERS

To understand whether adaptation strategies followed by farmers to overcome the negative effects of climate change (CC) can help in improving their efficiency, farmer's (n=250, Nellore district, AP) perception of the likelihood, consequence and risk rating of CC events on shrimp aquaculture during the last 10 years along with socio-economics, and adaptation strategies followed was collected. The technical and economic efficiencies of the farmers calculated by including both climatic and socio-economic variables indicated that farmers who had successfully overcome the negative effect of cyclones and floods have increased their efficiency levels.

DRAFT GENOME ASSEMBLY OF MANGROVE RED SNAPPER

The draft assembly of *Lutjanus argentimaculatus* genome is generated which is of 1.04 Gb length in 699 contigs with a N50 length of 12 Mb. The whole genome information will provide a new perspective for the genomics research of *L. argentimaculatus* with potential applications in conservation, management and selective breeding programmes of this species.

OVARIAN STEROIDOGENIC ENZYME GENE EXPRESSION IN *MUGIL CEPHALUS*

Gene transcripts of ovarian steroidogenic enzyme genes were higher in vitellogenic females compared to immature females and exhibited a positive correlation with plasma estrogen levels during maturation in grey mullet.

METABOLIC PATHWAYS ASSOCIATED WITH ACUTE SALINITY AND TEMPERATURE STRESS IN *PENAEUS INDICUS*

Experiments to decipher pathway level associations in *P. indicus* due to acute salinity and temperature stress, highlighted the role of genes encoding for lipid metabolism, stress responses and regulatory mechanisms like phosphomethylethanolamine, 6-phosphogluconate dehydrogenase, cell growth-regulating nucleolar protein, cytochrome P450 and inhibitor of growth proteins during stress.

CHROMOSOME-LEVEL GENOME ASSEMBLY FOR PEARLSPOT

A chromosome-level genome assembly with assembly length of 1.275 Gb and N50 metric of 50.27 Mb in 344 scaffolds was generated for pearlspot. The assembly has 98.9% BUSCO completeness.

INDIGENOUS MICROBIAL BIOMARKERS IN *PENAEUS VANNAMEI*

Through *in silico* meta-analysis, the *Acinetobacter* and *Alteromonas* were identified as potential microbial biomarkers for health and disease states, respectively for *P. vannamei*. The role of sucrose environment and beneficial microbes of the genera namely, *Acinetobacter, Bifidobacterium, Brevundimonas,* and *Lutibacter* for shrimp health is documented.

PEARLSPOT FULL-SIB FAMILIES AND THEIR GROWTH PERFORMANCE: AN INITIATIVE ON SELECTIVE BREEDING

Six pearlspot full-sib families were maintained in cages at MES pond and their growth performance was observed till 360 days post hatch. Mean body weight of the families ranged from 85 to 125 g after 360 dph. Survival ranged from 77 to 95% across families.

STRESS-RELATED GENE EXPRESSION IN *PENAEUS INDICUS*

The gene expression of Carbonic anhydrase (CA), Sodium potassium ATPase (Na^+/K^+-ATPase), Crustin, Pro phenol oxidase (PPO), Peroxinectin, Beta glucan binding protein (BGBP), Super oxide dismutase (SOD) and Hemocyanin were measured by qRT-PCR at low salinity stress (5 ppt) for a period of three weeks. The expression levels of CA, Na^+/K^+-ATPase, PPO and BGBP were observed to be up-regulated.

SOCIAL SCIENCES AND DEVELOPMENT

Disease is the major risk in shrimp farming and Hepatopancreatic Microsporidiosis (HPM) caused by *Enterocytozoon hepatopenaei* (EHP) with production loss up to 45% was a major production risk. It is estimated that shrimp farming offers a crop insurance business potential of ₹750 crores per year with 4% premium. Similarly, the micro credit requirement for shrimp farming was estimated to be ₹13,000 crores per annum, which is being serviced by the informal creditors at higher interest rates at present.

Economic analyses of pond based Asian seabass fish farming comprised of nursery, pre-grow out and grow-out phases as well as in cages were worked out and found profitable in both the systems. The mean technical efficiency of the seabass cage farming was 0.91 which indicated that the farmers were able to produce 91% of the maximum possible production with the given inputs.

Farming system diagrams was prepared using PRA exercises to highlight the fisheries and aquaculture based livelihoods practiced in coastal villages.

Techno-economic assessment of different nursery models practiced by the shrimp farmers indicated that they were efficient in terms of providing quality seed to grow out, facilitated in higher production with more than two crops in a year, risk mitigation and profitable shrimp farming.

Machine learning based Sugeno data aggregation model was found appropriate for the development of wireless senor network based Artificial Intelligence monitoring system for cage aquaculture.

Aquaculture Information System (AIS), a web based application software was developed to store and retrieve information about aqua farmers', their production systems and farming practices.

Sustainable Livelihood Framework analysis showed that adoption of

fish waste to wealth technology positively impacted (26%) the livelihood status of coastal families.

Integrated Multi-trophic Aquaculture (IMTA) utilizing the available natural water resources was identified as an alternative livelihood option for providing employment and income to the coastal villagers.

Under the SCSP, the institute organised awareness campaigns, farmers meetings, hands on trainings and demonstrations on viable brackishwater aquaculture technologies for the welfare of 3098 scheduled caste beneficiaries in seven different locations from Andhra Pradesh, Gujarat, Tamil Nadu and West Bengal states. It includes, eight training programs for 420 beneficiaries; six on-farm trials for 100 beneficiaries with the distribution of farm inputs such as seed, feed, fencing material, cages etc.; five front-line demonstrations for 94 beneficiaries and 14 awareness meetings in different villages involving 2,470 beneficiaries under this program.

Under the Scheduled Tribe Component (STC), on-farm/ on-site demonstrations (170 beneficiaries), hands-on trainings (130 beneficiaries); and awareness camps (835 beneficiaries) on aquaculture and allied technologies were organised in Tamil Nadu, Gujarat, Maharashtra, Odisha, and West Bengal. These developmental interventions provided livelihood upliftment and income generation for tribal communities in a range of ₹0.3 lakhs to ₹11.39 lakhs per cluster.

Introduction

Brackishwater aquaculture is an important food production system in the coastal agro-ecosystem, which utilizes the otherwise unusable coastal waters and land area for fish production. The central Institute of Brackishwater Aquaculture was established in the year 1987 under the Indian Council of Agricultural Research (ICAR) to serve as a nodal agency for the brackishwater aquaculture development in the country. The Headquarters of the Institute is located at Chennai, Tamil Nadu with an experimental field station at Muttukadu (MES), about 30 km south of Chennai. A second experimental farming facility, which spreads around 64 acres in the Muttukadu backwaters, located at Kovalam has been added recently as expansion of the farming infrastructure. The Institute has two Research Centres, one at Kakdwip in West Bengal on the east coast and the other at Navsari in Gujarat on the west coast of India. These centres' main objectives are to cater to the needs of aquaculture development with a regional perspective along the east and west coast of India.

India is one of the major seafood producer and exporter; with shrimp as a major commodity of 8.43 lakh tons cultured in about 1.67 lakh ha area. During 2021-22, the foreign exchange earning of approximates $5.83 billion from frozen shrimp export of 7.28 lakh tons. The brackishwater aquaculture and its ancillary industries support the livelihood of millions of people. Seafood is one of the most traded commodities across the world, and its demand is ever increasing. As most of the capture fisheries are over exploited, the aquaculture is only option to meet the demand. Further, the freshwater resources are scarce and competing with other human needs, brackishwater is the best option to enhance the aquaculture production. It is estimated that from the 1.2 million hectares of available brackishwater area resources, hardly 15 percent is utilized so far. Furthermore, about 8 million hectares of salt affected inland areas available in Punjab, Haryana, Rajasthan and Gujarat belt can also be brought under brackishwater aquaculture. Though shrimp farming will be the spearhead for brackishwater aquaculture development, which is bringing in more than 4 billion USD to the national income every year, the finfish farming also needs to be developed to make aquaculture more resilient. Finfish farming is more sustainable and withstands

many issues such as climate change, diseases and price variations. Diseases continue to be the major production risk in shrimp farming and Hepatic microsporidiosis (EHP), White spot syndrome (WSSV) and Infectious myonecrosis disease (IMNV) were more prevalent in farmed shrimp during the year 2022.

ICAR-CIBA plays significant and crucial role in conducting scientific research for the development of brackishwater aquaculture. Introduction of SPF tiger shrimp for farming is a welcome development and would help in diversification, the results of field performance is encouraging during the year 2022-23 with 74% increase in export of black tiger shrimp. Similarly, Indian white shrimp *Penaeus indicus* also needs to be promoted and selective breeding of the species is a priority. It appears that the domestic consumption of farmed shrimp is in a growing trend and the evolving model of partial harvesting for domestic market.

During 2022, research focus and major efforts were directed to indigenous species, Indian white shrimp and seabass for harnessing their market potential. It is very important to establish farmers' access to insurance and institutional credit facilitated by an insurance scheme that will help the in doubling farmers' income in much faster time frame. ICAR-CIBA is working and responding to the needs of the sector and with convergence to the national policy such as *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) and providing technical inputs to state and central departments. The current research focus and efforts are directed to indigenous species, Indian white shrimp and seabass for harnessing their market potential. We have put in place two important and novel initiatives, such as selective breeding program of Indian white shrimp with the support under PMMSY and developed and shrimp crop insurance product with the collaboration with Oriental Insurance Corporation Ltd and Alliance Insurance Brokers. Inland saline groundwater resources from north-western and western India, practices of shrimp farming have taken a good shape. However, there is a necessity of technological interventions and assessment of farmer-friendly practices for sustainability of this system, diversification with new species and specific best aquaculture practices.

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

The Annual Report is a compendium of comprehensive compilation on progress of ICAR-Central Institute of Brackishwater Aquaculture during the year 2022. It also gives the gist of infrastructural development and other administrative activities carried out during the last year. Adequate information is provided about the events and programs conducted by the institute as per its mandate.

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

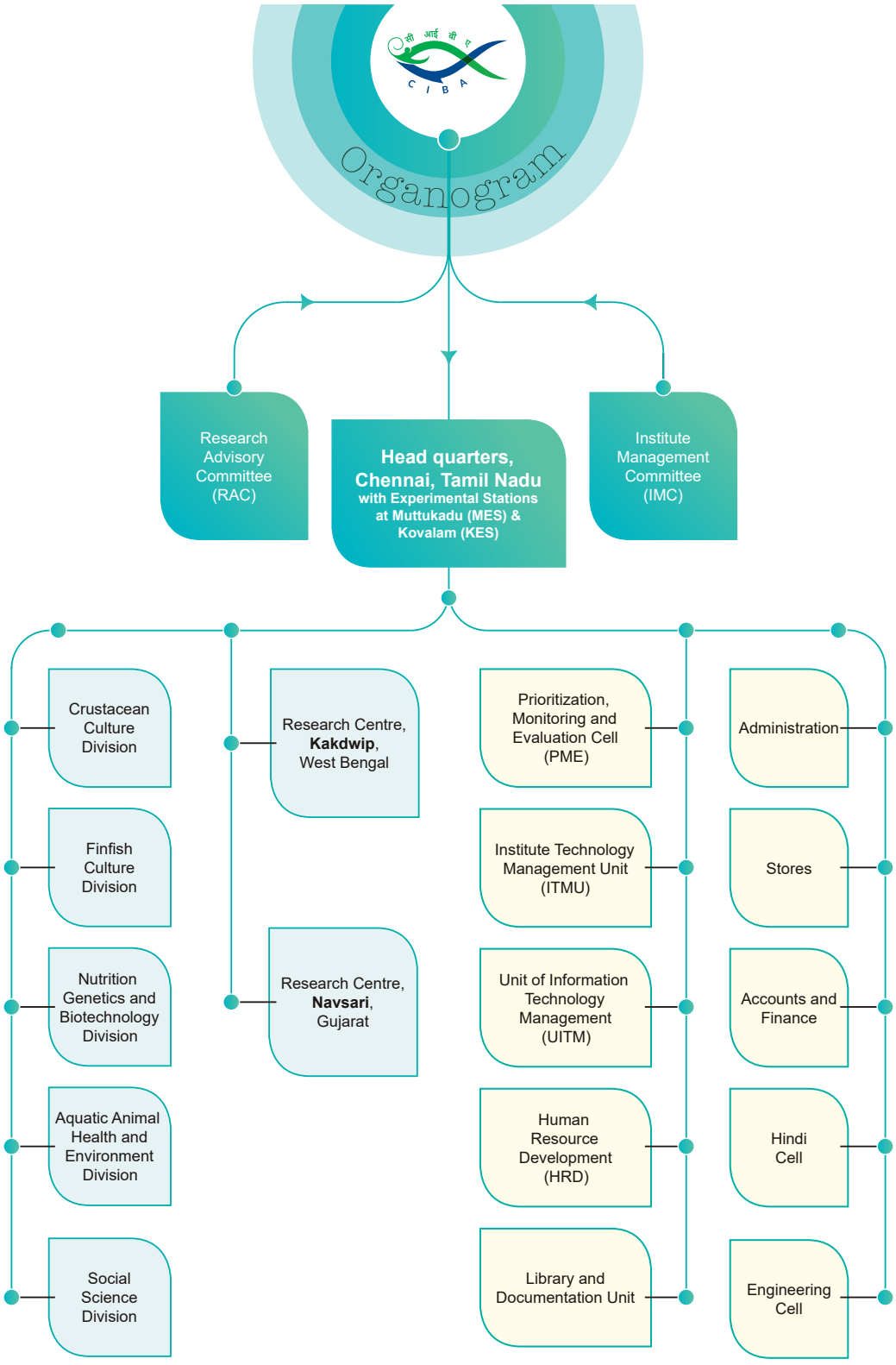
• Basic, strategic and applied research for techno-economically viable and sustainable culture systems for finfish and shellfish in brackishwater.

• 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


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: 2022-23

S. No.	Name of the Head of Account	Unified Budget (₹ in lakhs)		
		RE 2022-23	Expenditure upto 31.03.2023	Closing Balance as on 31.03.2023
1	2	3	4	5
GRANTS FOR CREATION OF CAPITAL ASSETS (CAPITAL)				
1	Works			
	(A) Land			
	(B) Building	91.84	91.84	0.00
	i. Office building			
	ii. Residential building			
	iii. Minor Works			
2	Equipments	46.30	46.30	0.00
3	Information Technonogy	8.51	8.51	0.00
4	Library Books and Journals	2.24	2.24	0.00
5	Vehicles & Vessels	0.00	0.00	0.00
6	Livestock			
7	Furniture & Fixtures	31.11	31.11	0.00
8	Others (TSP)	15.00	15.00	0.00
9	Others (SCSP)	15.00	15.00	0.00
	Total Capital (Grants for creation of Capital Assets)	**210.00**	**210.00**	**0.00**
GRANTS IN AID - SALARIES (REVENUE)				
1	**Estabilishment Expenses**			
	(A) Salaries			
	i. Establishment charges			
	ii. Wages			
	iii. Overtime Allowance			
	(B) Loans & Advances			
	Total -Establishment Expenses (Grants in Aid-Salaries)	**2683.00**	**2683.00**	**0.00**

S. No.	Name of the Head of Account	Unified Budget		
		RE 2022-23	Expenditure upto 31.03.2023	Closing Balance as on 31.03.2023
GRANTS IN AID - GENERAL (REVENUE)				
1	**Pension & Other Retirement Benefits**	**2296.00**	**2296.00**	**0.00**
2	**Traveling Allowances**	**30.87**	**30.87**	**0.00**
	(A) Domestic TA/Transfer TA			
	(B) Forign TA			
	Total - Travelling Allowances	30.87	30.87	0.00
3	**Research & Operational Expenses**			
	(A) Research Expenses	122.90	122.90	0.00
	(B) Operational Expenses	267.63	267.63	0.00
	Total - Res. & Operational Exp.	**390.53**	**390.53**	**0.00**
4	**Administrative Expenses**			
	(A) Infrastructure	208.16	208.16	0.00
	(B) Communication	1.85	1.85	0.00
	(C) Repairs & Maintenance			
	i. Equipments, Vehicles & others	37.79	37.79	0.00
	ii. Office building	32.62	32.62	0.00
	iii. Residential building			
	iv. Minor Works	17.60	17.60	0.00
	(D) Others (excluding TA)	157.80	157.80	0.00
	Total - Administrative Expenses	**455.82**	**455.82**	**0.00**
5	**Miscellaneous Expenses**			
	A. HRD	12.99	12.99	0.00
	B. Other Item (Fellowships, Scholarships etc.)			
	C. Publicity & exhibitions	6.79	6.79	0.00
	D. Guest House - Maintenance	3.00	3.00	0.00
	E. Other Miscellaneous (TSP)	50.00	50.00	0.00
	F. Others (SCSP)	80.00	80.00	0.00
	Total - Misellaneous Expenses	**152.78**	**152.78**	**0.00**
Total Revenue (Grants in Aid-salaries + Grants in Aid - General)		**6009.00**	**6009.00**	**0.00**
GRAND TOTAL (CAPITAL + REVENUE)		**6219.00**	**6219.00**	**0.00**

Staff position

Cadre Strength of CIBA, Chennai as on 31.12.2022			
Position	**Sanctioned**	**Filled**	**Vacant**
Director (R.M.P)	1	1	0
HOD/HoRs/PS	7	0	7
Sr. Scientist	14	7	7
Scientist	52	52	0
Technical Officers/ Technical Assistant	22	17	5
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	4	0
Principal Private Secretary	1	1	0
Private Secretary	2	2	0
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)	29	13	16
TOTAL	**165**	**111**	**54**

Research Projects

IN-HOUSE PROJECTS (Duration: April 2021- March 2024)

Sl. No.	Project Code	Project Title	Principal Investigator	Associated scientists
CRUSTACEAN CULTURE DIVISION				
1	FISHCIBASIL 202100100140	Technology upgradation and optimization of protocols for diversified systems and species of crustaceans through sustainable approaches	Dr. Akshaya Panigrahi	Dr. (Mrs) M. Jayanthi Dr. C.P. Balasubramanian Dr. (Mrs) N. Rekha Dr. S. Kannappan Dr. (Mrs) Shyne Anand Ms. Leesa Priyadarshini Shri. Jose Antony Shri. R. Arvind Dr. N.S. Sudheer Shri. Biju, I. Francis Dr. Vinay T. Nagaraju Dr. K. Ambasankar Dr. T.K. Ghoshal Dr. M. Kumaran Dr. Ezhil Praveena Dr. R. Geetha Dr. Sanjoy Das Mr Pankaj Patil
2	FISHCIBASIL 202100200141	Captive maturation, breeding biology and larviculture of candidate crustacean species for brackishwater aquaculture	Dr. C. P. Balasubramanian	Dr. (Mrs) M. Jayanthi Dr. A. Panigrahi Dr. S. Kannappan Dr. (Mrs) N. Rekha Dr. (Mrs) Shyne Anand Dr. Vinay T. Nagaraju Dr. N.S. Sudheer Shri. Jose Antony Shri. Biju, I.F. Shri. R. Aravind
FINFISH CULTURE DIVISION				
3	FISHCIBASIL 202100300142	Development of hatchery technologies for breeding and seed production of candidate brackishwater finfish species under improved captive rearing systems	Dr. M. Kailasam	Dr. M. Makesh Dr. R. Jayakumar Dr. K.P. Kumaraguru vasagam Dr. T. Senthil Murugan Dr. Krishna Sukumaran Dr. Prem Kumar Dr. Aritra Bera Ms. Babita Mondal Shri. Pankaj Amrut Patil Shri. Tanveer Hussain Shri. Dani Thomas Dr. R. Subburaj

4	FISHCIBASIL 202100400143	Development and demonstration of novel brackishwater finfish farming technologies	Dr. R. Jayakumar	Dr. M. Kailasam Dr. M. Makesh Dr. T. Senthil Murugan Dr. Krishna Sukumaran Dr. Prem Kumar Dr. Aritra Bera Ms. Babita Mandal Shri. Tanveer Hussain Shri. Dani Thomas Shri. Pankaj A. Patil Dr. R. Subburaj
AQUATIC ANIMAL HEALTH & ENVIRONMENT DIVISION				
5	FISHCIBASIL 202100500144	Investigation of existing/ emerging diseases in candidate brackishwater species and development of preventive/ treatment strategies for effective management	Dr. K.P. Jithendran	Dr. M. Poornima Dr. P.K. Patil Dr. S.K. Otta Dr. Sanjoy Das Dr. R. Ananda Raja Dr. P. Ezhil Praveena Dr. Sujeet Kumar Dr. T. Bhuvaneswari Dr. Vidya, Rajendran Dr. T. Sathish Kumar Dr. Leesa Priyadarshini
6	FISHCIBASIL 202100600145	Development of technologies for amelioration of pond soil and water quality in brackishwater aquaculture	Dr. M. Muralidhar	Dr. R. Saraswathy Dr. P. Kumararaja Dr. Satheesha Avunje Dr. A. Nagavel Dr. M. Jayanthi Dr. Aritra Bera Shri. Jose Antony
7	FISHCIBASIL 202200100151	Inland saline aquaculture development in India: Prospects and Challenges (IDP)	Dr. M. Muralidhar	Dr. K.P. Jithendran Dr. M. Jayanthi Dr. C.P. Balasubramanian Dr. M. Kailasam Dr. K. Ambasankar Dr. M. Kumaran Dr. P.K. Patil Dr. K.P. Kumaraguru Vasagam Dr. R. Ananda Raja Dr. P. Kumararaja Dr. Satheesha Avunje Dr. Aritra Bera Shri. K.P. Sandeep Shri. Jose Antony

NUTRITION, GENETICS & BIOTECHNOLOGY DIVISION				
8	FISHCIBASIL 202100700146	Integrating biotechnological and bioinformatics approaches for molecular and genetic characterization of brackishwater fish and shellfish candidate species	Dr. M.S. Shekhar	Dr. Sherly Tomy Dr. B. Sivamani Dr. K. Vinayakumar Shri Ashok Kumar Jangam Dr. J. Raymond Jani Angel Ms. Misha Soman
9	FISHCIBASIL 202100800147	Sustainable aqua feed formulations and feeding approaches for improved growth and health.	Dr. K. Ambasankar	Dr. J. Syama Dayal Dr. T.K. Ghoshal Dr. Debasis De Dr. K. P. Kumaraguru Vasagam Shri. K. P. Sandeep Shri. T. Sivaramakrishnan Dr. N. Lalitha
SOCIAL SCIENCE DIVISION				
10	FISHCIBASIL 202100900148	Communication and socio-economic validation of brackishwater aquaculture technologies for sustainable development	Dr. C.V. Sairam	Dr. T. Ravisankar Dr. B. Shanthi Dr. D. Deboral Vimala Dr. M. Kumaran Dr. P. Mahalakshmi Dr. R. Geetha
CIBA-KRC				
11	FISHCIBASIL 202101100150	Evolving brackishwater aquaculture technologies and its dissemination for livelihood security of Sundarban farmers (IDP)	Dr. Debasis De	Dr. T.K. Ghoshal Dr. Sanjoy Das Dr. Prem Kumar Ms. Babita Mondal Ms. Leesa Priyadarshini Dr. N. S. Sudheer Shri. I. F. Biju Ms. Misha Soman
CIBA-NGRC				
12	FISHCIBASIL 202101000149	Development of sustainable and cost-effective brackish-water farming technologies for shellfish and finfish in the north-west coast (IDP)	Shri. Jose Antony	Shri. Pankaj A. Patil Shri. Tanveer Hussain Dr. M. Kailasam Dr. C. P. Balasubramanian Dr. P. Mahalakshmi Dr. R. Saraswathi Dr. K. Ambasankar

NATIONAL PRIORITY PROJECTS (SPONSORED / PLAN SCHEME)

Sl. No.	Project Code	Project Title	Funding Agency	Collaborative Inter-divisional / Inter institutional	Principal Investigator	Co-PI's	Duration of the Project	Budget Outlay (₹ in Lakhs)
1	FISHCIBACOP 200800300036	Outreach activity on fish feed and Nutrient profiling of brackishwater fish and shrimp	ICAR -CIBA SFC Plan Scheme	Inter institutional	Dr. K. Ambasankar	Dr. J. Syama Dayal Dr. T.K. Ghoshal Dr. Debasis De Dr. Kumaraguru vasagam Shri. K.P .Sandeep Shri. T. Sivaram-akrishnan	Apr. 2021 – Mar. 2023	144.12
2	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 Shri. J. Ashok Kumar Dr. Premkumar Dr. P. Kumararaja Dr. N. Lalitha Dr. R. Geetha Dr. Aritra Bera Dr. Satheesha Avunje Shri. Sathish Kumar Shri. Jose Antony Dr. A. Nagavel	Apr. 2021 – Mar. 2026	40.75
3	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 T. Bhuvaneswari Dr. Vidya Rajendran	Apr. 2021 – Mar. 2026	-
4	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 Mandal Shri. Dani Thomas Shri. Tanveer Hussain	Apr. 2021 – Mar. 2026	-

5	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. M. Shashi Shekhar	Dr. K. Vinaya Kumar Shri. J. Ashok Kumar Dr. Raymond J. Angel Dr. M. Kailasam	Apr. 2021 – Mar. 2026	60.00
6	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 Shri. Ashok Kumar Dr. P. Ezhil Praveena Dr. T. Ravisankar Dr. R. Geetha	Apr. 2021 – Mar. 2026	50.00
7	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)	Shri. Ashok Kumar Jangam	Dr. J. Syama Dayal Dr. M. Shashi Shekhar Dr. K. Vinaya Kumar Shri. K.P. Sandeep Dr. Shyne Anand	Apr. 2021 – Mar. 2026	112.50
8	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. K.P. Jithendran Dr. S.K. Otta Dr. R. Ananda Raja Dr. T. Bhuveneswari Shri. T. Sathish Kumar	Apr. 2022 – Mar. 2025	53.70

9	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. K.P. Jithendran Dr. M. Poornima Dr. P. Ezhil Praveena Dr. Joseph Sahayarajan	Apr. 2022 – Mar. 2025	29.10
10	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
11	FISHCIBASOL 202200800125	Agricultural Drones Project (ADP)	Department of Agriculture & Farmer's Welfare	Inter institutional (Lead: ICAR-ATARI, Hyderabad)	Dr. K. P. Kumaraguru Vasagam	Dr. M. Jayanthi Dr. M. Muralidhar Dr. M. Kumaran Shri. Ashok Kumar Jangam	Aug. 2022 – Aug. 2023	35.00
12	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, Izatnagar	Dr. M. Makesh	Dr. Kailasam Dr. S.K. Otta Shri. T. Sivaramakrishnan Dr. Sujeet Kumar Shri. T. Sathish Kumar Dr. P. Ezhil Praveena Dr. K.P. Jithendran Dr. P.K. Patil Dr. S. Avunje Dr .T.N. Vinay Dr. R. Vidya	Apr. 2022 – Mar. 2026	221.75

EXTERNALLY FUNDED PROJECTS

Sl. No.	Project Code	Project Title	Funding Agency	Collaborative Inter-divisional / Inter institutional	Principal Investigator	Co-PI's	Duration of the Project	Budget Outlay (₹ in Lakhs)
1	FISHCIBASOL 201900300103	Resource Mapping of Brackishwater Aquaculture in Tamil Nadu	Dept. of Fisheries, Tamil Nadu	Inter-divisional	Dr. M. Jayanthi	Dr. M. Muralidhar Shri. J. Ashok Kumar Dr. M. Kailasam	July 2020 – Dec 2022	48.00
2	FISHCIBASOL 202000500108	Brackishwater integrated multi-trophic cage aquaculture of different species, Pearl spot breeding & Crab box culture in diverse rearing systems for alternate livelihood and Societal development of mangrove based fisher folks of Maharashtra	Mangrove Cell, Maharashtra	Inter-divisional	Shri. Pankaj Amrut Patil	Shri. Tanveer Hussain Shri. Jose Antony Dr. M. Kailasam Dr. Krishna Sukumaran Dr. C.P. Balasubramaniyan Dr. P. Mahalakshmi Dr. K. Ambasankar	Oct. 2020 – Dec. 2022	66.50
3	FISHCIBASOL 202100100109	Captive Breeding of Hilsa, *Tenualosa ilisha*: Phase II	NASF	Inter institutional	Dr. Debasis De	Ms. Babita Mandal Mr. Tanveer Hussain Dr. Tapas Kumar Ghoshal	Mar. 2021 – Feb. 2024	169.68
4	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	Inter-divisional	Dr. S. Kannappan	Dr. C.P, Balasubramanian Dr. R. Jayakumar Shri. R. Aravind	Apr. 2022 – Apr. 2024	61.79
5	FISHCIBASOL 202100400112	Solid state fermentation technology for development of cost effective customized plant protein products as fishmeal alternate for shrimp feed	DBT	Inter-divisional	Dr. J. Syama Dayal	Shri. K.P. Sandeep Dr. Sujeet Kumar	Jul. 2021 – Jul. 2024	72.77

6	FISHCIBASOL 202100500113	Unravelling signatures of growth and salinity adaptation in *Etroplus surentensis* through omics approaches	DBT	Inter institutional	Dr. Vinay Kumar Katneni	Dr. K.P. Jithendran Dr. Raymond Jani Angel Dr. M. Shashi Shekhar Shri. Ashok Kumar Jangam Dr. K.P. Kumaraguru Vasagam	Jul. 2021 – Jul. 2024	258.57
7	FISHCIBACOL 202100600114	Diversification of potential crop species in brackishwater aquaculture, adaptation for climate resilience	Indo -UK	Inter-divisional	Dr. K. Ambasankar	Dr. R, Saraswathy Dr. M. Shashi Shekhar Dr. Vinayakumar Dr. Raymond Jani Angel Shri. K.P. Sandeep Shri. T. Sivaramakrishnan	Sep. 2021 – Jun. 2022	50.12
8	FISHCIBACOL 202100700115	Monitoring impacts of physico-chemical characteristics on system generated syndromes of shrimp in a pond environment	Indo -UK	Inter-divisional	Dr. S. K. Otta	Dr. M. Shashi Shekhar Dr. Vinayakumar Dr. P. Ezhil Praveena	Feb. 2022 – Sept. 2022	50.00
9	FISHCIBASOL 202100800116	Precision brackishwater aquaculture using Machine Intelligence	DBT	Inter institutional	Dr. M. Muralidhar	Shri Ashok Kumar Jangam	Nov. 2021 – Nov. 2024	63.80
10	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	Inter-divisional	Shri Pankaj Amrut Patil	Dr. Kumaraguru Vasagam Dr. R. Jayakumar Shri. Tanveer Hussain Shri. Jose Antony	Aug. 2021 – Jul. 2023	45.10-
11	FISHCIBASOL 202200100118	Promotion of Integrated Multi-trophic Aquaculture (IMTA) Technology for income generation and optimum use of bio-resources	DBT	Inter-divisional	Dr. D. Deboral Vimala	Dr. P. Mahalakshmi Dr. T. Senthil Murugan Dr. T. Ravisankar Dr. P. Nila Rekha Dr. M. Kumaran Dr. Kumaraguru Vasagam Dr. S. Kannappan Shri. R. Aravind	Feb. 2022 – Feb. 2024	37.90

12	FISHCIBASOL 202200200119	Development of indigenous shrimp (Indian white shrimp) aquaculture : Genetic improvement Program of *Penaeus indicus*, Phase - I	PMMSY	Inter-divisional	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
13	FISHCIBASOL 202200300120	Novel approaches for disease-free health certification in finfish and development of high health shrimp for sustainable aquaculture	NASF	Inter institutional	Dr. Subhendu Kumar Otta	Dr. Akshaya Panigrahi Dr. P. Ezhil Praveena Dr. T Bhuvaneswari	May 2022 – Apr. 2025	47.2575
14	FISHCIBASOL 202200400121	Establishment of DBT Rural Bioresources Complex at Ramanathapuram District, Tamil Nadu	DBT	Inter institutional	Dr. P. Mahalak-shmi	Mr. K.P. Sandeep Dr. Debasis De	Feb 2022-Feb. 2024	10.15
15	FISHCIBASOL 202200900126	Mapping of salt-affected lands of Rajasthan with potential for saline aquaculture	Government of Rajasthan	Inter divisional	Dr. M. Jayanthi	Dr. M. Muralidhar Dr. M. Kumaran Dr. P.K. Patil Shri. Jose Antony	Oct. 2022 – Mar. 2023	5.00
16	FISHCIBASOL 202201100127	Demonstration of viable farming protocols for indigenous brackish water seaweed species for income generation among coastal folks	NFDB	Inter divisional	Dr. P. Nila Rekha	Dr. R. Jayakumar Shri. R. Aravind	Nov. 2022 – Nov. 2024	22.95

RESEARCH HIGHLIGHTS

BRACKISHWATER PRODUCTION SYSTEM

BRACKISHWATER PRODUCTION SYSTEM

Monoculture of milkfish as a climate resilient species and value addition for marketing

Availability of hatchery produced milkfish *Chanos chanos* seeds created momentum in scientific farming since 2015 in different parts of India. During July 2021, a monoculture trial was initiated in newly established KES-CIBA farm to formulate a cost-effective farming protocol. A pond with a WSA of 1,156 m^2 was renovated and prepared with organic manures. Milkfish fingerlings (20 g ABW, 11.6 cm tl.) were stocked @ 1.5 numbers/m^2 and fed with grow-out feed, Hilsa^{Plus} (Protein 30-35%, Fat 6%) @ 5- 3% of body weight. FCR calculated around 1.38 at the end of the culture period. This culture trial was conducted during pre-monsoon; monsoon and post monsoon period, where the salinity fluctuated 0 ppt to 32 ppt; water depth varied from 60-90 cm. As a climate resilient species milkfish survival rate was 93.7%. After 230 DOC, fishes have grown to average size of 340 g and 35.43 cm tl. Harvested biomass is 478 kg (4.78 t/ha productivity) till 230 DOC. Specific growth rate (SGR) was found to be 1.34 having length weight relationship of Log W= 2.647LogL-1.4801 till 230 DOC with allometric growth.

Initial studies conducted to explore market potential of deboned milkfish and also demand in marine aquariums for live trade, apart from conventional domestic consumption. Deboned the milkfish and found dressing loss is below 20% only. Deboning technique was popularized among two seafood restaurants in Chennai and boneless milkfish dishes received premium price compared to conventional seafood preparation. A total of 55 milkfish with ABW of 300 g live were transported to VGP marine kingdom and ₹4,950 generated from the sale and milkfish has been displayed in

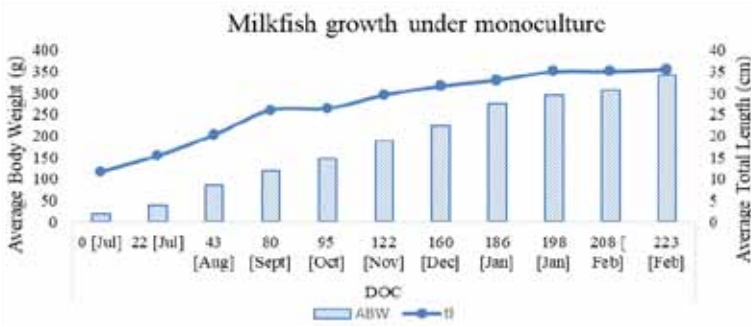


Fig. 1. Milkfish grown under monoculture system

one of the marine ecosystems in their aquarium. Total revenue of ₹65,450 was generated from sale of harvested milkfishes from KES farm.

Refinement of grow-out rearing protocol of hilsa

Experiment was conducted to improve the grow-out rearing protocols for hilsa in the pond based system. Before stocking of hilsa, pond was chlorinated to remove unwanted and predatory fish using 500 kg/ha bleaching powder. After dechlorination, Plankton^{Plus} was applied @ 160 kg/ha. Post 5 days of Plankton^{Plus} application nursery reared hilsa fry (11.23±0.82 g/ 10.40±0.32 cm) were stocked in brackish water pond (0.15 ha) @ 14,000/ha. During culture, pond was fertilized weekly alternate with Plankton^{Plus} (30 kg/ha)

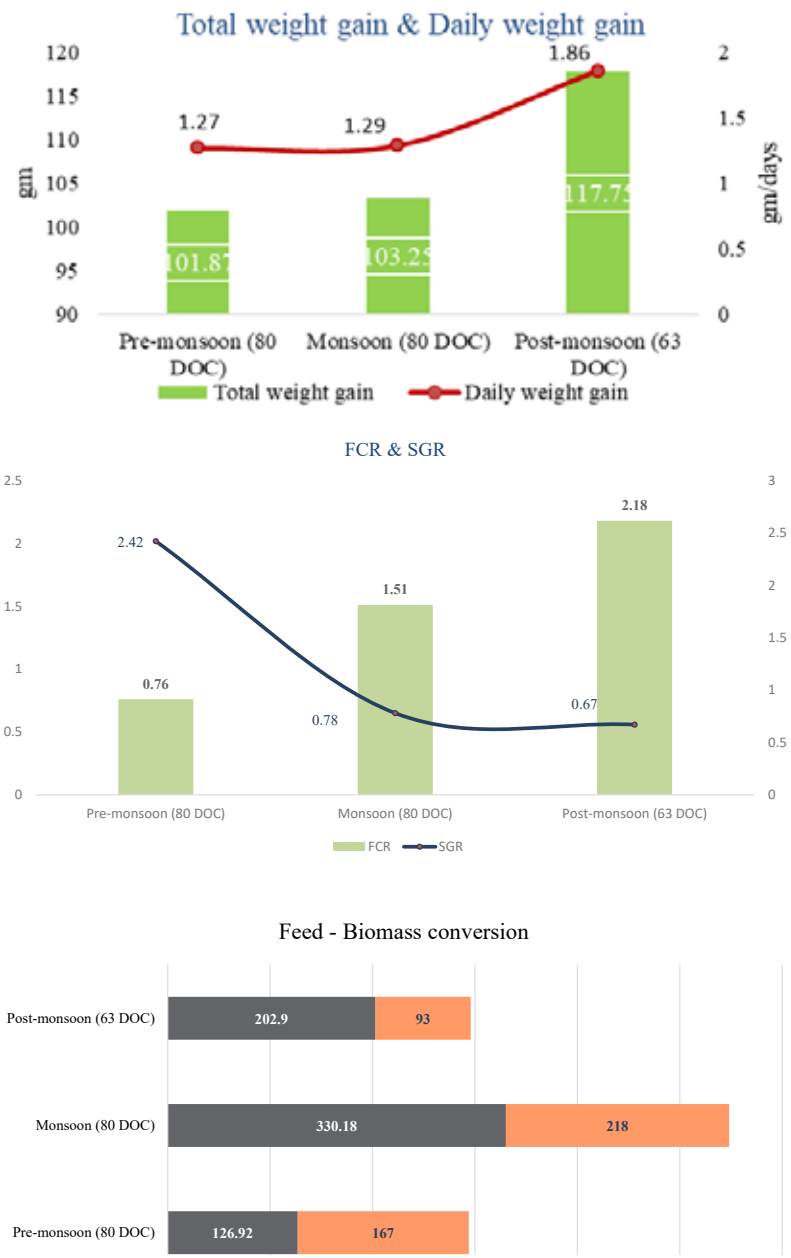


Fig. 2. Weight gain, FCR, SGR and Feed-Biomass conversion of milkfish under monoculture

Fig. 3. Value added products from milkfish

and mustard oil cake (60 kg/ha) to maintain the plankton population. Formulated slow sinking grow-out feed (Hilsa^{Plus}) was offered @ 10-5% body weight. After 184 days, fry gained av. body weight / av. body length of 37.43±7.14 g/16.08±0.7 cm. Plankton diversity indicated that copepod, cladocera and rotifers were major zooplankton in brackishwater grow-out culture pond.

Comparative growth assessment of Liza tade under monoculture and polyculture

Tade mullet *Liza tade* is a

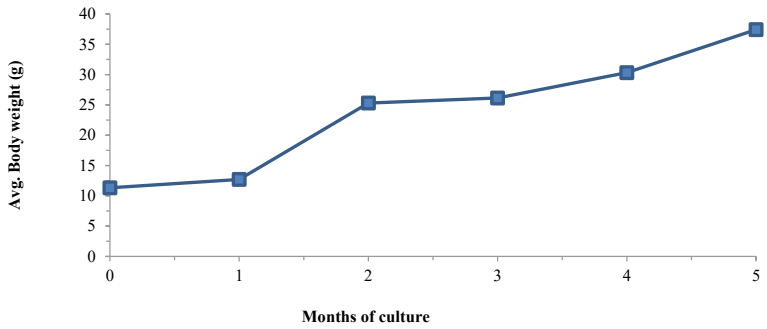


Fig. 4. Growth pattern of hilsa in grow-out pond

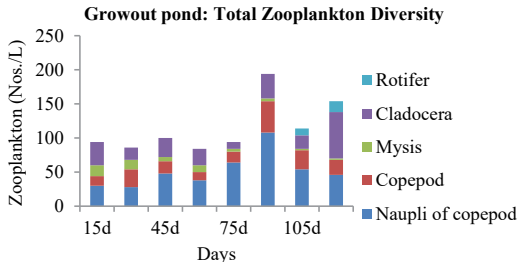


Fig. 5. Plankton profile in hilsa grow-out pond

brackishwater species cultured under traditional polyculture farming systems in West Bengal, India. It has high-quality flesh, good growth rate and wide salinity and temperature tolerance. Available reports on the growth rate of tade mullet are highly variable from farming trials. Hence, a comparative growth assessment study of tade mullet under monoculture and polyculture farming system was initiated in earthen pond of KRC. Tade fingerlings (4.7±0.8 g; 9.5±1.1 cm) were transported from a bhery of North 24 Parganas and stocked with a density 1.42 fingerlings/m^2 in monoculture and polyculture ponds. Milkfish fingerlings (3.9±1.8 g; 7.02±2.5 cm) 2,000 numbers were stocked with tade mullet in polyculture pond. Fishes were fed with floating feed (protein 28-30%, fat 5%) @ 2-3% of body weight.

Fig. 6. Sampling of hilsa reared in grow-out

Fig. 7. Dr. Kuldeep K. Lal, Director, CIBA holding a tade mullet farmed under monoculture system

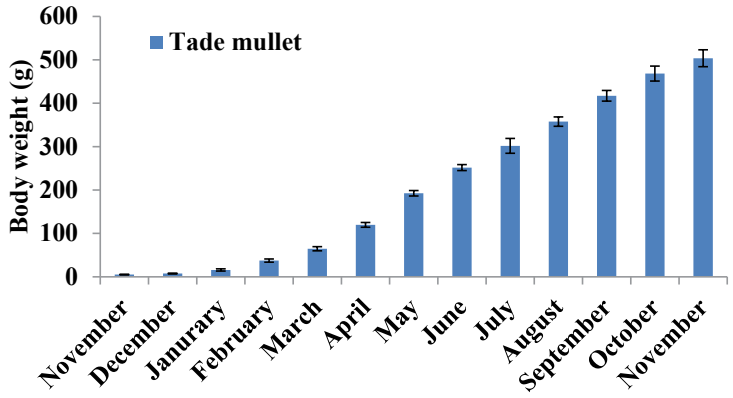


Fig. 8. Monthly growth rate assessment of tade mullet under monoculture

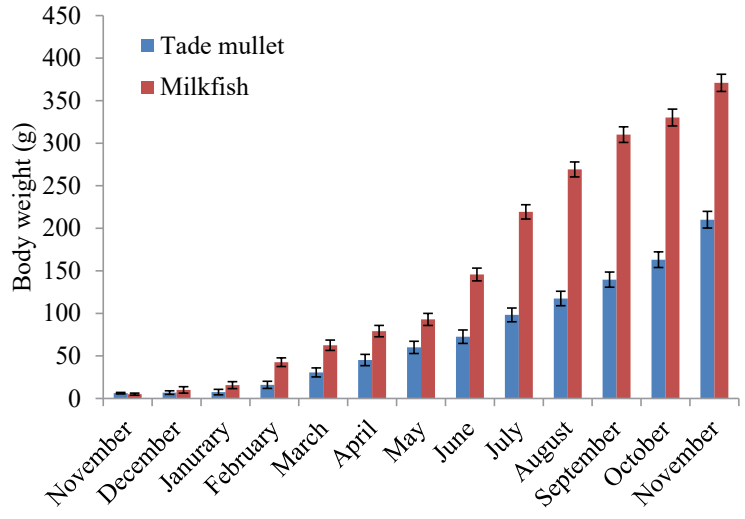


Fig. 9. Growth pattern of tade mullet under polyculture

This culture trial was conducted for one year from November 2021 to October 2022, where salinity ranged from 2–10 ppt. Survival of the tade mullet was recorded 95% and 90% in monoculture and polyculture ponds, respectively. The final harvested average body weight of tade mullet under monoculture and polyculture was 503.67±19.5 g and 210.11±9.8 g respectively; whereas the average body weight of milkfish was 370.95±10.11 g. Specific growth rate (SGR) was recorded at 1.18 for milkfish, 0.97 for tade mullet in polyculture, and 1.27 for tade mullet in monoculture. Overall productivity indicated maximum of 700 kg/ha in monoculture system compared to 500 kg/ha in polyculture system.

Assesement of growth performace of Bengal bream in RAS

Bengal bream, *Acanthopagrus datnia* is an important candidate species for aquaculture due to its high market demand, taste and consumer preference. Current work is conducted to understand the growth potential of *A. datnia*. A total of 100 numbers of *A. datnia* (initial average weight: 8.2 g; initial average length: 72.3 mm) were stocked @ 6 m^2 in recirculatory aquaculture system (RAS) in duplicate and reared for seven months (April-October). Fishes were fed once to the satiation with pelleted feed (32% protein). Except evaporation loss no water was exchanged during the grow-out period. Range of physico-chemical parameters viz. dissolved oxygen (5.5-7.5 ppm), pH (7.5-8.4), salinity (5-7 ppt), hardness (1,400-1,500 ppm), temperature (28-30°C) and total ammonia (0.04-0.17 ppm) were within the acceptable range for brackishwater

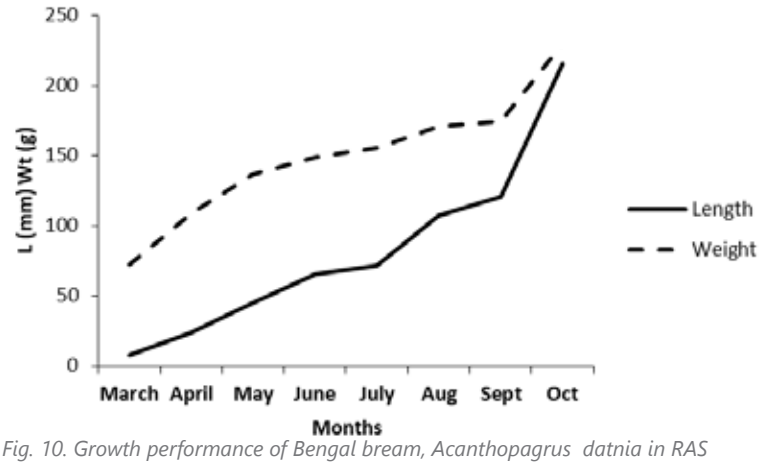


Fig. 10. Growth performance of Bengal bream, Acanthopagrus datnia in RAS

fish rearing. Feed conversion ratio was 1: 1.8. After seven months of rearing, fish attained the weight of 215 g and total length of 230 mm. Overall result showed that *A. datnia* has good farming potential in brackishwaters.

Promotion of live seabass fish sales

To promote seabass marketing and popularizing among restaurants, fish culture division arranged supply of live seabass fish to M/s Thoondil restaurant, Panaiyur, Chennai around 90 kgs of seabass grown in tanks and 40 kgs from cage reared fishes at Kottaikadu. The consumers have the choice to select live fish from display tank and culinary made by them as per their wish got overwhelming response. CIBA supported restaurant for live fish supply, transportation and live fish maintenance in restaurant.

Demonstration of integrated multi-trophic aquaculture (IMTA) in Gad creek as livelihood activity

The NGRC-CIBA developed three IMTA cage culture sites in Gad Creek, Malvan, and Sindhudurg for the demonstration of the IMTA system in low volume cages in brackishwater creek as a livelihood generation activity. Each IMTA SHG member was trained on the importance of timely fish and shrimp feeding, analysis of daily water quality parameters, cage net cleaning, and culture management. For demonstration of an integrated multi-trophic aquaculture system (IMTA) in low volume cages installed in creeks, Asian seabass (700 no.), pearlspot (400 no.) and tiger shrimp (20,000 no.) were stocked at each site in the months of November and December, 2021, respectively, whereas *Kappaphycus* seaweed (20

Fig. 11. Growth performance of Bengal bream, Acanthopagrus datnia in RAS Live fish sale at Kottaikadu village

Fig. 12. IMTA cage culture units at Sindhudurg, Maharashtra

Fig. 13. Harvested seabass, tiger shrimp, green mussels and seaweed from IMTA sites at Sindhudurg, Maharashtra

Species	Stocking size	Density per cage	Harvest size	Total harvest kg (3 cage)	Rate (₹)	Income (₹)
Seabass	30-40 g	700 nos.	340-725 g	560.5	400	2,24,200
Green mussel	3-5 g	50 ropes	25-60 g	820.3	330	2,70,600
Tiger shrimp	PL 14-15	15,000 PL	12.5-20.2 g	353.9	300	1,06,180
Pearlspot	10-15 g	400 nos.	60-100 g	73 kg	270	19,710
Kappaphycus seaweed	100-120 g	20 kg	700-1,300 g	120 (wet) kg	300	3,600
Total (₹)						**6,24,290**

Table 1. Particulars of IMTA cage culture and income generation

kg) and 50 green mussels (150–200 mussels/rope) were stocked at each site. In June 2022, the total stock was harvested and generated revenue of ₹6.24 lakhs.

Demonstrations of low volume cage culture of seabass and pearlspot as an alternative livelihood activity

The NGRC of ICAR-CIBA, in collaboration with the Department of Fisheries, Government of Gujarat has initiated demonstration of cage culture of Asian seabass and pearlspot in brackishwater creeks and ponds as an alternative livelihood activity for coastal fishermen. In 2021, three sites and fishermen's self-help groups (SHGs) were selected in Jafarabad, Shil, and Mendhar villages of Amreli, Junagadh and Navsari districts, respectively. The selected SHG members were trained on cage farming techniques. A total of 8 cages of 4 x 4 x 2 m (32 m^2) dimensions and 4 cages of size 6x4x1.5 m (36 m^2) were fabricated using galvanized iron (GI) pipes (1.5") and installed in creeks at the Jafaradbad and Shil sites and in a pond at the Navsari site, respectively. Seabass fingerlings (20–25 g) were procured from Andhra Pradesh in December 2021 and stocked @ 20, 25, and 30 nos/m^3 and fed with trash fishes @ 5% body weight twice a day. Whereas pearlspot seed (2–3 inches) was stocked @ 70, 80, and 90 no/m^3 in one cage at each site and was

Fig. 14. Seabass and pearlspot cage culture units

Fig. 15. Seabass fingerlings grading by SHGs

fed formulated feed @ 6–8% body weight twice a day. After 60 days culture period seabass attained the body weight of 50–80 g and a survival rate of 70–90%. Pearlspot fish reached a weight of 20–25 g and a survival rate of 90–95%. The culture is in progress.

Brackishwater cage culture in abandoned quarry

Brackishwater aquaculture is gaining momentum in the coastal regions. There is a huge potential to expand the brackishwater aquaculture in the abandoned quarries of inland regions. As an experiment, the abandoned quarry at Kovalam Experimental Station (KES) of ICAR-CIBA was used for nursery and grow-out rearing of brackishwater finfishes in hapa and cages. The quarry being located nearer to the brackishwater lagoon, the water in the quarry had salinity in the range of 6-12 ppt during the culture period. One seabass nursery experiment using hapas and cage culture of seabass and milkfish was conducted to explore the utility of the abandoned quarry water. Seabass fingerlings (body weight (18 g) was stocked @ 200 numbers in a small volume cage (1 m diameter) and @ 1,500 nos in a large circular cage (5 m diameter). Fish could attain 300-400 gram

Fig. 16. A haul of milkfish harvested from the cages installed in the quarry

Fig. 17. The fisher youth with cultured seabass

Fig. 18. Abandoned quarry used for fish culture

body weight with 95% survival at the end of four months. After that the fishes were released into the quarry and this trial could able to show that abandoned quarry can be suitable for cage culture of brackishwater fishes.

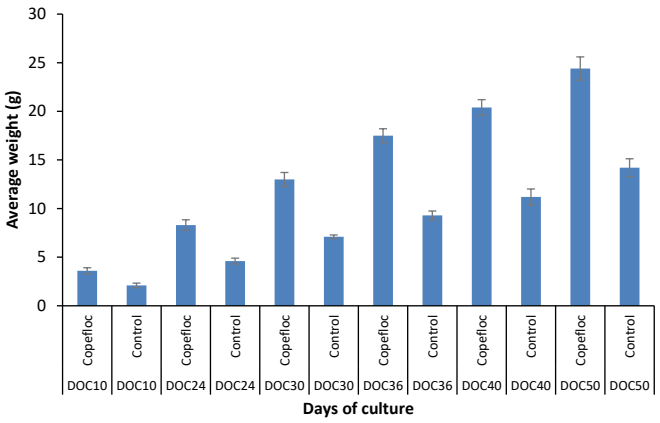
Farming technology of brackishwater catfish, *Mystus gulio*

The long whiskers catfish, *Mystus gulio* (Hamilton, 1822) is commonly called Nona tengra in West Bengal. High nutritional value, market demand, hardy nature, and faster growth make this fish a desirable candidate species for aquaculture diversification. To make *M. gulio* farming profitable and sustainable, the Kakdwip Research Centre (KRC) of ICAR-CIBA has developed a scientific farming methodology for *M. gulio* with hatchery-produced seeds. In this trial, seeds (size range: 40.15-42.50 mm: 0.85-0.86 g) were stocked at a stocking density of 10 and 20 individual/ m^2 and fed with formulated feed developed by KRC of CIBA @ 5-3% of the biomass. In the seven months of rearing including three months of winter, fish attained the size of about 28-32 g with a production of 2.0 t/ha at a stocking density of 20/ m^2. The total cost of production is around ₹90-120 kg^{-1} and it had a ready market of ₹250-300 kg^{-1}, which is economically profitable.

Successful summer crop of *Penaeus vannamei* in lined pond using copefloc technology

Post larvae (PL10) of *P. vannamei* reared in copefloc with a density of 2,500 nos/m^3 found significant difference in growth (an average size of 0.902 g ranges from 0.691 to 1.231 g) and percentage survival (98.1±0.8 %) compare to control

Fig. 19. Haul of harvested M. gulio from KRC pond



tank (Average growth of 0.525 g ranges from 0.421 to 0.715 g) in triplicate for a period of 30 days. Copefloc were generated using filtered fermented juice of rice bran powder, molasses and yeast and inoculated 3 species of copepods namely *Dioithona rigida*, *Pseudodiaptomus annandalei* and *Evansula pygmea*. Copefloc based nursery reduced 20% of supplementary feed than the control. For the grow-out farming, *P. vannamei* stocked in the lined pond of 1,000 m^3 area at a stocking density of 40 nos/m^3 in both copefloc and control ponds reared for 40 days. A total biomass of 440 kg harvested with 91.5% survival with a productivity of 4.4 ton/ha in copefloc treatments which is significantly higher than control. Average size of the harvested shrimp was 24.4±01.2 g compared to control of 14.2±0.92 g on 50th day.

Similar kind of experimental demonstration was conducted using copefloc in an earthen pond for 75 days observed a productivity of 7 tons/ha with an FCR and percentage survival of 1.4 and 85%, respectively. The composition of life stages of copepods in nursery dominated by nauplius during initial days and adult with eggs on later period. Grow-out pond is dominated by beneficial microalgae

Fig. 20. Copefloc reared P. vannamei in lined pond (DOC 50)

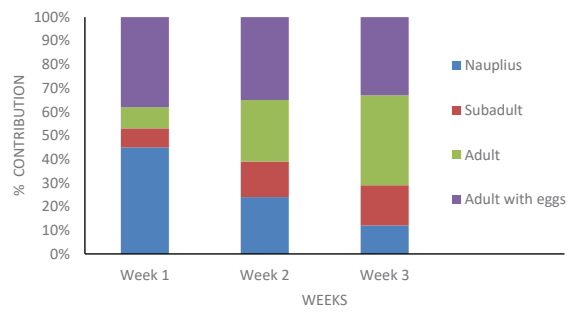


Fig. 21. Percentage contribution of copepod life stages during nursery period

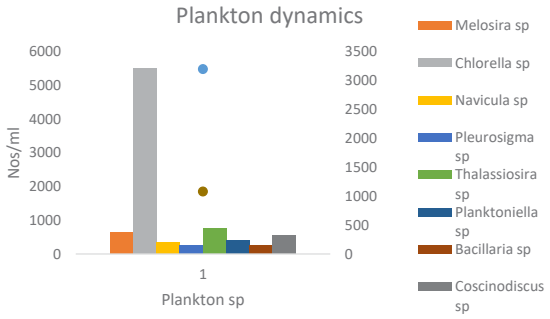


Fig. 22. Dynamics of plankton during grow-out culture period

throughout the culture period. The studies conclude copefloc reared juvenile shrimp shows compensatory growth, significantly higher survival, lower FCR during grow-out culture show the potential of this technology for future growth of shrimp industry.

Evaluation of farm based feed for *Penaeus vannamei* culture for reducing input cost

The experiment was conducted in earthen ponds of 1,500 m^2 area in duplicate with shrimp stocked at a rate of 30/m^2. Farm based feed was formulated and prepared using locally available feed ingredients at the feed mill of KRC, Kakdwip. At the end of 100 days of culture, yielded the growth of 13.85±0.8 g, but with encouraging total production of 1.6 ton/acre. Economic analysis of this pilot scale experiment shows that good returns can be realised from the farm based feed due to the low cost of production of ₹208/kg. Shrimp farming with a target of low count shrimps produced by low-cost inputs is an alternative method for profitability, of small-scale farmers. Such shrimp is possible to market through domestic trade channels. The result from this pilot study shows a path to improve and develop a model for low input and moderate return from shrimp farming by small to medium scale farmers.

Supplementation of potassium and magnesium ions improves growth and survival of whiteleg shrimp, *Penaeus vannamei* post-larvae reared in freshwater

Rearing of whiteleg shrimp *Penaeus vannamei* in freshwater (FW) is an emerging area of interest, whereas little information exists on the suitability of FW (TDS <500 ppm) as a medium to rear marine shrimp. An experiment was performed to evaluate the performance of P. vannamei PL in FW (TDS-367.5 ppm) and compared with FW supplemented with potassium (K1, K2, K3) and magnesium ions (M1, M2, M3) equivalent to reconstituted seawater (SW) of salinity, 1.0, 1.5, and 2.0 ppt, respectively. *P. vannamei* PL19 acclimated to FW was stocked to different treatment groups (30 nos./tank) in triplicate and reared for 30 days. All the shrimp reared in FW died by 28 days. Shrimp reared in freshwater supplemented with potassium equivalent to levels observed in reconstituted seawater of 1.5 and 2.0 ppt resulted in significantly higher survival (K2 & K3: 52.2-52.6%) than the corresponding magnesium supplemented groups (M2 & M3: 33.2-35.4%) and K1 (34.2%), whereas it was similar to M1 (40.2%). FW supplemented with magnesium ions (TDS: 468-615 ppm) resulted in numerically higher growth (0.55-0.70 g) when compared to potassium supplemented groups (TDS: 380-399 ppm; 0.21-0.42 g). The study clearly indicates that FW (TDS <500 ppm) is not a suitable medium to grow *P. vannamei*. Supplementation of potassium in FW, increases the survival rate, whereas adequate growth in FW clearly requires TDS >500 ppm.

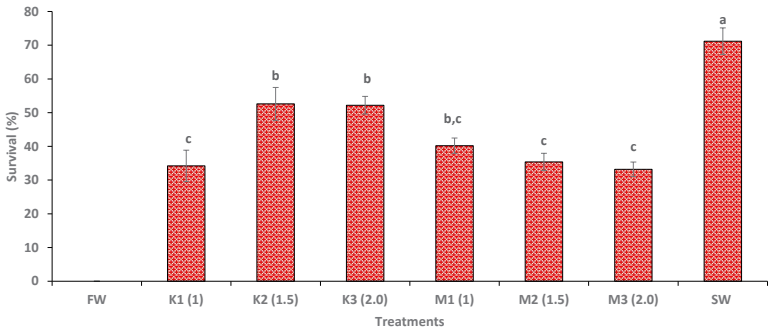


Fig. 23. Survival rate of Penaeus vannamei PL reared in freshwater supplemented with potassium (K1, K2, & K3) and magnesium ions (M1, M2, & M3) at the end of 30 days in comparison to raw freshwater and seawater.

Effects of supplementing equal levels of potassium, magnesium and calcium individually on the growth and survival of *Penaeus vannamei* juveniles reared in freshwater (TDS<500 ppm)

Farming of pacific white shrimp *Penaeus vannamei* in freshwater (FW) is an emerging area of interest given the remarkable osmoregulatory ability of the shrimp. Experimental media were prepared by supplementing FW with potassium (K1, K2, K3), magnesium (M1, M2, M3) and calcium (C1, C2, C3) ions, such that the targeted ion was raised by 5 ppm sequentially to three levels while the other ions remain constant. *Penaeus vannamei* juveniles (ABW~0.48 g) previously acclimated to FW were released to the different treatment media maintained in triplicate at 30 nos./tank and were reared for 30 days. All the shrimp reared in raw FW died by the end of the experiment. Shrimp reared in treatments K3 and M3 wherein potassium and magnesium

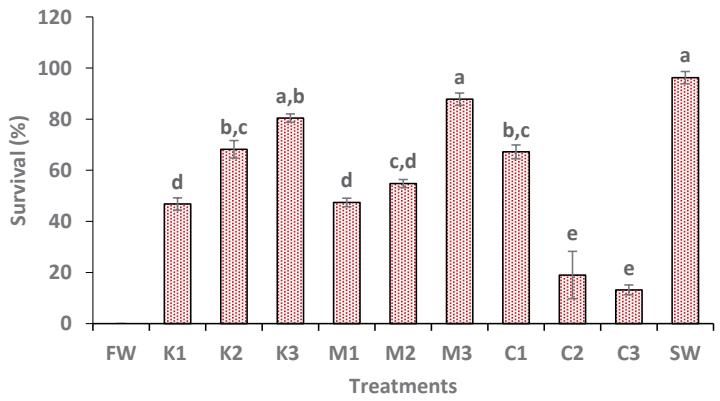


Fig. 24. Survival rate of Penaeus vannamei juveniles reared in freshwater (FW) of TDS < 500 ppm supplemented with potassium (K1, K2, K3), magnesium (M1, M2, M3) and calcium ions (C1, C2, C3) in comparison to ordinary FW and seawater (SW). Different superscript letters on the bars indicate a significant difference at p<0.05.

were increased by 15 ppm from basal levels respectively, resulted in significantly higher survival (80.4-87.8%) and were similar to shrimp reared in SW (96.25%). Overall, survival followed a linear relationship with magnesium (47.4-87.8%) and potassium levels (46.8-80.4%) in FW, whereas an inverse relationship was observed for calcium supplemented (67.2-13.2%). The mean body weight and weight gain (%) at the end of the trial did not vary significantly between the FW treatment groups and was significantly higher for shrimp reared in SW (3.67 g). The study reveals the importance of individual ions and gives a fair idea on minimal ionic requirement for commercial operations.

Production characteristics of *P. vannamei* post-larvae reared in amended inland saline groundwater of varying total hardness

Inland saline groundwater is generally characterised by a higher total hardness than seawater of similar salinity due to greater proportion of calcium and magnesium. Deeper understanding on the effects of total hardness of inland saline groundwater on the growth and survival of shrimp is generally lacking. The present study consisted of seven amended inland saline groundwater (ISW) treatments with varying total hardness i.e., relative hardness of 0.5 (T1), 0.75 (T2), 1.0 (T3), 1.25 (T4), 1.5 (T5), 1.75 (T6) and 2.0 (T7). Salinity of all the treatment media were maintained at 10 ppt with an Mg^{2+}/Ca^{2+} ratio of 1.5:1 and the potassium levels were maintained at 100% equivalent to that of seawater. *Penaeus vannamei* juveniles (0.178 g) previously acclimated to the test media were stocked to tanks at 40 nos./tank in triplicate. At the end of 49 days, shrimp reared in ISW with relative hardness of 1.25 (T4) and 1.50 (T5) resulted in significantly higher survival of 92.5-94.1% as compared to those with relative hardness 0.5 (T1-73.3%), 1.75 (T6-74.1%), and 2.00 (T7-73.3%). Survival rates did not vary significantly between treatments T2, T3, T4 and T5. Mean body weight at the end of the trial was significantly lower in T1 (0.5) as compared to treatments T4 (1.25) and T5 (1.50). The study indicates that ISW of total hardness 1.25 to 1.5 times as that of seawater, results in the best production parameters for *P. vannamei* whereas survival rate decreases when relative hardness exceeds 1.5 and goes below 0.75.

Growth and survival of *P. vannamei* post-larvae in inland saline ground water of varying salinities and ionic parameters

While surveying inland saline groundwater (ISW)-based shrimp

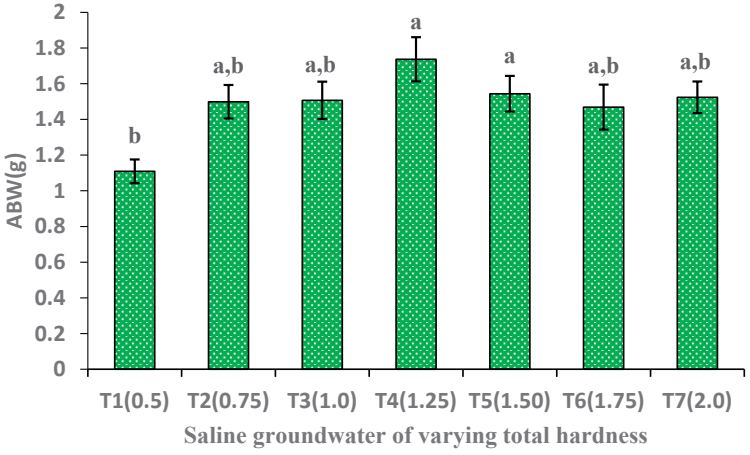


Fig. 25. Final mean body weight of P. vannamei juveniles reared in amended inland saline groundwater test media of varying total hardness at the end of 49 days. Different superscript letters above the bars indicates a significant difference at p<0.05.

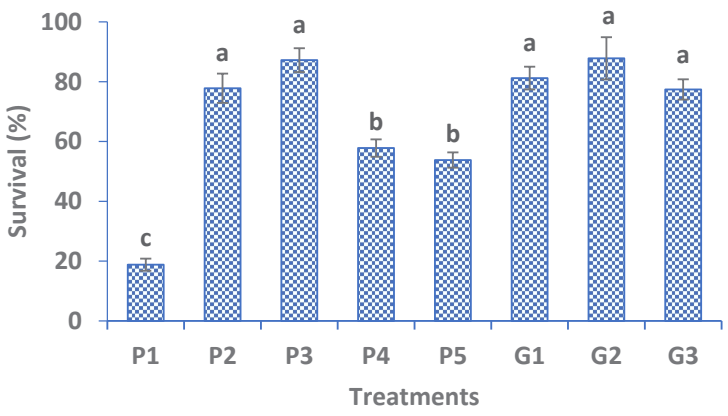


Fig. 26. Survival rate of P. vannamei PL reared in ISW treatment media of varying salinities and ionic parameters at the end of 30 days. Treatments P1, P2, P3, P4, P5, G1, G2, G3 refers to artificially produced ISW test media similar to samples collected from the field. Among the treatments, 'P' refers to ISW samples wherein shrimp were performing poorly in the field and 'G' refers to ISW samples where shrimp performed optimally in the field.

farms in Rajasthan, farms that reported poor and high productivity were identified and the waters were artificially created using IP grade salts. The trial consisted of 8 ISW treatment media i.e., P1 to P5 (waters that reported poor productivity) and G1 to G3 (high productivity). *Penaeus vannamei* PL (0.06 g) previously acclimated to the different salinities were stocked in to different ISW treatment media in triplicate at 35 nos./tank and nursery reared for 30 days. ISW treatment P1 with a relative hardness <0.5 resulted in significantly lower survival (18.8%) and final mean body weight (0.18 g). Treatments P4 and P5 with relative hardness of 1.02 and 0.86 resulted in significantly lower survival (52-55%) and final body weight (0.32 g). ISW test media P1, P4 and P5 resulted in poor production parameters as observed in the field. ISW treatment media P2 and P3 resulted in normal growth and survival as in the case of samples G1 to G3, contrary to field observations. The lower production performance of P2 and P3 in the field conditions may have occurred due to other ions which was not the part of this study or poor management practices followed by the farmer. Superior production performance of ISW treatments G1-G3 were repeated in the indoor trial indicating that ISW treatments with relative hardness of 1.5 resulted in optimum production performance of *P. vannamei*.

Demonstration on use of CIBA-Plankton^{Plus} in shrimp culture in West Bengal

Potential of Plankton^{plus} was demonstrated in farmer's ponds at Charaktala, Bamanagar, Kakdwip, West Bengal. Four ponds each of 1,600 m^2 were taken for demonstration with two treatments, i.e., control without Plankton^{Plus}

Fig. 27. Demonstration site of CIBA-Plankton^{Plus} in shrimp culture in West Bengal

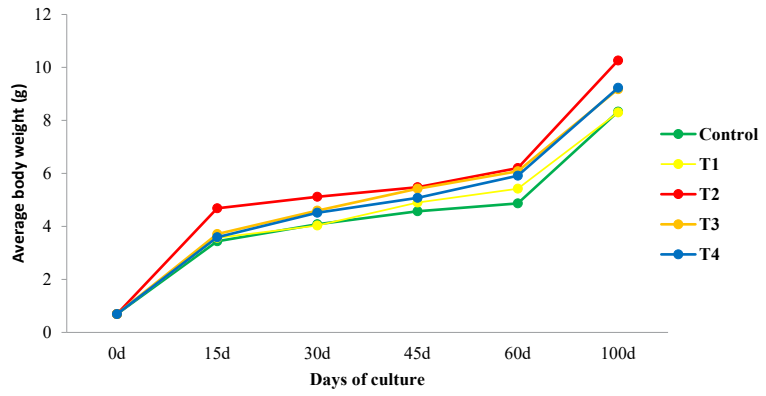


Fig. 28. Growth performance of Penaeus vannamei fed with Ascophyllum nodosum extract in tank system.

application and T1, supplemented with Plankton^{Plus}. Commercial shrimp feed was used for the demonstration. Plankton^{Plus} was used at 40 ppm and shrimps were stocked @ 60 pcs/sq m. After 120 days of culture, average productivity of 11.21 t/ha was achieved with survival of 90.93% when Plankton^{plus} was supplemented compared to control ponds with productivity of 9.63 t/ha and survival of 85.40%.

Effect of *Ascophyllum nodosum* extract on growth performance of *Penaeus vannamei* in tank system

Ascophyllum nodosum extract (ANE) have been explored for their ability to improve plant growth and agricultural productivity. The commercial seaweed extract of *Ascophyllum nodosum*, was used in the present study. The extract was serially diluted to form different concentrations [0.00% (control), 0.10% (T1), 0.01% (T2), 0.001% (T3) and 0.0001% (T4)]. The said dosage was vacuum coated to the commercial shrimp feed having 35% protein for oral delivery through feeding. A 100-day outdoor experiment was conducted to study the potential application of ANE to enhance growth of *P. vannamei*. Nursery reared shrimp (average body weight (ABW): 0.69±0.12 g) were randomly distributed to FRP tanks with 30 numbers per tank. Feed requirement was calculated and the experimental feed was provided 3 times daily at 9 am, 1 pm and at 5 pm for 30 days followed by control diet till the end of the study. The shrimp fed with 0.01% (T2) ANE showed significantly better growth in the tank system. This brown seaweed extract has a potential application in shrimp farming activities.

Effect of stocking density and rearing system on growth performance of speckled shrimp *Metapenaeus monoceros*

The present study was, carried out to evaluate the optimum stocking density and better rearing system for the grow-out culture of *M. monoceros*. A 2 × 3 factorial design was carried out using hatchery-produced juveniles of *M. monoceros* (3.924±0.04 g) using a rearing system as first factor (mixotrophic, biofloc, and control with zero water exchange system) and stocking density as the second factor (30 and 60 no/m^3). At the end of 50 days trial, the highest body weight was recorded in the mixotrophic density system (MxT18: 7.66±0.33 g; MxT9: 7.4±0.32 g), followed by biofloc system (BFT18; 7.39±0.13; BFT9: 6.15±0.3). Similarly, the highest survival (96-100%) was recorded in mixotrophic low and high-density groups, the study revealed that specked shrimp

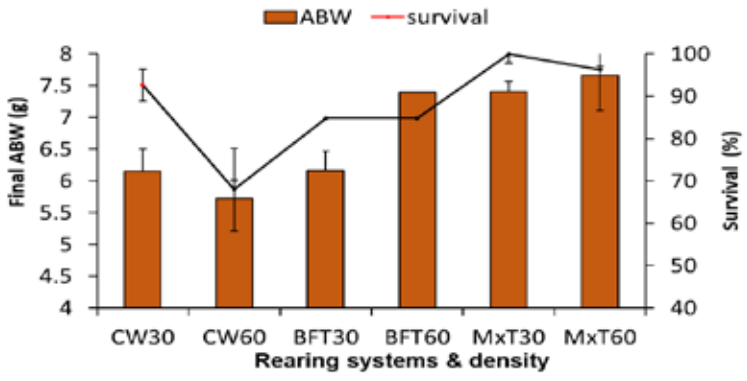


Fig. 29. Final average body weight and survival of Metapenaeus monoceros reared in different rearing system at different stocking densities.

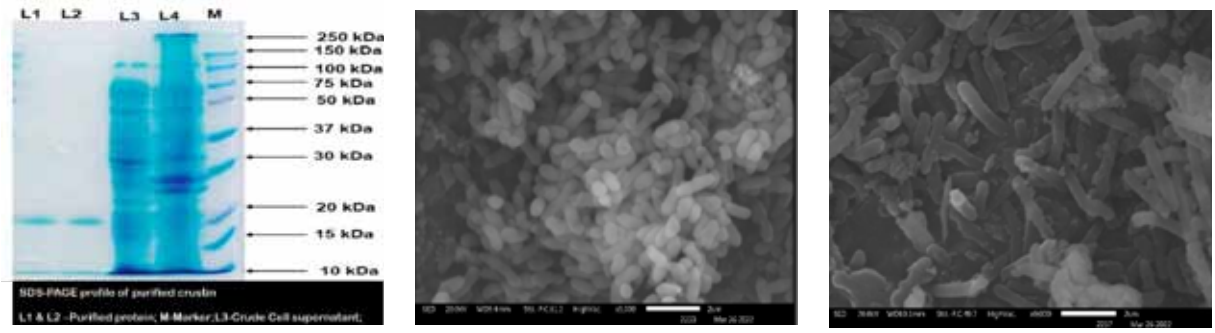


Fig. 30. SDS_PAGE profile of purified crustin and SEM images showing the structural deformity of V. parahaemolyticus cells against AMP treatment.

can be well cultured in mixotrophic and biofloc based units with better growth performance.

Evaluation of therapeutic efficiency of a new antimicrobial peptide against *Vibrio parahaemolyticus* infection

A new antimicrobial peptide showing potential anti-biofilm activity against *V. paraheamolyticus* was characterized. The protein was cloned in pET-21b (+) vector and protein expression was done by using *E. coli* BL21 (DE3) pLysS cells. SEM imaging confers the structural deformity of *V. parahaemolyticus* cells against AMP treatment. The present results suggests that the biofloc technology enhanced the immune system by promoting expression on novel peptide-Crustin, further it will be used as a non-toxic bio therapeutic agent to treat the shrimp diseases.

Carbon sources influencing gut microbes and carbohydrate metabolism

To understand the protein and carbohydrate metabolism, certain digestive enzyme genes were studied with respect to different carbon sources used for biofloc generation like tapioca (T1); rice bran (T2), T3 (wheat flour) and T4 (rice flour) and control. The gene expression was unregulated in the entire treatment group when compared to control group. The prominent enzymes involved in protein and carbohydrate metabolism such as trypsin, chymotrypsin, cathepsin L, cathepsin B, α-amylase, pyruvate kinase, crustacean hyperglycaemic hormone, triacylglycerol lipase, and fatty acid synthase, which help in the digestive process in shrimps. All the enzymes mentioned above showed significant differences in the expression levels. Among treatment, higher fold expression was observed predominantly in T4 followed by T2, T3, and T1 than control. In conclusion, carbon

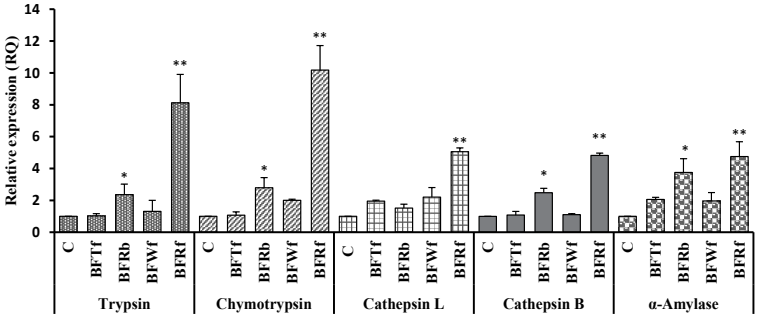


Fig. 31. Comparative mRNA expression levels of Trypsin, Chymotrypsin, Cathepsin L, Cathepsin B and α-Amylase.

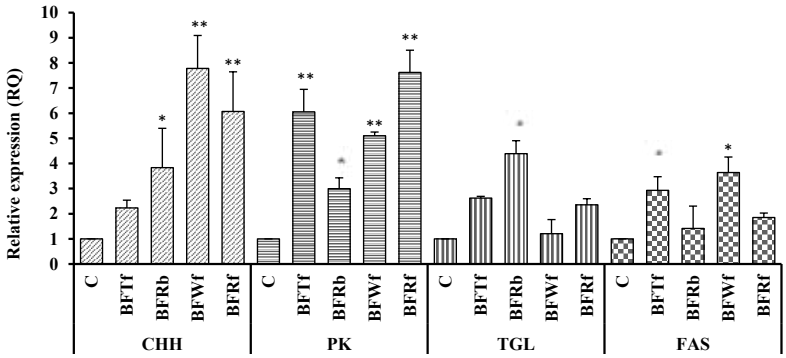


Fig. 32. Comparative mRNA expression levels of carbohydrate and Fatty Acid metabolism-related genes, Crustacean Hyperglycemic hormone (CHH), Pyruvate Kinase (PK), Triacylglycerol lipase (TGL), and Fatty acid Synthase (FAS).

sources can enhance the efficacy of the system by augmenting diverse beneficial microbes, thereby increasing growth performance, immunity, and production

Demonstration of floating and submerged mud crab box culture to SHGs

The NGRC-CIBA demonstrated mud crab box culture in three districts of Maharashtra such as Palghar (500 boxes), Ratnagiri (500 boxes), and Sindhudurg (500 boxes) as a livelihood generation activity for farmers and SHG members. The SHG members were provided hands on training for the technical activities such as designing and fabrication of PVC frame crab box, identification of crab species (green and orange), stocking, feeding, water quality analysis, cleaning of crab boxes and pond management. The SHG members of Palghar and Sindhudurg stocked self-collected wild juveniles of orange crab and green crab and fed with trash fishes @ 3 to 5% body weight twice a day. After 4–8 months of culture, Palghar and Sindhudurg SHGs sold orange crab (size: 380–460 g) and green crab (size: 650–1,275 g) respectively to local crab buyers, and earned an amount of ₹3.28 lakhs.

Artemia biomass production under diverse management and salinity regime

Artemia biomass production in confined system is an emerging

Fig. 33. Floating crab box culture units

Fig. 34. Harvested orange and green mud crabs

Species	Initial size per box	Density per unit	Harvest Size	Total harvest kg (3 cages)	Rate (₹)	Income (₹)
Green mud crab	80-200 g	550 nos.	550-1,275 g	274.12	850	2,33,500
Orange mud crab	50-120 g	800 nos.	300-420 g	237	400	94,800
Total (₹)						**3,28,300**

Table 2. Details of the mud crab stocked in crab box culture and income generation

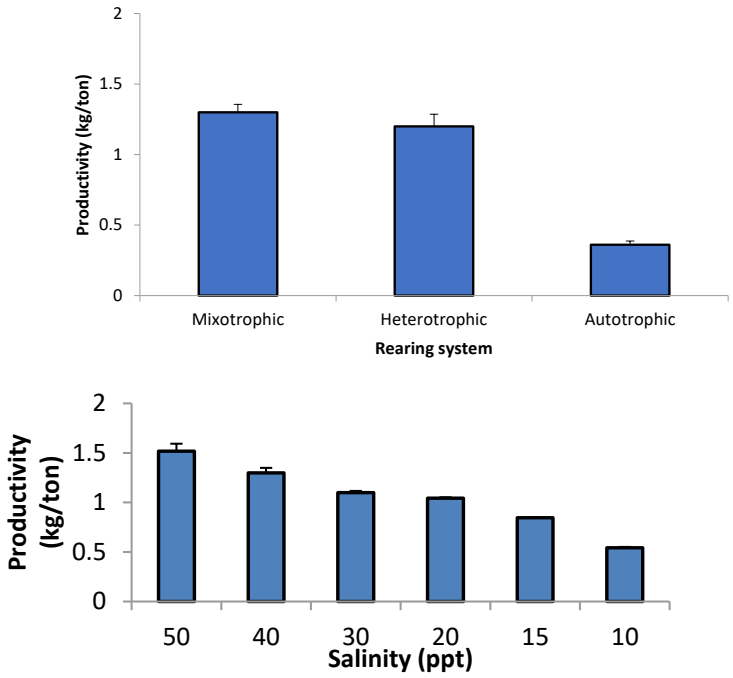


Fig. 35. Total production of Artemia biomass under different dietary management and salinity management regime

live feed industry where live maturation feed can be produced in a biosecured systems with a scope to culture in inland or areas adjacent to hatcheries compared with saltpan ecosystem. Two sets of experiments were carried out to optimize different management regimes in tank based *Artemia* biomass production, and to explore its role as a maturation diet for Indian white shrimp. In trail I, *Artemia* biomass production was carried out in autotrophic (microalgae, T_A), heterotrophic (TH), and mixotrophic (T_{MX}) rearing systems for a period of 18 days in tanks (100 L). In trial II, artemia biomass production was evaluated at diverse salinity regimes (10, 15, 20, 30, 40, and 50 ppt). At the end of Exp 1, significantly higher ($P < 0.05$) yields (1.3±0.95 kg ton^{-1}) were recorded in mixotrophic (T_{MX}) and heterotrophic groups, TH (1.22±0.15 kg ton^{-1}) compared with autotrophic units, T_A (0.360±0.47 kg ton^{-1}). In Exp 2, salinity played a significant variation in Artemia biomass production with the highest ($p<0.05$) productivity (1.51±0.08 kg ton-1) recorded at 50 ppt followed by 40 ppt (1.30±0.051 kg ton^{-1}). The highest percentage of the matured population was recorded at 40 ppt and 30 ppt. Tank-based biosecure production potential of the Artemia model can open new vistas for its wide acceptability as SPF live maturation diet for commercial shrimp hatcheries.

Culture of marine polychaete worm, *Perineris nuntia*

Various sizes of *Perineris nuntia* (6 to 15cm size) were collected from the sandy cum calcareous substrate of the seashore of Maraikkayar Pattinam region of Mandapam area. These worms were transferred in the earthen pots with the wet soil substrate collected from the sampled area. The worms were identified using conventional and PCR methods with cytochrome C oxidase subunit, I (COI) gene (700 bp) by using the primers of polyLCO-HCO (Carr et al., 2011). The worms were analysed for their biochemical composition, particularly protein, fat and fibre (8.07, 3.15 & 0.09% (WWB), respectively. The parameters like pH, electrical conductivity, organic carbon, Total available phosphorous and available nitrogen contents of the soil substrate were also reported as 8.3, 3.408, 0.164, 0.67, 29.12 and 3.75, respectively

Fig. 36. Marine polychaete worm, Perineris nuntia biomass

and compared with the Coastal Aquaculture Authority standards. A total of around 425 juvenile, sand worms (0.28 g of 7.1 cm size) *P. nuntia* were stocked into 17 rectangular tubs of 2.4 sq m area (40 cm × 60 cm area, 25 numbers stocked per tub). They are fed 50 ml of algae *Chaetoceros calcitron* (106/cfu/ml) with 5 g of powdered CIBA shrimp larval feed (1) alternatively in the morning and evening. The worms were grown for 120 days and they reached to the size of 1.1 g average, harvested 374 g with 80% survival.

Gracilaria salicornia culture in brackishwater

Optimum biomass density, salinity, depth of culture and days of culture and for *Gracilaria salicornia* has been standardized using a series of experimental trials in MES and KES shrimp pond. Seaweed seedlings were collected from Ramanathapuram coastal region. The epiphytes and encrusting organisms from the collected algae were removed, and the algae were stored in FRP tank with filtered seawater. Three CRD experiments were conducted of which the first trial is to standardize the optimum initial biomass intensity. Six treatments viz., the initial biomass density of 25 gm^{-2}, 50 gm^{-2}, 75 gm^{-2} , 100 gm^{-2}, 150 gm^{-2} and 200 gm^{-2} in triplicate was done in 100 L tanks for 45 days. Results showed that higher SGR was found in 50 gm^{-2}, followed by 25 gm^{-2} and 75 gm^{-2}. Second CRD experiment is to find the optimum salinity with six treatments of salinity viz., 15 ppt, 20 ppt, 25 ppt, 30 ppt, 35 ppt, 40 ppt in triplicate was done. The result showed a higher SGR in 20 ppt followed by 25 ppt. The third experimental trial is to find the optimum depth at which the culture is to be done. The result

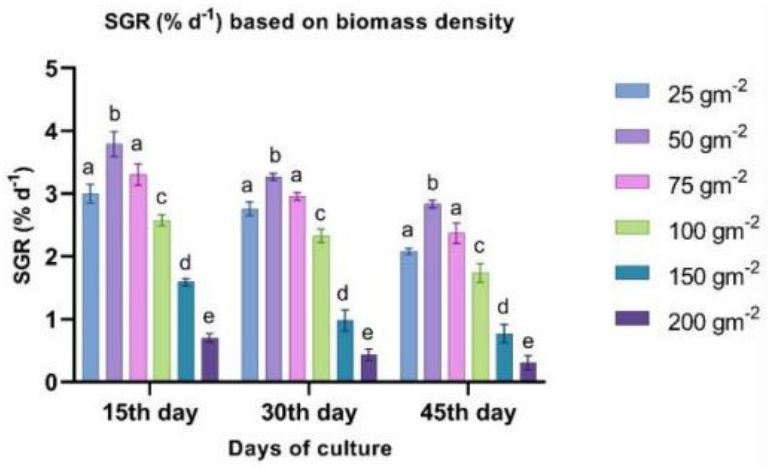


Fig. 37. G. salicornia SGR based on biomass density

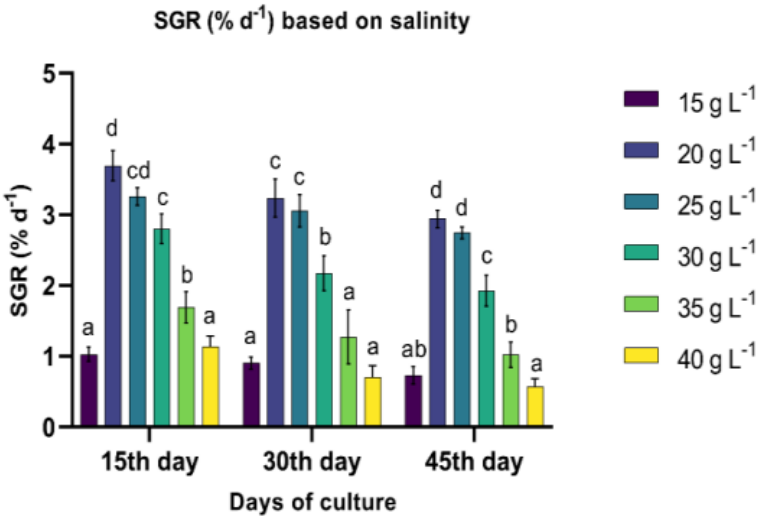


Fig. 38. G. salicornia SGR based on salinity

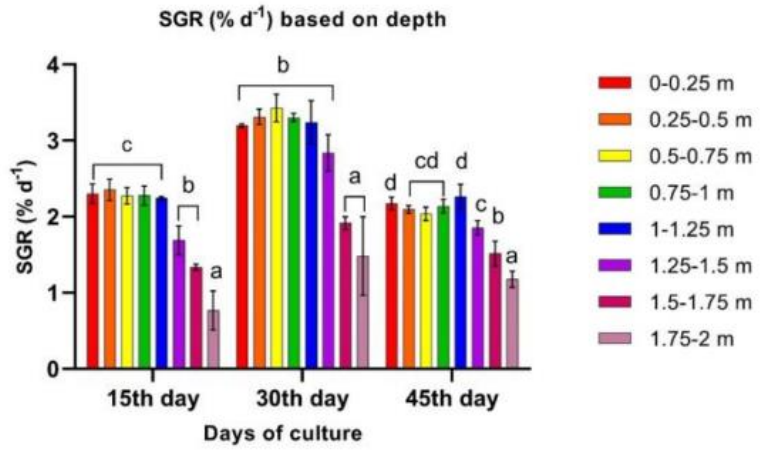


Fig. 39. G. salicornia SGR based on depth

indicates that SGR was higher for 0.5 to 0.75 m. Subsequently, based on this results two pond trials were conducted and the results were validated, further more study is required. Thus study helped to

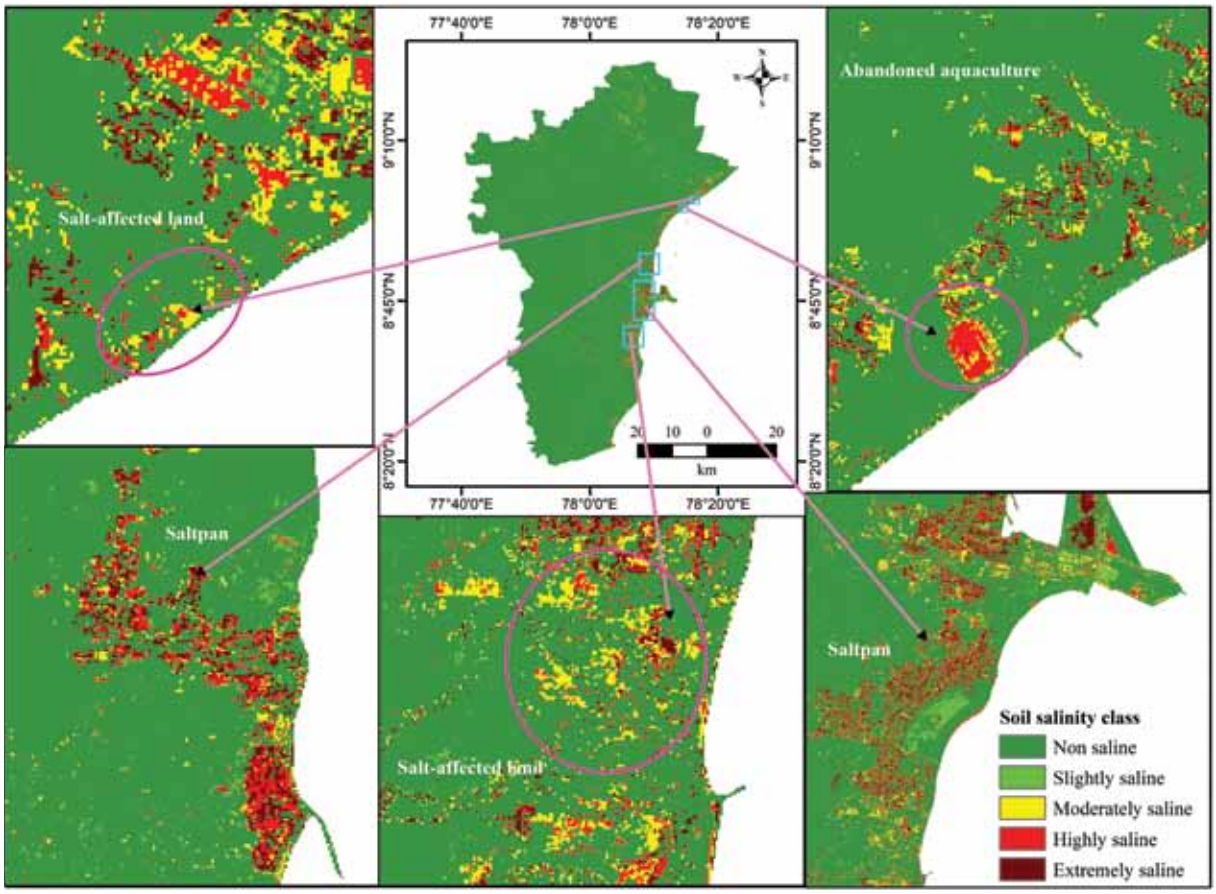


Fig. 40. Salt-affected land of 2020 using Landsat-8 satellite images In Thoothukudi District, Tamil Nadu.

arrive at optimum culture practice for the seaweed species *Gracilaria salicornia* with initial biomass density is 50 gm^{-2}, salinity 20 ppt, depth of culture 0.5 to 0.75 m from surface and the days of culture is 45 days.

Identifying the different levels of soil salinization for aquaculture using machine learning techniques in Google Earth Engine

Assessing salt-affected land (SAL) remains a major challenge worldwide, especially in developing countries due to limited data availability. The development of remote sensing (RS) digital satellite data and their spectral characteristics pave the way to assess soil salinity. A comparative assessment has been carried out between two different spatial resolution satellite images to find out the most suitable satellite image for assessing soil salinity. Sentinel-2 and Landsat-8 data of 2020 were imported from Google Earth Engine (GEE) data catalog. Spectral indices of vegetation (Normalized Difference Vegetation Indices, Enhanced Vegetation Indices, Soil Adjusted Vegetation Indices, Generalized Difference Vegetation Index) and soil salinity (Normalized Difference Salinity Index, Canopy Response Salinity Index, Salinity Index (SI), SI-I, SI-II, SI-III, Salinity index 1 (SI1), SI2, SI3, SI4, SI5) were calculated. The Random Forest model was used for the analysis. Collected soil samples' electrical conductivity values were used to train and validate the model. 70% of the soil samples were used for model training and 30% for validation. The result shows Sentinel-2 is more capable of detecting saline soil regions compared to Landsat-8. Based on 5-fold cross-validation, the overall accuracy of Sentinel-2 and Landsat-8 were assessed as 98.31% and 97.19%. The total SAL area using Landsat-8 and Sentinel-2 were 12,446 ha and 13,225 ha respectively. The study showed the effectiveness of RS techniques to detect the SALs in different spatial resolutions, which can help to evaluate unproductive land and its management at the state or regional level for the creation of alternative livelihood options.

Geospatial database for

shrimp farm

Shrimp farm clusters with individual farms location and the Land Use Land Cover map were prepared using Sentinel 2 satellite image downloaded from https://scihub.copernicus.eu/dhus/ using ArcGIS pro. Existing aquaculture in the study area is about 660 hectares, and the inactive aquaculture farm is about 330 hectares as shown in Fig. 41. Spatial data viz. drainage pattern, soil texture, geomorphology, lithology, Land Use Land Cover (LULC) and socio-economic data viz. size of the pond, species reared, source water, water salinity, the intensity of culture, survey number, village name, owner name, total land area, address and registration number are incorporated into the database.

Suitability assessment of inland saline groundwater resources from north-western India for shrimp farming based on the production performance and water quality variables

Inland shrimp farming in Haryana, Punjab and Rajasthan is growing rapidly and site selection based on water quality variables of saline groundwater is imperative for the overall success of the farming operation. Saline groundwater samples from operational farms growing whiteleg shrimp, *Penaeus vannamei* in the states of Haryana, Rajasthan and Punjab were collected and water quality variables were estimated. The collected saline groundwater samples were further grouped based on the farm productivity data viz., high (yield >3,000 kg/acre; n=79), medium (yield 1,500-3,000 kg/acre; n=37) and low productivity (yield < 500 kg/acre; n=8). Relative hardness varied significantly between the sample groups, wherein highly productive farms demonstrated a mean RH of 1.53±0.03, and the medium and low productive groups indicated mean values of 1.79±0.07 and 0.93±0.07, respectively. Mg^{2+}/Ca^{2+} ratio was significantly higher for the highly productive group (1.48±0.04) as compared to samples with medium productivity (1.20±0.06). Inland saline groundwater with total hardness exceeding seawater diluted to the same salinity up to RH level of approximately 1.5 has been found to improve the growth and production of *P. vannamei*. Source waters with RH exceeding 1.8 have been observed to reduce productivity. Samples with total hardness less than that of seawater of the same salinity i.e., RH <1.0 is not suitable for growing *P. vannamei* and resulted in total mortality to low productivity. The study concludes that the relative hardness of the source water is a principal criterion for the selection of a site and a minimum Mg^{2+}/Ca^{2+}

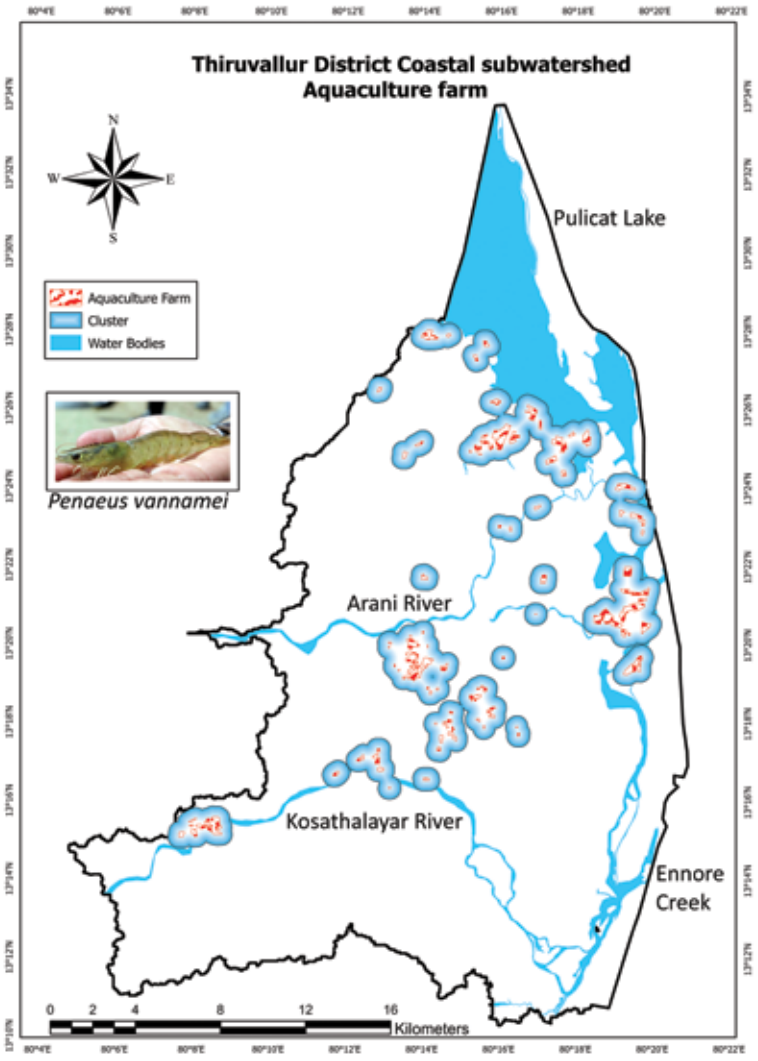


Fig. 41. Shrimp farm clusters in Thiruvallur district

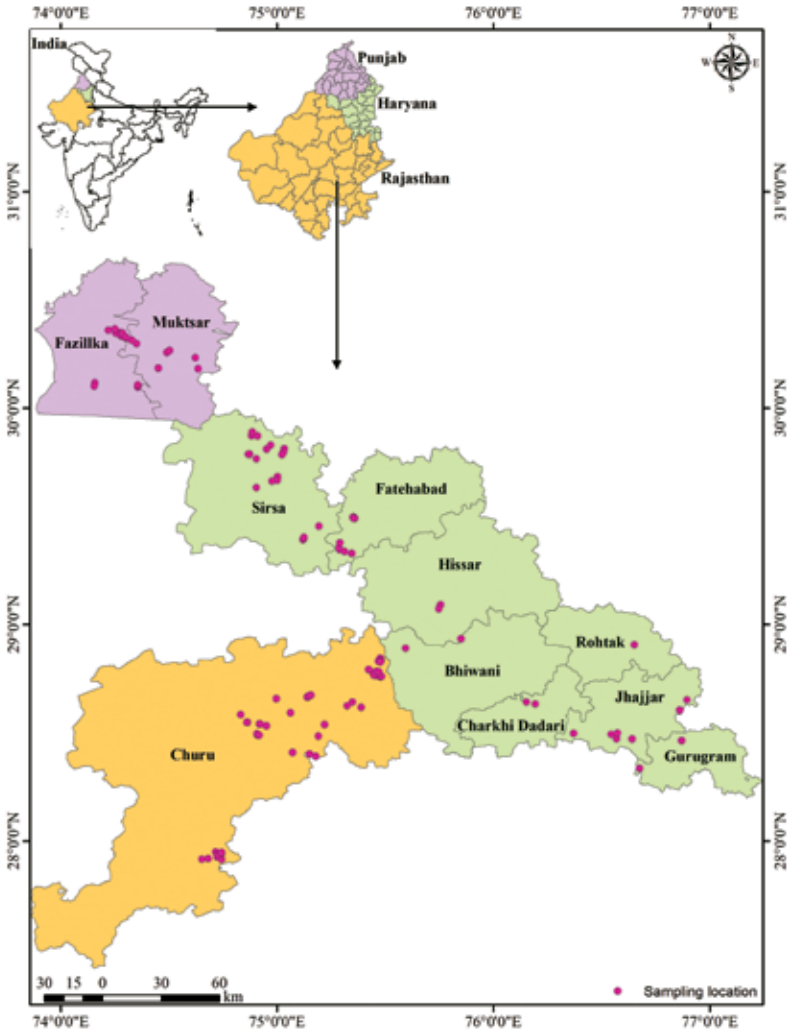


Fig. 42. Sampling sites for assessment of inland groundwater resources from north-western India.

ratio of approximately 1.5:1 to be suitable for rearing *P. vannamei* in inland saline ground waters.

Multi-criteria coastal resources vulnerability assessment using analytic hierarchy process based uncertainty analysis integrated into GIS

Changes in environmental conditions influence vulnerability due to interacting stresses and pressures across the nations and regions. Coastal resources are under severe stress due to climate change, growing trade and commerce, and the human population depends on them. The coastal vulnerability to changing climatic variables has created a major concern at regional, national and global scales. The present model study assessed the coastal vulnerability of the densely populated districts in South India, which are prone to extreme climatic events at a higher frequency. The seven crucial influencing variables that have been selected for the study were sea-level rise, coastal elevation, coastal slope, extreme rainy days, historical shoreline change, tidal range, and geomorphology. The identified variables were ranked by relative importance and linked by weightage using analytical hierarchy process-based uncertainty analysis. Mapped and reclassified variables have been integrated to derive the overall vulnerability using geospatial techniques. The study shows that the coast has experienced high vulnerability to SLR impact,

	Relative Hardness	$Mg^{2}+/Ca^{2}+$ Ratio	Na+/K+ Ratio	Total Alkalinity (ppm)
High Productivity (H)				
H: Yield >3,000 kg/acre	1.5398± 0.0317^{b}	1.4848± 0.0481^{b}	249.24± 22.16^{b}	238.13±6.71^{b}
Medium Productivity (M)				
M: 1,500-3,000 kg/acre	1.7931± 0.0784^{a}	1.2015± 0.0615^{c}	208.60± 39.69^{b}	231.41±14.02^{b}
Low Productivity (L)				
L: < 1,500 kg/acre	0.9385± 0.0743^{c}	1.9424± 0.0516^{a}	422.07± 59.21^{a}	417.81±85.97^{a}
F Statistic	21.0222	13.2998	4.9433	15.7609
p value	< 0.0001	< 0.0001	0.0086	< 0.0001

Table 3. Ionic parameters of inland saline groundwater samples from operational shrimp farms in Haryana, Punjab and Rajasthan (n=130). Values expressed as mean±SE. Different superscript letters within the same column indicate a significant difference at p < 0.05.

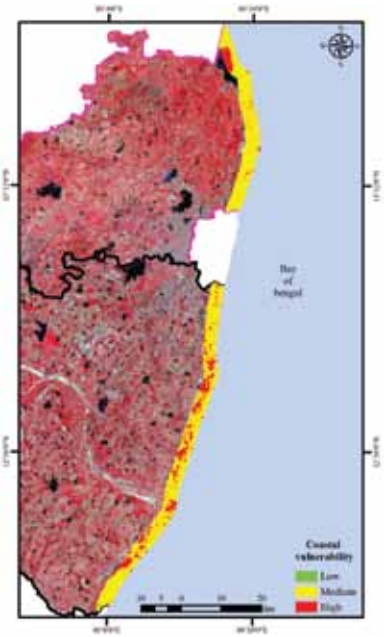


Fig. 43. Overall vulnerability map of coastal districts of North Tamil Nadu, India

extreme rainfall, geomorphology, and elevation; medium vulnerability to the shoreline change and least vulnerable to coastal slope and tidal range. Of the coastal regions studied, 29% and 14.3% had high vulnerability; 70.5% and 85.7% had medium vulnerability in the two selected densely populated districts (Kancheepuram and Tiruvallur districts). Applying geospatial techniques to assess the environmental vulnerability resulted in reliable and informative maps which will serve as a model to determine the critical coastal regions to plan for the conservation and adaptation measures.

Multi-decadal status of water bodies using remote sensing and GIS - a model study in the southeast coast of India

Concerns have been raised about the threat of ecological imbalance due to the loss of water bodies in densely populated areas. The present study explored the changes in water bodies in terms of area, number, and size in northern districts of Tamil Nadu, India, between 1978 and 2018 using satellite data, geographic information system, spatial analysis, ground truth verification, and field validation. The analysis indicated that the water bodies' area has reduced by 3,027 ha and 4,363 ha in the Kancheepuram and Tiruvallur districts, respectively. Almost 179 water bodies have entirely disappeared, and 628 water bodies have been partly converted for other purposes. Of the disappeared water bodies, small, medium, and large water bodies account for 53, 93, and 33, respectively. The main reason for the changes in water bodies was the conversion to agriculture and buildings. Overall, the water bodies' area and number have been reduced by 9% and 12%, respectively, while the population has grown by 37%. The water bodies lost due to anthropogenic activities demand the scientific inventory of water bodies and integrated water resources management at a state or national level with strict monitoring regulations to protect them.

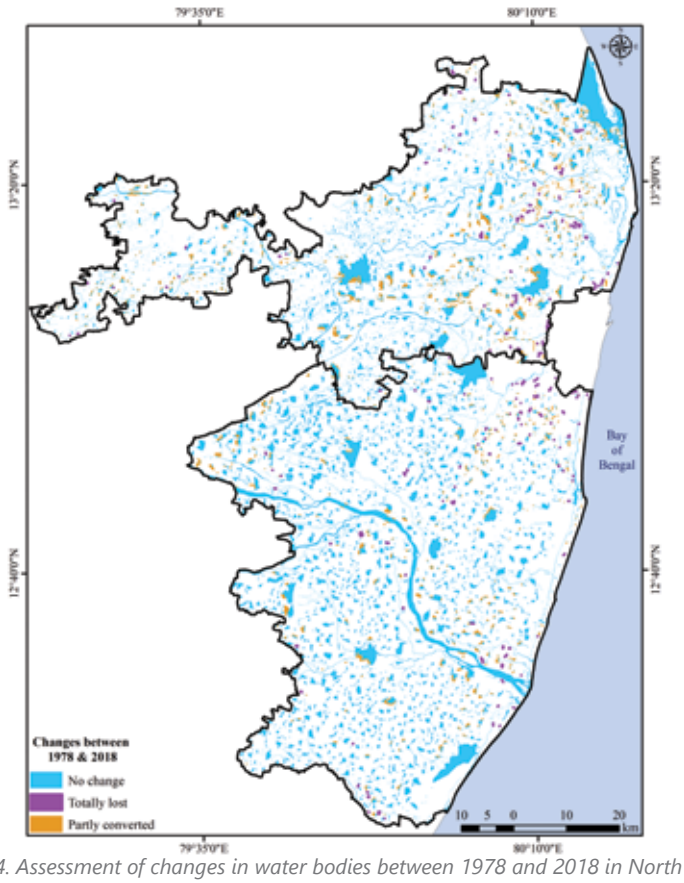


Fig. 44. Assessment of changes in water bodies between 1978 and 2018 in North Tamil Nadu

REPRODUCTION, BREEDING & LARVAL REARING

REPRODUCTION, BREEDING & LARVAL REARING

SALIENT ACHIEVEMENTS

Breakthrough in breeding of gold lined seabream fish

The gold lined seabream fish (*Rhabdosargus sarba*) belongs to Sparidae family is widely preferred food fishes in India, fetches a premium price @ ₹400-500/kg in the domestic market. Being a euryhaline species, *R. sarba* has a better potential for farming both in the ponds and cages. Broodstock development and breeding of *R. sarba* in captivity at finfish hatchery was initiated and about 45 brood fishes in the size ranged from 350 g to 1,800 g have been maintained in the Recirculation Aquaculture System (RAS) and small volume cages for two years since December, 2020.

Mature males in oozing condition and females with developing oocytes were observed from the 1st week of November 2022. During 2nd week of December 2022, female fish (917 g) had an oocyte diameter of 414 µm and two oozing males (907 g & 240 g) were administered with HCG and LHRHa hormones as priming and resolving doses at 24 hrs intervals. After 12 hrs of resolving dose, spontaneous spawning observed on 9th December 2022 and total of 7,000 eggs (878 µm) collected. Fertilization and hatching rates estimated were @ 71% and 40%, respectively. Subsequently, 4 days of batch spawning was observed continuously from the same fish. In total, 5 batches were obtained. The fecundity of those batches of 2nd to 5th was 8,000, 14,000, 13,000 and 6,000, respectively and 5th spawning eggs were unfertilized. The newly hatched larvae measured 1.92 mm in length. The incubation time was estimated as 16 hours at 35 ppt salinity and 25ºC water temperature.

Larval rearing

Newly hatched larvae, averaging 1.96±0.1 mm in total length were

stocked in indoor FRP rectangular larval rearing tanks (LRT) at 10 larvae/L. Green algae, *Chlorella salina* was added to LRTs from day-2 to day-22 after hatching. From the 2nd day evening to day 25 after hatching larvae were fed with rotifers. Rotifers were added to rearing tanks twice daily and enriched six hours before feeding to fish larvae with algae. The density of rotifers at 4-8 individuals/ml was maintained in LRTs for initial 6 days and gradually increased up to 15 individuals/ml for the remaining days. *Artemia* nauplii were supplied as feed from 12 day post hatch and continued upto 25th day@ 0.5-6 nauplii/ml twice daily. Artificial feed were supplied from 19th dph. The larvae metamorphosed to juveniles between 35 and 37 days after hatching. The temperature noticed during the culture period was between 26-27°C±0.5. The salinity was maintained at 35 ppt until 30th dph and then lowered to 30 ppt for the remaining culture period of 40 days. A total of 1,500 early fry could be produced up to 25 days of rearing. Up-scaling the larval rearing is being attempted.

REPRODUCTION, BREEDING AND LARVAL REARING

Asian seabass breeding and seed production

A total of 12 induced spawning trials were undertaken in seabass

Fig. 1. Goldlined seabream brooder

Fig. 2. Fertilized eggs

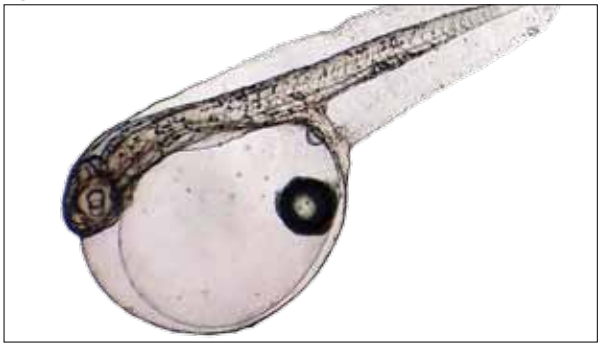


Fig. 3. Newly hatched larvae

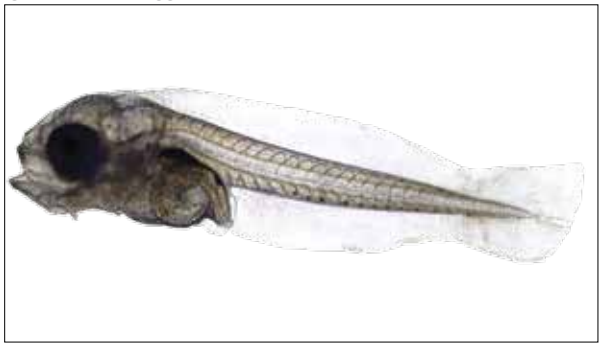


Fig. 4. 10th dph larvae

Fig. 5. 26th dph fry

Fig. 6. Fingerlings of seabream

from January to December 2022 and successful 28 spawning were observed. Apart from the induced breeding trials, four spontaneous spawning could be observed from July to September 2022. A total of 7.08 million eggs obtained from all spawnings, the average fertilization rate was 66% and hatching rate was 73%. A total of 2.8 million eggs were supplied to the private seabass hatchery and 5.15 lakhs fry and fingerling size seed supplied to the farmers and in house projects. A total of 20 farmers benefitted from the seed supply.

Strengthening of seabass broodstock

Pond reared seabass broodstock (17 numbers) in the size range of 2 to 3 kg were procured from Chettipulam village, Vedaranyam taluk, Tamil Nadu and brought to hatchery by road with oxygen support. After quarantine, broodstock fishes were weaned to trash fish and being maintained for breeding trials.

Captive breeding and seed production of mangrove red snapper

A total of ninety broodstock fishes of mangrove red snapper *Lutjanus argentimaculatus* were maintained in two types of fish holding systems such as 100 ton capacity RCC tank (n=30; body weight, 3.5 to 6.2 kg) and 600 m^2 earthen pond (n=60; body weight, 3.2 to 4.5 kg). Both of stocks have attained the maturity during March to October 2022, which is evident from gonadal histology. Significant presence ($p < 0.05$) of spermatozoa and reduced somatic cells were observed in testis which was again confirmed by presence of running milt among males during sampling. Histology of ovary revealed abundant presence post-vitellogenic stages

Fig. 7. Captive matured mangrove red snapper L. argentimaculatus

Fig. 8. Hatchery produced juvenile L. argentimaculatus (180 dph)

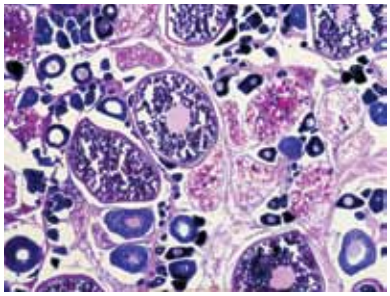


Fig. 9. Ovarian section of red snapper showing presence of post vitellogenic stage (PV), primary yolk globule stage (PYS), cortical alveoli stage (CA) and peri nucleolar (PN) stages

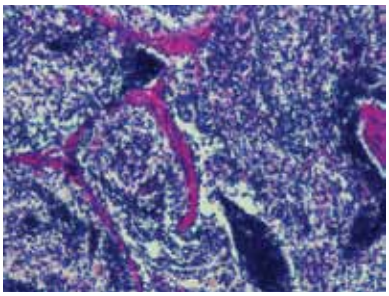


Fig. 10. Testis of red snapper during reproductive season showing abundant spermatozoa (SZ)

(PV) compared to primary yolk globule stage (PYS), cortical alveoli stage (CA) and peri nucleolar (PN) stages. Maturity percentage varied from 35 to 58% during this period and males were dominantly noticed than the females. Matured females having oocyte diameter of above 450 µm and readily oozing males were considered for breeding experiments. A total of six induced breeding experiments conducted using hCG hormone and successful spawning, fertilization and hatching observed in four trials. Larval rearing conducted by feeding with rotifers and copepod nauplii initially and followed by *Artemia* nauplii. After 20th dph, formulated larval diet supplied. A total of 200 juvenile red snapper produced from the hatchery were stocked in the cages for grow out culture. Reduction in larval survival rates were observed at 6th day post-hatch and 11th day post-hatch during rearing. Attempts are being made to develop the mass culture of copepod and optimum size rotifers to upscale the seed production of *L. argentimaculatus*.

The effect of initiation of first feeding on morphological changes, growth and survival of mangrove

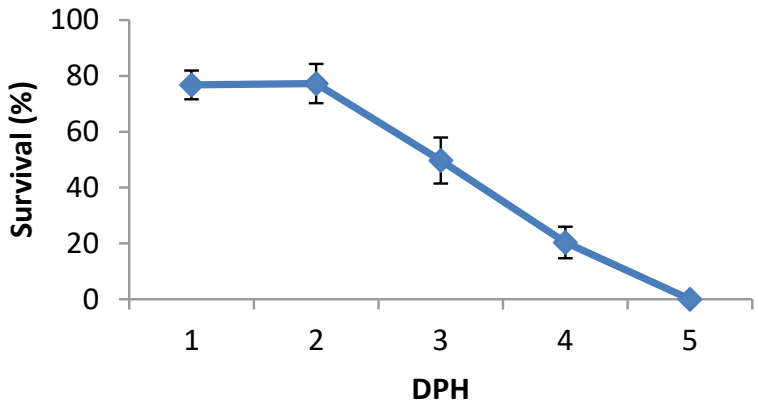


Fig. 11. Survival rate of mangrove red snapper larvae under different feeding time

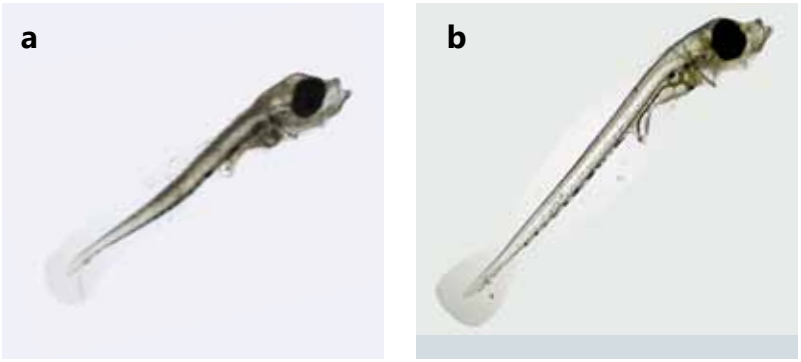


Fig. 12. Effect of feeding on pigmentation pattern and growth a) 5 dph larvae which initiated feeding at 2 dph and b) 5 dph larvae with empty stomach which initiated first feeding at 4 dph

red snapper, *Lutjanus argentimaculatus* larvae

The effects of the initiation of first feeding on the point-of-no-return (PNR) and growth of mangrove red snapper, *Lutjanus argentimaculatus* larvae were studied under controlled conditions. The larvae were exposed to different initial feeding delays. The food was offered for the first time on 1st, 2nd, 3rd, 4th and 5th dph. Larval feeding was done using rotifer in green water system using phytoplankton, *Nanochloropsis occulata*. To evaluate the effect of food deprivation on growth; the standard length, yolk absorption pattern and larval development pattern were observed. Larval growth was significantly affected by the time of first exogenous feeding. The larvae fed from 1st to 2nd dph showed a significantly higher ($p < 0.05$) survival and development than those fed from 3rd dph. The larvae reached the PNR on 3rd dph at a temperature of 28±1°C. Early starvation resulted in serious morphological deformities, growth delay, and high mortality. Survival and larval growth strongly depended on the timing of initial feeding. In order to avoid potential mortality by starvation and to obtain good growth, the mangrove red snapper larvae must establish successful initial feeding within 48 hrs (2nd dph) after hatching. Complete mortality was recorded on 5th dph for the larvae which initiated first feeding at 4th dph.

Domestication of milkfish broodstock and captive seed production

Domestication of fishes is a key requirement for broodstock development activities under sustainable breeding plans. To continue previous years (2015-2021) success in captive seed production, broodstocks of milkfish *Chanos chanos*, are being maintained at two dedicated system i.e. 100 ton RCC tank-based system and lined pond-based system. Total of 38 milkfish broodstock (average body weight: 6.2 kg, total biomass: 238 kg) were stocked equally in two numbers of RCC tanks, each with 100 ton water holding capacity. In addition to the existing stock, eight fishes were newly recruited in another 100 ton water holding capacity RCC tank. RCC tank. They have attained average body weight of 4.5 kg (average total length- 82 cm) from the initial body weight of 1.5-2.5 kg (total length 62-69 cm). Around 190 second line sub-adult milkfishes (body weight 2.0-2.5 kg and age 5-7 years) are being maintained in broodstock pond. Stunted yearlings

Months	Total fish	Oozing male	Vitellogenic female (Oocyte dia. 450 - 720 µm)	Total maturation (%)
March	17	4		23.52
April	22	7	8	68.18
May	22	11	8	81.81
July	21	10	7	80.95
September	20	8	5	65

Table 1. Female ration and maturation percentage in Kakinada groups

Fig. 13. Sub adult of Caranx ignobilis

(250 number) of milkfishes aged between 4.0-4.5 years (body weight: 140-250 g, total length 18-25 cm) are also maintained in 50 ton HDPE tank. Like previous years during 2022 both the populations of milkfishes (Chennai and Kakinada) were implanted with six doses of hormone pellet (combination of GnRHa and 17 α- Methyl Testosterone) during January and October. Kakinada group has showed significantly higher maturation (23.5 to 81.81%) compared to Chennai group (29.4-56.25%). Maturation was estimated with presence of running milt and vitellogenic oocytes having 450–720 µm dia. A total of six spawning (2 Chennai populations, 4 Kakinada populations) was observed in two domesticated population during March to September. Total 12,250 hatchery produced milkfish fry were distributed among farmers from Kerala, Maharashtra, Andhra Pradesh, Orissa, Tamil Nadu, Uttar Pradesh and ₹52,514 revenue generated.

Captive broodstock development of giant trevally

A total of 75 giant trevally, *Caranx ignobilis* are being maintained in earthen ponds and they have attained the size range of 0.75 to 2.5 kg from 0.5 to 1 kg size in 12 months period. Broodstock development of fishes is being continued.

Salinity tolerance of giant trevally and its impact on growth, survival and serum osmolality

Giant trevally, *Caranx ignobilis*, is considered as an important food fish, because of their fast growth rate and economic value. The study was carried out to determine the salinity tolerance of giant trevally, *C. ignobilis* with varying salinity and its impact on growth, survival and serum osmolality. A total of 300 numbers of *C. ignobilis* juveniles (14.23±1.21 g) were stocked in 300 L tanks containing 35 ppt seawater. Later the salinity was reduced by 5 ppt at every 12 hrs intervals to have a final salinity of 5, 15, 25 and 30 ppt with triplicates per salinity treatment. The experiment was carried out for 30 days and the fishes were fed with artificial feed @ 5% of the biomass. At

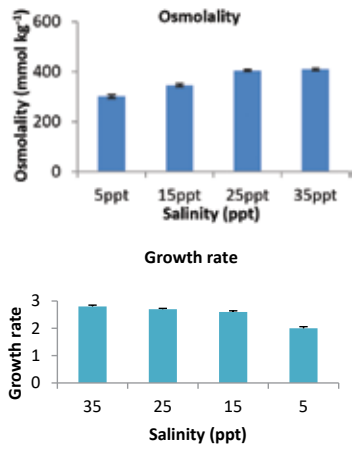


Fig. 14. Serum osmolality and growth performance of Caranx ignobilis

the end of the trial, the serum osmolality significantly varied among the salinity levels. Highest osmolality was in 30 ppt (409±2.8) and lowest in 5 ppt (301±2.4). The mean body weight of fish reared in lower salinity (5 ppt) was varied significantly compared to other higher salinities ($P < 0.05$). Overall, better growth performance was shown by the fishes reared in the higher salinity compared to the lower ones (5 ppt). For the first time, the salinity tolerance of *C. ignobilis* is documented and identified as a potential fast growing food fish for brackishwater farming.

Maturity assessment of pond reared broodstock of grey mullet

Pond based broodstock development of grey mullet *Mugil cephalus* has been initiated at NGRC of ICAR-CIBA farm for seed production. Grey mullet fingerlings (10–15 g) were stocked in the earthen pond (2,400 sq. m) and maintained by feeding with pellet feed (CP: 40%, CF: 10%). After two years of culture from December, 2020 to December 2022 the fishes have attained the weight 700–1,100 g. A total of 300 adult fishes were maintained separately by feeding with 3 to 6 mm pellet feed. Water was exchanged every two weeks based on the tide level of the nearby creek. In the monsoon and summer, pond salinity ranges from 2 to 45 ppt. From September 2022 to December 2022, 60 randomly selected fish were sampled monthly basis to assess their maturity status using the biopsy method. The oocyte diameter ranged between 552.02 and 610.18 µm from the female fish-size ranging from 812 to1,223 g in December (water temperature: 14°C in night and 22.5°C day hours). However, during January 2023 the water temperature was very low (12.3°C in night and 21.8°C day hours) and cannulation biopsy revealed that reabsorption stage of maturity by the presence of yellow fluid or black blood. The study noticed significant

Fig. 15. Pond raised broodstock of grey mullet and gonadal maturity assessment

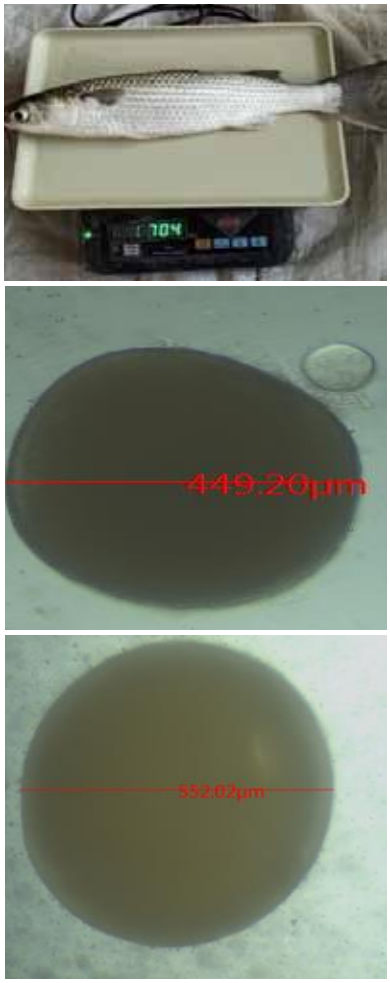


Fig. 16. Pond raised grey mullet broodstock and gonadal biopsy showing different size oocytes

changes in oocyte diameters at monthly intervals and indicates that grey mullet attains maturity in brackishwater ponds with a peak in December.

Nursery rearing trials on Indian salmon *Eleutheronema tetradactylum*

Indian salmon E*leutheronema tetradactylum*, the four finger threadfin is a ray-finned fish of the family Polynemidae which occurs in the Indian and western Pacific Ocean. Aquaculture production of the fish has been reported from Singapore, Taiwan and Thailand. This is an excellent food fish forming a good fishery in India. Presently, there is very little scientific information available on biology, ecology and culture aspects of *E. tetradactylum* from India which is hindering its aquaculture. Wild collected *E. tetradactylum* fry of 1.0 to 1.3 cm size 3,800 numbers were procured from Machilipatnam, Krishna Dt., Andhra Pradesh during August 2022 and acclimatized to the salinity of 25 ppt in FRP tanks. Graded and stocked according to the size. The fry were fed with formulated feeds (crude protein 46% and crude fat 10%) of 0.8 mm and 1.2 mm size at *ad libitum* thrice a day. After 30 days of rearing attained 4.5 cm sizes. Very actively swimming fingerlings could be easily weaned to artificial diets.

Demonstration of pearlspot spawning in floating net cages, seed production and larval rearing in RAS system

Three pearlspot hatcheries were established in the Palghar, Ratnagiri, and Sindhudurg, districts of Maharashtra and demonstrated pearlspot breeding and seed production. Floating net cages used to hold the brood fishes for spawning and tub based RAS facility used for larval rearing and seed production. As a livelihood generation activity, selected SHG members were provided hands on training for various activities, including segregation of male and female brooders, stocking in cages, attaching substrate (clay bowls) for spawning, daily observation for presence of eggs on the clay bowls, collection of eggs, feeding, *Artemia* hatching and feeding to larvae, water quality parameter analysis, record keeping, cleaning, and periodical disinfection of the breeding system. In January to December, 2022, Palghar site SHGs earned ₹2,49,500 through the sale of 20,200 pearlspot fingerlings (1-2 inches) @ ₹12–20 per

Fig. 17. 1.2 cm fry at the time of stocking

Fig. 18. 4.5 cm size fingerlings after rearing 30 days

Fig. 19. RAS based pearlspot seed production hatchery unit

Fig. 20. Pearlspot broodstock feeding and installation of egg substratum

Fig. 21. Pearlspot fertilized eggs on substratum and fry produced in hatchery

fingerling. Whereas, Ratnagiri and Sindhudurg SHGs earned ₹1,81,296 and ₹1,87,600 through the sale of 17,934 and 19,502 pearlspot fingerlings (1 inch) @ ₹10-12 per fingerling, respectively. NGRC of ICAR-CIBA provided technical support to the SHG members to undertake pearlspot breeding and seed production.

Development of low-cost cage based seed production technology of pearlspot to cater to the need of small scale farmers of the Sundarbans region

Pearlspot *Etroplus suratensis* is a euryhaline herbivore fish, popular as a food and ornamental fish. Pearlspot was introduced in West Bengal by ICAR-CIBA through its Kakdwip Research Centre and many farmers have adopted it for polyculture farming. However, farming could not be popularized due to the lack of availability of seeds on a mass scale. Farmers in W.B. have reported natural breeding of pearlspot in the pond. A low-cost, simplified technology for mass-scale seed production is needed to popularize farming. Hence, Bamboo-based low-cost cages (12 x 12 x 8 ft) were designed which can be operational for 2 – 3 years easily. The cage was floated with the help of four numbers of 50 L capacity sealed drums and placed in the pond during February. A total of fifteen pairs (1 male: 1 female) were stocked in the cage. Fifteen mud pots were hung at an equal distance for egg deposition by pairs. Spawning was observed from March to October, with the highest spawning frequency during May and July. Fertilized eggs on

Fig. 22. Hatchery produced pearlspot fry

the substrate were brought to the indoor hatchery for further hatching and incubation. The highest number of hatchlings was produced in June. During eight months of operation, a total of 1,02,247 eggs were produced by using 15 pairs of pearlspot brooders maintained in the cage. From these fertilized eggs, 23,017 pearlspot fry were produced with an average survival rate of 85.5% in the hatchery. This simplified technology can be disseminated to farmers of Sundarbans for mass-scale seed production of pearlspot in the state.

Evaluation of ideal age of pearlspot larvae for outdoor nursery rearing in hapas

Experiments was carried out to shorten the indoor larval rearing

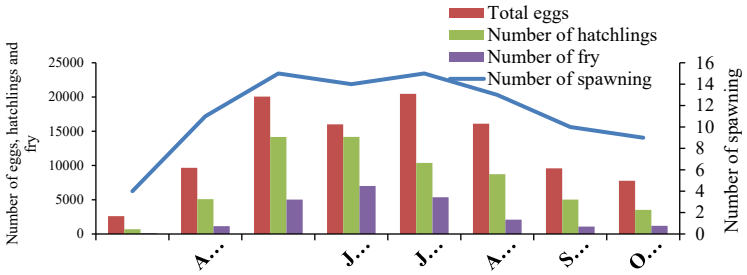


Fig. 23. Number of spawning during eight months in the cage

phase of pearlspot *Etroplus suratensis* and to evaluate ideal age of larvae for outdoor nursery rearing. Pearlspot larvae of different age groups were divided into two groups early stocking (5, 10 and 15 day old) and late stocking (20, 25 & 30 day old). Different age groups of pearlspot larvae stocked in nylon hapas (2×1×1 m) in triplicates installed in brackishwater pond. Larvae were fed with combination of *Artemia* nauplii and artificial larval diet @ 20% body weight in 2 rations. The results revealed that late stocking group (20, 25 & 30 day old) had better survival rate (78-85%), as compared to early stocking groups survival rate (19.86–37.33%). 30 day old pearlspot larvae (16.2±0.12 mm) attained fingerling size (4.12±0.38 cm) in 40 days of rearing in nylon happas with 83% survival rate. From the overall results, it is concluded that 30 day old larvae (16.2±0.12 mm) is ideal for outdoor nursery rearing in nylon hapas to produce fingerlings size.

Broodstock development of hilsa

Wild collected hilsa sub-adults (158.84±12.50 g/ 22.85±0.72 cm) were stocked in 0.15 ha brackishwater pond. Pond was fertilized weekly, alternate with Plankton^{Plus} (30 kg/ha) and mustard oil cake (60 kg/ha) to maintain the plankton population. The plankton abundance and diversity in broodstock ponds revealed that copepoda, cladocera and mysida were the prevalent zooplankton. Formulated feed with CP 42.16% and fat 15.06% was offered @ 5-3%. After 16 months of culture, fish attained av. body weight/ length of 480±54.09 g/ 36.21±1.26 cm.

Tagging of captive broodstock and monitoring of gonadal maturation

To monitor the maturation status of captive reared hilsa, attempts were made to tag the fish with Biomark 8 mm PIT. Tagging was done under anaesthesia. Tagged fishes could recover themselves from the initial trauma within 10-15 minutes of anaesthesia and there were no mortality. USG tests were carried out in brood-stock fishes to understand the proper gonadal maturation status in anaesthetic conditions. GSI of captive broodstock (183.4 g) was 6.49 in the month of September. Oocyte diameter was found to be 427.08±3.24 µm.

Sampling of hilsa broodstock reared in the pond

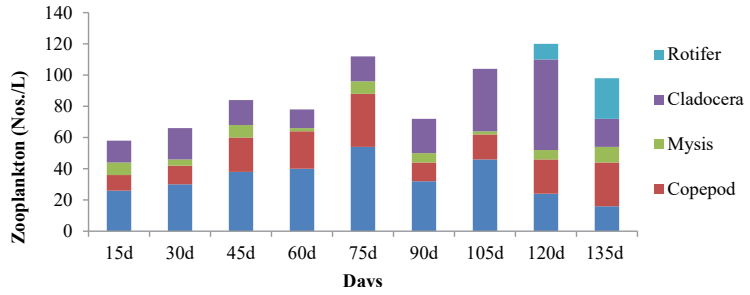


Fig. 25. Plankton diversity and density of broodstock pond

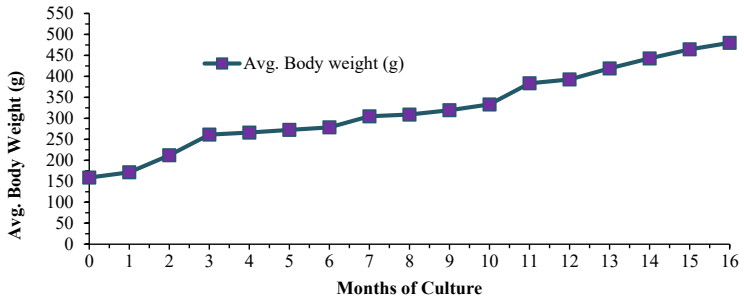


Fig. 26. Weight gain of hilsa reared in broodstock pond

Fig. 27. Pond reared female & male broodstock of hilsa

Artificial breeding of hilsa (*Tenualosa ilisha*)

Artificial breeding of hilsa was conducted on-boat using wild collected broodstock (female 963.4-980 g / 30-47 cm and male 225-258 g / 26.5-32.5 cm) from Hooghly estuary at Godakhali, South 24 Parganas (22°39'N, 88°14'E), West Bengal through dry stripping method and could get success with fertilization of 92±0.94 and hatching rate of 88.78±1.12% in the month of February, 2022. Larvae produced from the trial were stocked in earthen pond after 5 days of hatching for rearing.

Parameters	Range
pH	7.10 - 8.20
Temperature(°C)	16.2 - 31.5
Salinity (ppt)	2.2 - 3.1
Dissolved oxygen (mg/l)	6.4 - 7.2
Alkalinity (ppm)	116 - 160
Total hardness (ppm)	600 - 900
Ammonia (ppm)	0.01 - 0.04
Nitrite (ppm)	0.01 - 0.02

Table 2. Water quality parameters in broodstock pond

Nursery rearing of hilsa

Nursery ponds (30 m^2) were fertilized with three different treatments i.e., mustard oil cake @ 75 ppm (T1), Plankton^{Plus} @ 75 ppm (T2) and combination of both at the ratio of 1:1 (T3) six days prior to stocking of hilsa hatchling. Six days old hatchlings were stocked in rectangular shaped nursery ponds. They were supplemented with formulated feed (CP 34.54% and Fat 12.10%) twice in a day with feeding rate of 50 g/nursery

Fig. 28. Tagging of hilsa broodstock

Fig. 29. Dorsal tag position in hilsa

Fig. 30. Ventral tag position in fish

Fig. 31. Assessment of gonadal maturity using USG

Fig. 32. Ultrasound scan image

Fig. 33. Stripping of hilsa egg

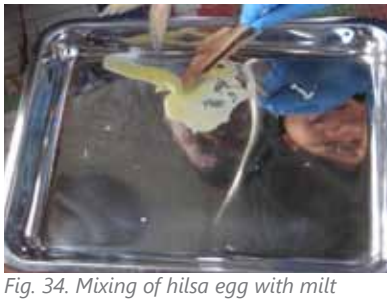


Fig. 34. Mixing of hilsa egg with milt

pond for initial 2 weeks followed by 20-10% bodyweight for rest of the culture period.

Qualitative and quantitative analysis of plankton revealed that zooplankton density was found to be higher in T3 nursery pond followed by T2 and T1. Among zooplankton population copepod, cladocera were dominant zooplankton in T3 nursery pond. After 90 days of nursery rearing, apparently higher (P >0.05) body weight (15.31±0.03) and better (P <0.05) survival (27.0±1.0%) was found in T3 nursery pond when combination of Plankton^{Plus} (37.5 ppm) and mustard cake (37.5 ppm) was supplemented as plankton booster. The results revealed that plankton density in nursery pond has direct effect on fish growth and survival.

Induced breeding technique of Bengal bream

Kakdwip Research Centre of ICAR-CIBA has made breakthrough in induced breeding of *Acanthopagrus datnia* during 2021. In the current year, the technology of induced breeding was refined. In brief, broodstock were reared brackishwater (5-7 ppt) Recirculatory Aquaculture System (RAS) from February to August.

Fig. 35. Nursery reared hilsa fry

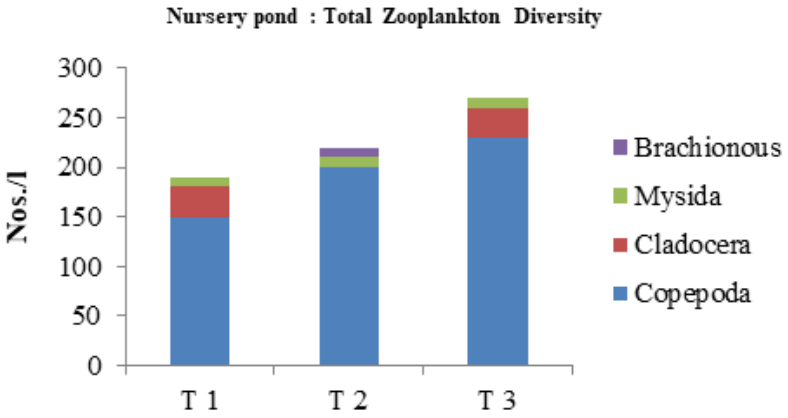


Fig. 36. Effect of Plankton^{Plus} and mustard cake on plankton density

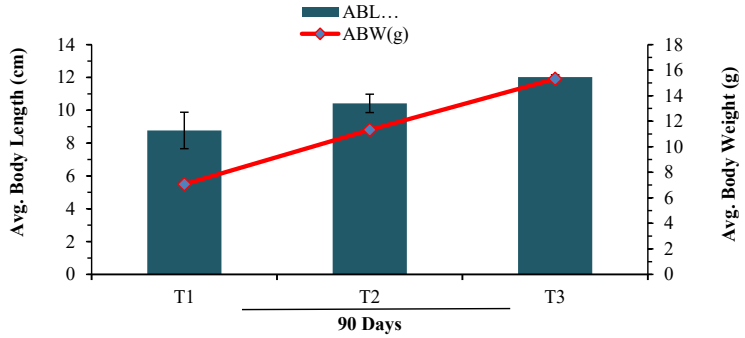


Fig. 37. Effect of Plankton^{Plus} and mustard cake on growth of hilsa in nursery ponds

Fig. 38. Administration of hormone

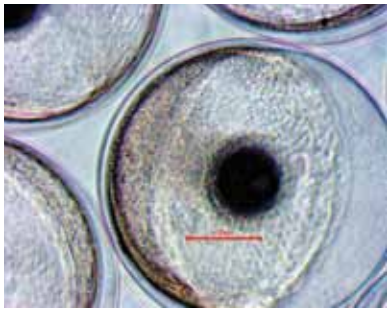


Fig. 39. Blastula

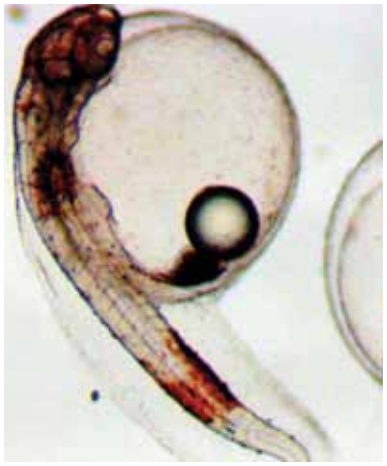


Fig. 41. Larvae of yellow fin bream

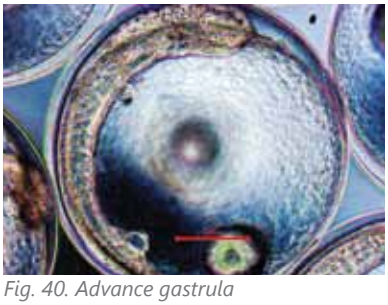


Fig. 40. Advance gastrula

Inception of gonadal development was noticed during August/ September. Broodstock were implanted with LHRHa hormone pellet (25 µg/pellet) and maintained till the attainment of final maturity. Fishes were fed with low cost fish once daily to the satiation. Mature female (oocyte >350-400 µm) and oozing male were shifted to breeding tank (8,000 L) and salinity was gradually increased @ 5 ppt/ day. Once salinity reached 30 ppt, brooders were administered with LHRHa hormone @ 30 µg kg^{-1} body weight to female and half the dose to male intramuscularly. Fish spawned successfully after latency period of 55-58 h. The current finding indicated that the broodstock of *A. datnia* can be developed in brackishwater (5-7 ppt) and high salinity (30 ppt) required for final maturation, spawning, egg incubation and larval rearing.

Year-round gonad development of Bengal bream collected from wild

Bengal bream, *Acanthopagrus datnia* is an important candidate species for aquaculture due to its high market demand, taste and consumer preference. To understand the gonadal development pattern and fatty acid mobilization from muscle to ovary fresh sample *A. datnia* were collected from January to December, 2022. In the mid of the each month 10 adult fishes of different sizes (110-450 g) were sampled (n=10). Total length, weight, weight and gonad weight were measured. For histological analysis gonad samples were fixed in 10% NBF, and for fatty acid analysis tissue sample were kept at -40°C. Result of study showed that all the collected samples of *A. datnia* are bisexual in nature. Histological examination revealed the asynchronous type of ovarian development. Previtellogenic, vitellogenic, mature and spent

oocytes dominated from April to October, mid-October to November, December to January and mid-January to March. Whereas as ovarian biopsy showed the oocytes development in between August-September (60-80 µm), October (80-200 µm), November (200-320 µm), December (320-370 µm), last December (370-410 µm), January (410-430 µm). Therefore, the ideal time for induced breeding is between December and January.

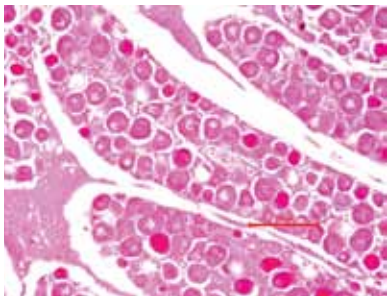


Fig. 42. Pre-vitellogenic oocytes

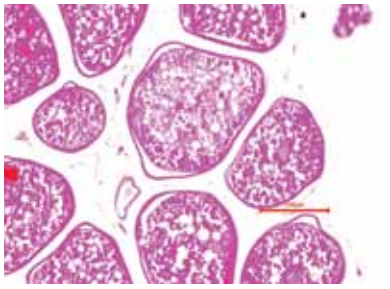


Fig. 43. Vitellogenic oocytes

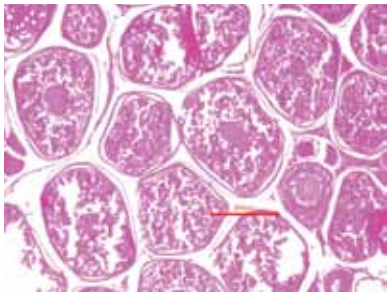


Fig. 44. Mature oocytes

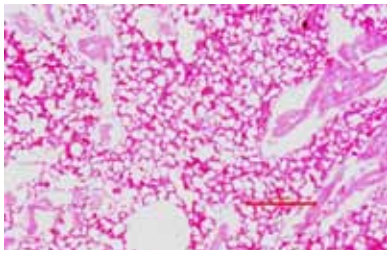


Fig. 45. Spent oocytes

Effect of different salinities on the breeding performance and larval development of orange chromide

Current study was conducted to find the ideal breeding salinity for orange chromid, *Etroplus maculates* in the fishes (average size: 1.82 g; 22 mm) which attained sexual maturation (8-12 g and 78-86 mm) in both freshwater and brackishwater (salinity: 0-10 ppt) in four months. To evaluate the breeding performance and larval development, mature male and female (weight: 8-12 g and Total length: 78-86 mm) in sex ratio of 3:1 (male: female) were distributed in three different salinities (0, 5 and 10 ppt) in triplicates (n=3) and reared for three months. Fish were fed with boiled smashed egg. After hatching, larvae were reared in same salinities and its development was studied. Result of the study showed that the average spawning interval was 10, 17 and 22 days at 0, 5 and 10 ppt, respectively. Average incubation period was 75.66, 75 and 66.66 h at 0, 5 and 10 ppt salinities, respectively. Fertilization and hatching rate were 84.23, 83.98 and 37.56%; 60.33, 59.31 and 51.36% at 0, 5 and 10 ppt salinities, respectively. Total length of newly hatched larvae was 3,417±15 µm, 3,239.22±18 µm, 2,612.20±5 µm at 0, 5 and 10 ppt salinities, respectively. Mouth of newly hatched larvae opened on 4-5 days of post hatching (dph). Mouth gap ranged between 295-300 µm. Average yolk sac volume of newly hatched larvae were 0.781,

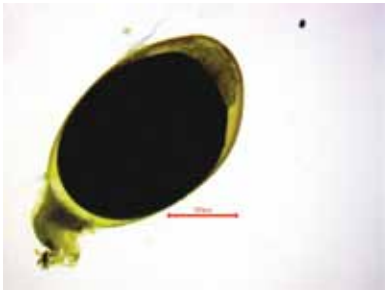


Fig. 46. Embryo at 0 ppt

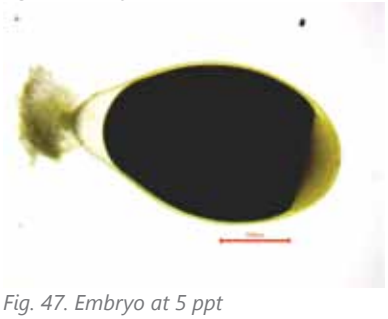


Fig. 47. Embryo at 5 ppt

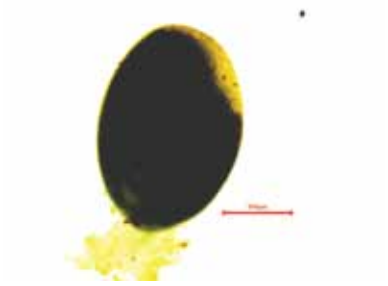


Fig. 48. Embryo at 10 ppt

Fig. 49. Larvae at 0 ppt

Fig. 50. Larvae at 5 ppt

Fig. 51. Larvae at 10 ppt

Fig. 52. Silver moony fry (30 days old) for nursery rearing

0.759 and 0.331 mm^3 at respective salinities of 0, 5 and 10 ppt. Yolk sac absorbed earlier (6 dph) in 10 ppt salinity than the lower salinities of 0 and 5 ppt. Larval survival was 45.9, 60.82 and 36.94% at respective salinities of 0, 5 and 10 ppt. Result conclude that 0-5 ppt is the ideal salinity range for breeding and larval rearing of *E. maculatus*.

Popularization of nursery rearing of silver moony in freshwater ornamental farms

Silver moony, *Monodactylus argenteus*, is a high value brackishwater ornamental fish. Its schooling behaviour, colour pattern, tolerance to sudden fluctuation in salinity, high market price and compatibility with other species (marine, brackish and freshwater) in aquariums makes it popular among aquarium hobbyists. Considering the high price and demand, CIBA took efforts to popularize the nursery rearing of silver moony in pure freshwater to attract more fresh water ornamental farmers to take up the nursery rearing of silver moony in fresh water areas. As a first trial, hatchery produced silver moony fry (30 days old) were distributed to the freshwater ornamental farmer from Madhavaram, Chennai. Farmer successfully completed the nursery phase (30 days) in fresh water with 98% survival and was able to fetch a good market price and demand compared to wild collected stock due to high survival rate of hatchery produced seeds.

Standardization of captive breeding and larval rearing protocols of estuarine knight goby fish

Gobies are also among the commonly occurring fish fauna of the Sundarbans mangrove zone and knight goby, *Stigmatogobius sadanundio* is available in Indian Sundarbans, having an attractive colour pattern over its body and considered as an important ornamental fish. Hence, efforts were initiated to achieve its seed production in captivity. A total of 200 nos. of knight gobies (size 6 to 10 g) were collected and reared in tanks. Spawning observed within 60 to 90 days after domestication spontaneously with the provision of sand base and a substrate to lay eggs. Sex ratio of 1: 3 (female: male) leads to the successful pairing of fishes and spawning. Male guards the fertilized eggs post-spawning. Spawning can be achieved throughout the year under the temperature of 25–30°C in captivity. The highest numbers of eggs and hatchlings were recorded in June and August. A pair can lay 1,000–2,000 eggs on a substrate. Water salinity of 3.0–5.0 ppt and a temperature of 25–30°C noticed during the incubation of eggs. Hatchlings were stocked @ 25 no/l in the larval rearing tank. Mouth

Fig. 53. Female (L) and male knight goby (R)

(90±10 µm) opening observed on 2nd dph. Completely formed pectoral fins were observed on 3rd dph. Fourth dph larvae were fed with freshwater ciliates (size 30–50 µm; density 30±5 no/ml) and microalgae (*C. vulgaris*; density 2 x 10^6/ml). Complete yolk absorption was observed on 7th dph and larval rearing is being continued.

Captive broodstock development of *Penaeus indicus* in tank system

Captive rearing of *P. indicus* broodstock to close the life cycle is one of the major thrust areas of research to develop the breeding program. As broodstock ponds are subjected to seasonal fluctuation and biosecurity breaches, efforts were carried out for broodstock development in tank-based systems. Toward this goal, the domestication of *P. indicus* is carried out in the HDPE tank system. A comparative study of growth and reproductive performance of post larvae (G1) produced from wild broodstock (G0) was compared with fourth-generation PL produced from captive-reared broodstock. By 374 DOC, female and male captive-reared stocks (G4) attained 31.5±0.56 g and 27.2±3.6 g, respectively, compared to 24.99±3.5 and 25.43±1.7 g attained by the female of G1. The minimum size at first mating (17-20g) and the percentage of the male population with matured spermatophore (20-40%; 20 g male at 223 DOC) were higher in captive-reared *P. indicus* compared to PL produced from wild broodstock. This indicates domesticated broodstock has later maturity with a better advantage on faster growth rate and bigger broodstock size over a generation.

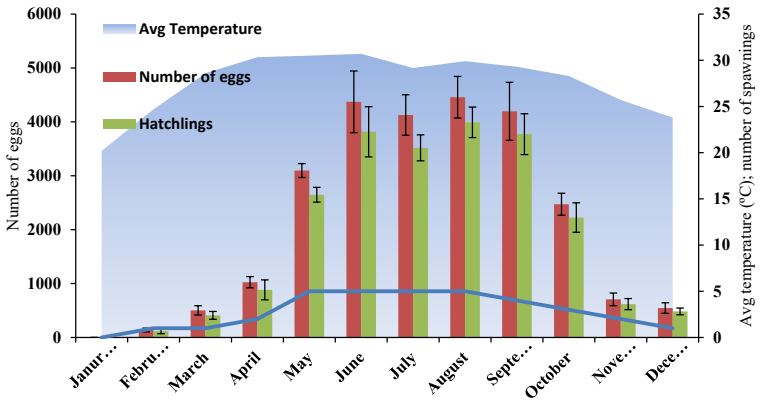


Fig. 54. Spawning performance round the year

Fig. 55. Knight goby completely developed embryo inside egg case

Fig. 56. Larvae on 6 dph with full gut

Moulting interval and mating of *P. indicus* in indoor vs outdoor tank

Mating in confined systems is one of the major constraints breeding of closed thelycum shrimp. However, in the confined indoor rearing system, poor mating efficiency was recorded. As mating in closed thelycum is closely linked with moulting, the indoor and outdoor mating trial was carried out in 500 L tanks for a period of 40 days using eye stalk ablated and non-ablated female *P. indicus* (28-34 g) and male at 1:1 ratio. The study revealed ablation increased moulting interval (11-12 days) and moulting frequency (2-3 times) in broodstock compared to un-ablated stock (1-2 times) with poor mating efficiency (below 15%) in both systems.

Biofloc technology (BFT) based maturation and breeding *Penaeus indicus*

Male and female *P. indicus* were subjected to eye stalk ablation and reared in different combination of biofloc and clear water system

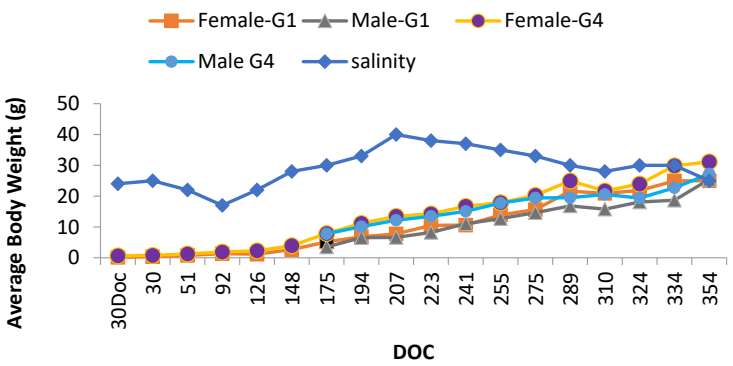


Fig. 57. Average body weight of captive reared broodstock in tanks

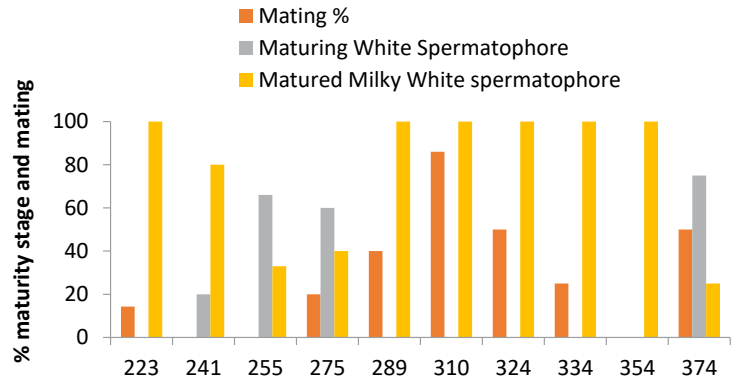


Fig. 58. Maturity stage and mating during captive development

to study the effect of biofloc on maturation and easy maintenance of broodstock in our future endeavours.

The maturation observed after 6-7 days of eye stalk ablation in ESA+BFT group, but Control and only ESA group showed little higher latency period of 10-12 days, peak showed during 12-15 days in all treatments, the ESA+BFT showed higher percentage of maturation in both C:N10 (53.33±5.77) and C:N15 (56.66±5.67) than control. ESA only showed a maturation percentage of 40±10. Similarly, the male maturity in terms of sperm viability also showed higher survivability in both the BFT system than control, first the initial viability taken in all treatments, after 45 days of rearing the sperm viability was checked.

The spermatophore from biofloc reared animals showed significantly higher viability of sperm than control animals. Average fecundity and nauplii production also observed higher in biofloc reared brood stock than control brood stock showed significantly higher numbers of eggs and nauplii production. The average fecundity ranged from 1540.68±197.34 nos (control) to 1739.49±326.56 nos (ESA+BFT) group. The hatching rate (%) observed almost similar (ranged from 85.93±5.03 to 92.40±2.41), little higher in biofloc group (not significantly than control). The average length for protozoea larvae also taken after metamorphosis from nauplii to protozoea. The protozoea from biofloc reared animals showed a higher ABL (average body length, 1601.15±192.01) µm than protozoea from control (1312.51±325.61) µm. The average fecundity, hatching rate increased

in ESA+BFT group significantly than that of control. This study demonstrates that shrimp maturation was significantly higher in the biofloc treatment tanks in captive condition.

Gonad development of captive-reared Indian white shrimp in low and high saline maturation system

As salinity is one of the critical parameters which affect the gonad development of penaeids, In the southwest coast of India, the seawater salinity fluctuates to 22 to 36 ppt, and during the off-season, the gonad development of captive-reared broodstock is found to be regressed. Against this background, a study was conducted to understand the effect of salinity on gonad development and mating or moulting efficiency of *P.indicus* (28-35 g) during the off-season when salinity was 20 ppt with manipulated seawater (32 ppt) using brine. Although gonad development was noticed on par with 32 ppt, regression of ovaries was recorded in 22 ppt salinity.

Hatchery production performance of speckled shrimp *Metapenaeus monoceros*

Diversification of aquaculture is vital for the long-term success of the industry. Speckled shrimp, *Metapenaeus monoceros* is native penaeid in India, and one of the least explored species for its aquaculture potential, although this species is a part of the traditional farming systems in India. Several attributes of this species are proved to be its potential for developing as a commercial aquaculture species. Mass seed production and larval rearing of this species at commercial scale have not been addressed so far. To evaluate the various aspects of hatchery production and grow out such as reproductive performance, seed production, and the culture potential wild caught broodstock of *M. monoceros* (53 shrimps) were obtained from the southeast coast of India. The average body weight of female broodstock was 28.9±1.2 g (range: 19.5-49.2 g), and total length was 145±0.2 mm (range: 124-190 mm). The hatchery production was about 55,000 PL during this period.

Effect of different larval feeds in growth and survival of speckled shrimp, *Metapenaeus monoceros* post larvae

In order to evaluate the effect of different live feed on survival and growth of post-larvae an experiment was carried out using post larvae (PL) produced in the research hatchery of ICAR-CIBA. PL fed with commercial feed was the control, and other feeding treatments were either microalgae (*Thalassosiera pseudonana*) alone or in combination with different zooplankton, such as Artemia, rotifer (*Brachionus plicatilis*) or copepod (mainly *Pseudodiaptomus annandalei* and *Dioithonia rigida*). Survival of post-larvae was observed best in the tanks fed with rotifer (75.5%) followed by control treatment, where powder feed is fed (71.1%) and survival is least observed in treatment with phytoplankton alone, *Thalassosiera pseudonana* (42.22%). The highest growth (0.387 cm) was found in the treatment fed with copepods followed by larvae fed with powder feed (0.234 cm). The least growth was recorded in larvae fed with *Artemia* nauplius (0.1395 cm). The present result indicates that *Artemia,* one of the indispensable component of hatchery production is not essential for the PL production of *M. monoceros*, which provides an additional advantage over other commercial penaeid species.

Improved protocol for hatchery production of mud crab

Mass rearing of mud crab, *Scylla serrata* has often been constrained due to mass mortality of zoeal stage and issue in conversion of penultimate zoeal stage to the megalopa stage. It has been reported that the addition of micro algae induces morphological abnormalities in zoeal stages via consumption of rotifer in the later phase of zoeal stages. In this context, several experiments were conducted to optimize the feeding schedule and protocol for the hatchery production. The improved

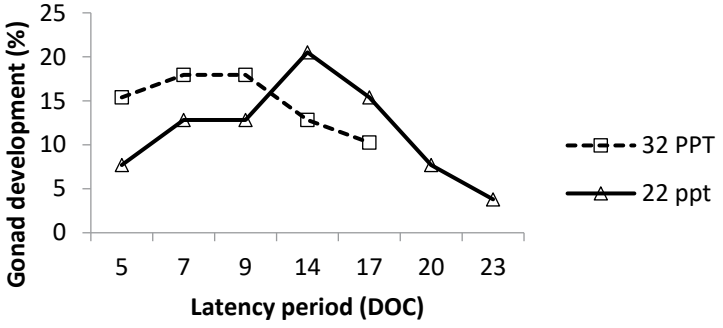


Fig. 59. Gonad development of captive reared broodstock under different salinity

protocols for mass production of larvae are summarized in the Table.

Development of protocol for the production of crab instars

In order to optimize the nursery culture of mud crab, *S. serrata*, a special nursery system has been developed. Two 30 tonne cement tanks were used for the nursery culture, and each tank was fixed with 2 m^2 (6 numbers) net cags/ hapas. These net cages were stocked with 3-day old megalopa at a rearing density of 100 megalopa/ m^2. Animals were reared for 25 days, at the stagnant water without any refreshment of the water. During the nursery trials, animals were fed with minced clam meat (each hapa were fed with 450 g of clam meat twice daily). After 25 days of rearing, megalopa grown up to crab size CW: 17.1±0.46 and BW: 0.59±0.12 with a mean survival of 83.7±2.06. Although survival is higher than the megalopa stocked in hapa constructed in open pond, average body weight is significantly smaller than the net cages constructed in the open pond. This may be partially due to the higher natural productivity of the pond.

Evaluation of megalopa nursery rearing in pond and cement tank based system

Rearing of megalopa larval stage of mud crab is a crucial part in the final instar production of mud crabs. Cannibalism and mortality are the major factors affecting survival in this life stage. Our previous studies had devised an outdoor nursery rearing technique for the megalopa for higher survival and reducing the hatchery cycle. In the present experiment the outdoor megalopa rearing experiment was evaluated in earthen ponds and cement tanks. 4 days old megalopa produced in the mud crab hatchery was stocked at the rate of 200 numbers in net hapa of size 2 x 1 x 1 m. The megalopa stages were fed *ad libitum* with minced clam meat and Artemia flakes at a ratio 1:1 three times a day. At the end of 15 days the megalopa converted to the instar stage in all the net hapa. Percentage survival and size uniformity was significantly higher in the megalopa reared in the cement tanks. Significantly higher bodyweight was observed in the pond reared megalopa however the coefficient of variation was higher in the converted instars. Nursery rearing of megalopa in net hapa erected in cement tanks is better for survival and production of uniform size instars.

Artemia biomass production under diverse management and salinity regime

Artemia biomass production in confined system is an emerging live feed industry where live maturation feed can be produced in a biosecured systems with a scope to culture in inland or areas adjacent to hatcheries compared with saltpan ecosystem. Two sets of experiments were carried out to optimize different management regimes in tank based *Artemia* biomass production, and to explore its role as a maturation diet for Indian white shrimp. In trail I, *Artemia* biomass production was carried out in autotrophic (microalgae, T_A), heterotrophic (T_H), and mixotrophic (T_{MX}) rearing systems for a period of 18 days in tanks (100 L). In trial II, artemia biomass production was evaluated at diverse salinity regimes (10, 15, 20, 30, 40, and 50 ppt). At the end of Exp. 1, significantly higher ($P < 0.05$) yields (1.3±0.95 kg ton^{-1}) were recorded in mixotrophic (T_{MX}) and heterotrophic groups, T_H (1.22±0.15 kg ton^{-1}) compared with autotrophic units, T_A (0.360±0.47 kg ton-1). In Exp. 2, salinity played a significant variation in Artemia biomass production with the highest ($p < 0.05$) productivity (1.51±0.08 kg ton^{-1}) recorded at 50 ppt followed by 40 ppt (1.30±0.051 kg ton^{-1}). The highest percentage of the matured population was recorded at 40 ppt and 30 ppt. Tank-based biosecure production potential of the *Artemia* model can open new vistas for its wide acceptability as SPF live maturation diet for commercial shrimp hatcheries.

Nursery trial in customised biofloc system

Biofloc based nursery rearing experiments were conducted by using antimicrobial peptide coated feed. Stylicin from *Penaeus vannamei* and Crustin from *Scylla Serrata* were coated through vacuum coating. The appropriate size formulated feed were administrated 2 times per day

Parameters	Earthen Pond	Cement Tank
Body weight (g)	0.35±0.07[a]	0.27±0.03[b]
Carapace width (mm)	12.98±0.55[a]	11.74±0.37[b]
Survival (%)	76.83±2.89[a]	88.00±1.05[b]
Percentage variation (%)	72.277	42.44

Table 3. Growth and survival of megalopa nursery reared in earthen pond and cement tanks

Fig. 60. Megalopa net hapa nursery rearing system and the mud crab instars produced

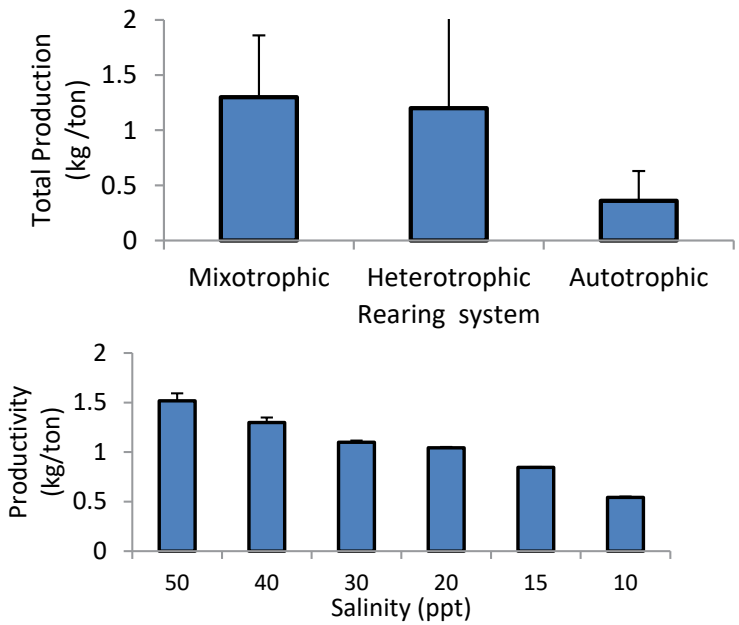


Fig. 61. Total production of Artemia biomass under different dietary management and salinity management regime

along with normal feeding (6 times per day). Animals supplemented with Stylicin coated feed showing better performance followed by Crustin coated feed and normal feed. Crustin treatment considerably affect the colony formation through metabolic arrest. Comparative transcriptome analysis revealed that, crustin treatment significantly down regulates the Pyruvate kinase pathway, and trans-membrane transport pathway of *V. parahaemolyticus*. Crustin treatment significantly affects the amino acid biosynthesis, ATP synthesis and glucose metabolism makes the pathogenic cells starve and inhibit colony proliferation.

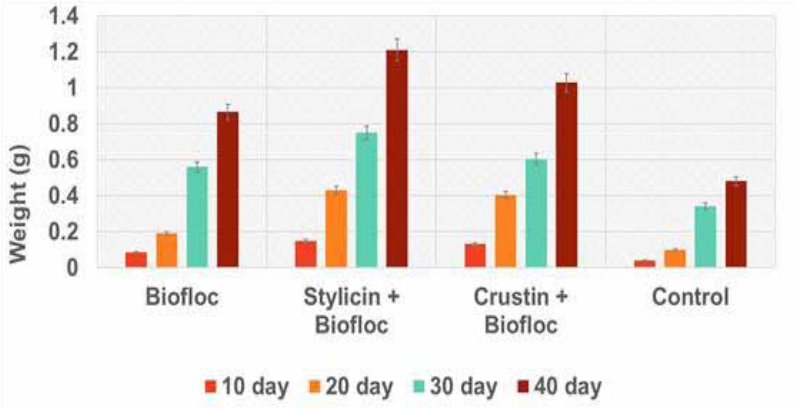


Fig. 62. Comparison of customized biofloc system

NUTRITION & FEED TECHNOLOGY

NUTRITION & FEED TECHNOLOGY

Marine yeast, *Meyerozyma guilliermondii* as a functional additive in the diet of shrimp *Penaeus vannamei*

The marine yeast *Meyerozyma guilliermondii*, procured from NIOT was subjected for nutrient analysis and was found to contain 13.82, 16.04, 7.64 and 62.50%, respectively for CP, EE, total ash and carbohydrates. (Fig. 1.)

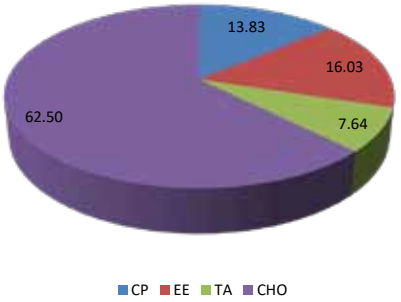


Fig. 1. Nutrient composition of marine yeast Meyerozyma guilliermondii

In order to evaluate the nutrient and immune stimulating potential of this yeast, a feeding experiment was conducted in the late PLs of *P. vannamei*. The yeast was included at 0, 1 and 2% in the standard vannamei nursery diet and the effect of inclusion on growth, survival and immunity was ascertained.

Ascertaining the optimal protein and lipid requirement of *Mugil cephalus*

In the pursuit of feed development of the candidate species the essential requirement is to find out its nutrient requirement. To know the nutrient requirement of the fish species, the experiment has to be conducted in the hatchery bred fry from the same brood as it will void the variability among the fry/fingerlings. Protein and lipid are the key nutrients for any aquaculture species and hence two experiments were conducted to

determine the optimal protein and lipid requirement. In the first experiment, hatchery bred and reared early fingerlings of grey mullet with a mean average body weight of 1.412 g were used to study the protein requirement in an 8 week feeding experiment. Six practical diets containing 20, 25, 30, 35, 40 and 45% crude protein have been prepared and tested in triplicate tanks of 350 L capacity containing 15 animals per tank. The results revealed best performance in group fed with 30% protein containing diet and further increase in dietary protein did not any effect on growth performance indicators and survival. This finding infers that it would be ideal to fix the protein requirement for grey mullet fingerlings at 30%. In the second experiment, hatchery bred and reared early fingerlings of grey mullet with a mean average body weight of 9.232 g were used to study the lipid requirement in an 8 week feeding experiment. Six practical diets containing 4, 6, 8, 10, 12 and 14% lipid have been prepared and tested in triplicate tanks of 350 L capacity containing 15 animals per tank. The results revealed the best performance in group fed with 8% lipid containing diet and further increase in lipid has no beneficial effect on growth performance. This finding infers that it would be ideal to fix the lipid requirement for grey mullet fingerlings at 8%.

Development of broodstock feed for hilsa

Formulated feed (CP 42.16 % & EE 15.06%) for broodstock rearing of hilsa has been developed and are being tested in pond. This specially designed feed was used for two months before the onset of breeding season. Specially designed broodstock feed was rich in PUFA and some essential amino acids like, lysine, leucine, threonine etc. Broodstocks were maintained using Hilsa^{Plus} grow-out feed. After feeding of specially designed broodstock feed, 80% of fish were found to be in different stages of maturity. Gonads of captive hilsa reared with formulated were found to have better amino acid profile compared to that of wild hilsa with similar gonado-somatic index (Fig. 3, 4).

Further effort was taken to compare

Fig. 2. Broodstock feed sample

Parameter	Percentage (%)
DM	82.63
Protein	42.06
Fat	15.06
Fibre	8.14
Ash	11.25

Table. 1. Feed composition for broodstock feed

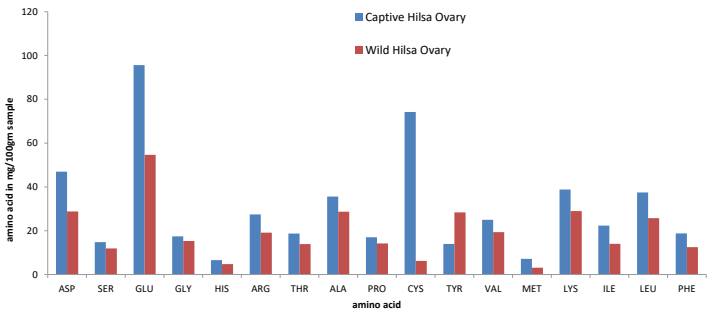


Fig. 3. Comparative amino acid profile of ovary of captive and wild hilsa

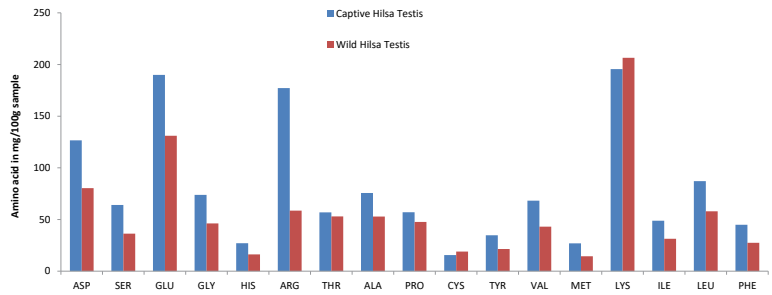


Fig. 4. Comparative amino acid profile of testis of captive and wild hilsa

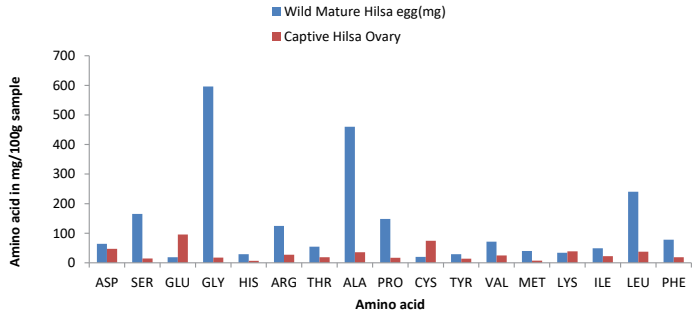


Fig. 5. Comparative amino acid profile of egg of captive hilsa and wild mature running phase hilsa

the biochemical composition of captive hilsa ovary with that of fully matured (running phase) wild hilsa ovary and after studying the differences in nutritional composition of eggs, broodstock feed was fine-tuned.

Optimization of dietary inclusion level of flower waste in diet of *Penaeus vannamei*

To determine potential use of flower waste (FW) in diet of *Penaeus vannamei* replacing soybean meal feed was carried out using flower waste on dry basis. All the feed were isoproteinous (CP-34%) and isolipidic (EE-5%) and were tested in P. vannamei (Av. Body wt. 2.41±0.003 g) juveniles in triplicate tanks (500 L) containing 25 shrimps per tank. Shrimp of group FW_0, $FW_{2.5}$, FW_5, $FW_{7.5}$ and FW_{10} were offered feed with 0, 2.5, 5, 7.5 & 10 % of Flower waste, respectively, at satiety level twice (10 am & 5 pm) daily. After 90 days of experiment

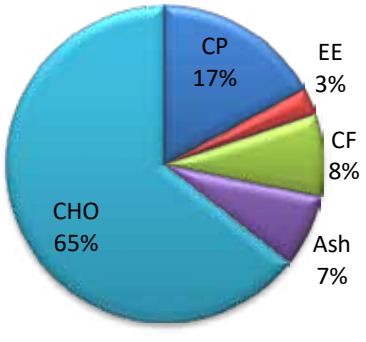


Fig. 6. Nutrient composition of flower waste

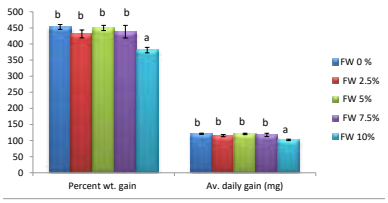


Fig. 7. Weight gain of P. vannamei fed diet with different level of flower waste

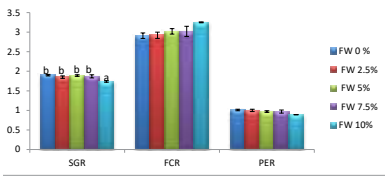


Fig. 8. Feed utilization efficiency of P. vannamei fed diet with different level of flower waste

it was found that average daily gain, SGR were higher (P <0.05) in groups FW_0, $FW_{2.5}$, FW_5, and $FW_{7.5}$. Protein efficiency ratio (PER) was apparently higher (P >0.05) and feed conversion ratio (FCR) was lower (P >0.05) when shrimps were fed diet up to 7.5% flower waste but no significant difference in FCR was observed in shrimps fed 2.5, 5, 7.5% flower waste and control (FW0). Nutrient digestibility did not differ among the groups even at the highest level of 10%. Survival (%) was similar among the groups. Therefore, it can be concluded that flower waste has potential to replace 7.14% soybean meal and can be incorporated up to 7.5% level in diet of *P. vannamei*.

Optimization of dietary inclusion level of nano zinc in diet of *Mystus gulio*

Zinc (Zn), the second important microelement, performs a variety of functions such as cell division, co-factor reproduction, immunological response, and antioxidant defence. The availability of zinc is often an issue due to presence of several interacting nutrients at gut level. Present experiment was conducted to study the effect of nano zinc in diet of *Mystus gulio*. Six isoproteinous (CP-30%) and isolipidic (EE-6%) feed were prepared with different form and different level of zinc for the experiment. Mystus gulio fry (Av. Body wt. 0.41 ± 0.003 g) were randomly distributed in 18 tanks (500 L) containing 25 fry per tank and the feeding trial was carried out in triplicate. The fry in each tank designated as NC, PC, T1, T2, T3 and T4 were offered feed without Zn supplementation (Negative control), feed supplemented with 40 ppm inorganic zinc (positive control), feed supplemented with

Parameter	NC (Negative Control)	PC (Positive Control Inorganic Zn 40 ppm)	T1 (Organic Zn 40 ppm)	T2 (Nano zinc-10 ppm)	T3 (Nano zinc-20 ppm)	T4 (Nano zinc-40 ppm)
Blood Glucose **(mg/100 ml)	185.00±2.31^{f}	170.33±2.60^{e}	159.67±0.88^{d}	147.00±2.08^{c}	137.67±0.88^{b}	113.67±2.73^{a}
SOD**	0.83±0.02^{c}	0.63±0.01^{b}	0.63±0.03^{b}	0.45±0.30^{a}	0.40±0.03a	0.38±0.003^{a}
Catalase**	1.42±0.17^{b}	1.13±0.05^{a}	1.02±0.02^{a}	1.01±0.01^{a}	1.04±0.02a	0.96±0.002^{a}

Table. 2. Effect of nano zinc on the level of blood glucose and stress enzyme in M. gulio

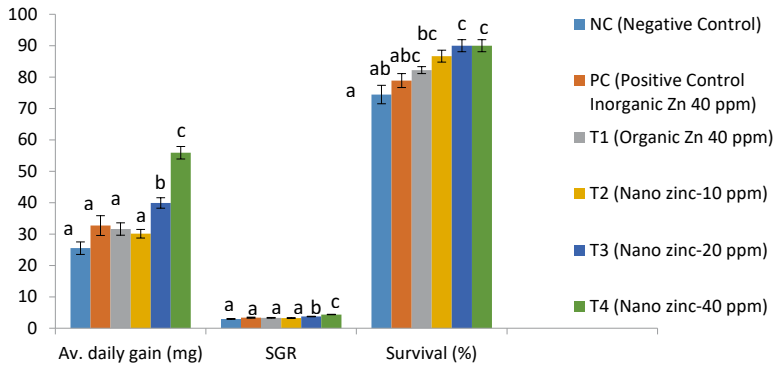


Fig. 9. Weight gain and survival of M. gulio fed diet with different forms and levels of zinc

40 ppm organic zinc (T1), feed supplemented with 10 ppm nano zinc (T2), feed supplemented with 20 ppm nano zinc (T3) and feed supplemented with 40 ppm nano zinc, respectively, at satiety level twice (10 am & 5 pm) daily. After 90 days of experiment, it was found that average daily gain (g), weight gain percent, SGR were significantly higher (P<0.01) in group T4 followed by group T3. However, weight gain and SGR were similar among NC, PC, T1 and T2. Survival was higher (P <0.01) in all nano zinc supplemented groups (T2, T3, & T4) followed by organic zinc supplemented group (T1). Digestive protease, amylase and lipase activity were significantly higher in nano zinc supplemented groups. Serum SOD was significantly lower (P <0.01) in nano zinc supplemented groups. SOD and catalase activity was highest in groups without zinc supplementation (NC). Blood glucose level was significantly higher in NC followed by PC, T1, T2, T3 and T4. From the study it was found that nano zinc supplementation can reduce the stress and improve survival of *M. gulio*. Nano zinc supplementation @ 40 ppm can improve growth performance of *M. gulio* fry. Therefore, it can be concluded that Nano zinc can be incorporated @20-40 ppm in diet of *M. gulio* to improve its production performance.

Inclusion level study of cottonseed meal (raw and fermented) in the diet of brackishwater catfish, *Mystus gulio*

The high price rise of conventional plant protein like soybean, mustard oil cake in aquafeed necessitates exploring the utilization of alternative plant protein sources to reduce feed cost in fish diet. Cottonseed meal (CSM), a by-product of the cotton fibre and cottonseed oil industries is the third leading plant protein by weight used worldwide and is available at relatively lower cost. A study was conducted to study the inclusion

Fig. 10. Cottonseed meal (raw)

Fig. 11. Cottonseed meal (fermented)

Parameters	Control (CSM-0%)	CSM-raw (5%)	CSM-raw (10%)	CSM- ferm. (5%)	CSM- ferm. (10%)
Initial body wt. (g)	1.71±.003	1.71±0.003	1.72±0.003	1.72±0.003	1.72±0.003
Final body wt. (g)**	4.19±0.04^{b}	4.18±0.01^{b}	3.77±0.04^{a}	4.19±0.01^{b}	4.15±0.06 ^{b}
Wt. gain %**	144.76±2.94^{b}	143.77±1.08^{b}	119.80±1.71^{a}	143.13±0.24^{b}	141.55±3.52^{b}
SGR**	2.13±0.03	2.12±0.01	1.8±0.02	2.12±0.002	2.10±0.04
FCR*	2.86±0.06^{a}	2.86±0.02^{a}	3.10±0.12^{b}	2.87±0.01^{a}	2.78±0.04^{a}
PER*	1.16±0.02^{b}	1.17±0.01^{b}	1.08±0.04^{a}	1.16±0.01^{b}	1.20±0.02^{b}
Survival %	90±00	90±00	83.33±3.33	90±0.00	86.67±3.33

* P <05, ** P <01, a, b values bearing different superscript in a row differ significantly.

Table 3. Performance M. gulio fed diet with different level of inclusion of cottonseed meal

level of raw and fermented CSM in the diet of *M. gulio* fry. In order to improve its nutritional quality, cottonseed cake was treated by solid state fermentation using *Bacillus subtilis* for three days. Cottonseed meal (raw) used in the experiment was found to contain 30.40±0.10% crude protein, 5.07±0.02% lipid, 18.26 ± 0.06% fibre and 5.29±0.04% ash whereas fermented CSM contains 31.56±0.14% crude protein, 4.87 ± 0.02% lipid, 17.18 ± 0.06% fibre and 5.44±0.02% ash. The solid state fermentation was carried out with *Bacillus* sp. Five isoproteinous and isolipidic experimental diets were prepared with inclusion of 0 (control), raw CSM-5% (T1), raw CSM-10% (T2), fermented CSM-5% (T3) and fermented CSM-10% (T4) replacing 5 and 10% mustard oil cake. The experiment was

Fig. 12. Haul of vannamei shrimp produced with azolla incorporated feed

conducted in 500 litre FRP tank (10 nos. of fry in each tank) in triplicate for 42 days. Final body weight, FCR, PER and SGR did not differ significantly between the control, T1, T3 and T4 whereas all the parameters reduced significantly in T3. Hence it was concluded that cotton seed meal (raw) can be included up to 5% level whereas by fermentation, the inclusion level can be increased up to 10% in *M. gulio* diet without compromising production performance.

Demonstration of *P. vannamei* farming with azolla meal incorporated diet

Feed contribute to around 60-70% of the total cost of any aquaculture practice. In the shrimp farming sector quality feed is expensive and often results in the higher cost of production. To address this issue an experiment was conducted to study the production performance of *P. vannamei* using azolla based low cost feed. Brackishwater earthen ponds of 1,500 m^2 in duplicate were stocked with P. vannamei PL at a density of 50/m^2. One pond was fed with feed formulated with locally available ingredients with 33% crude protein and 5% lipid (control) whereas other pond was cultured with 4% azolla incorporated feed (treatment) with same protein and lipid level. Both the feed was prepared in the feed mill of KRC of ICAR-CIBA. Though the final bodyweight (10 g) was lower in azolla fed shrimp than the control group (12 g) at end of 100 days of culture period, but higher survival was observed in shrimps fed with the azolla feed. Azolla based and control feed resulted in a total biomass production of 1.8 tonne/acre and 1.78 tonne/acre, respectively. The production cost/kg shrimp was lower in azolla based feed. The colour of the shrimp with azolla feed looks more natural and appealing whereas no difference was noticed in the cooked product (2 minutes boiling). Overall, the shrimp growth was lower in both the experimental groups due to the lower salinity and high turbidity in the ponds caused due to runoff during the rainy season.

Effect of total replacement of fishmeal or fish oil in milkfish, *Chanos chanos* grow-out feeds on growth, digestive enzymes, fatty acid profiles and metabolic pathways

Three experimental grow-out milkfish, *Chanos chanos* iso-nitrogenous and iso-lipidic diets were prepared by replacing fishmeal or fish oil. A 60 day feeding experiment was conducted in an indoor RAS system using hatchery produced juveniles of milkfish. Milkfish juvenile growth is significantly lower in diets fed with total fishmeal replacement in terms of weight gain (180.8±3.67%) compared to control (223.1±5.16%). Similarly pepsin secretion is significantly lower in the pyloric caeca and stomach of the juveniles fed with zero fishmeal diet (1.53, 2.39 & 1.25 U/mg protein) compared to control (1.76, 2.53 & 1.46 U/mg protein). Pancreatic digestive enzymes are significantly reduced in juveniles fed with zero fish meal diet. Though the essential fatty acid profiles are lower in the muscle and liver of milkfish fed with zero fishmeal diet

Comparative production performance of *P. vannamei* using azolla based feed

Economic parameters (on per acre basis)	Control group	Azolla based feed
Total production (kg/acre)	1781	1800
Survival (%)	74.22	90
Body weight at harvest (g)	12	10
FCR	1.4	1.38
Production cost/kg (₹/kg)	178	174

Table 4. Comparative production performance of P. vannamei using azolla based feed

Fig. 13. Colour of azolla fed shrimp

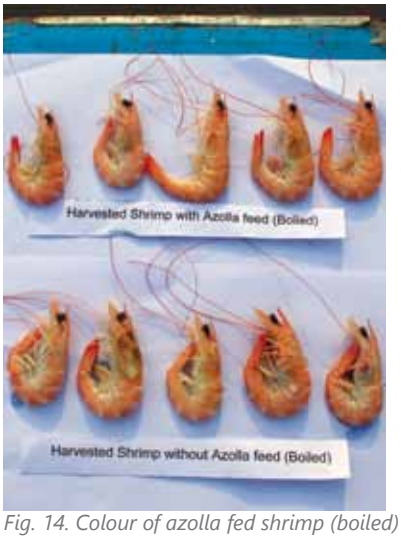


Fig. 14. Colour of azolla fed shrimp (boiled)

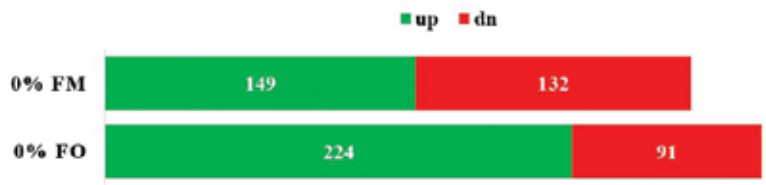


Fig.15. Differentially Expressed Genes (DEGs) in milkfish juveniles fed on fishmeal or fish oil replacement.

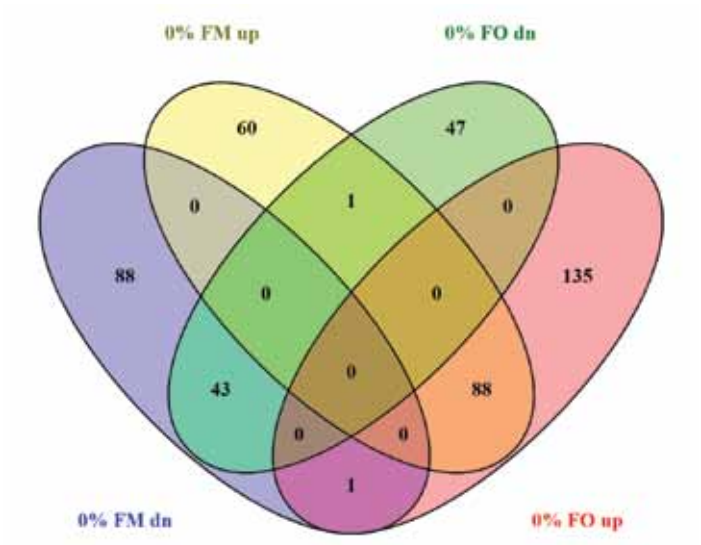


Fig.16. Differentially Expressed Genes (DEGs) distribution in milkfish juveniles fed on fishmeal or fish oil replacement.

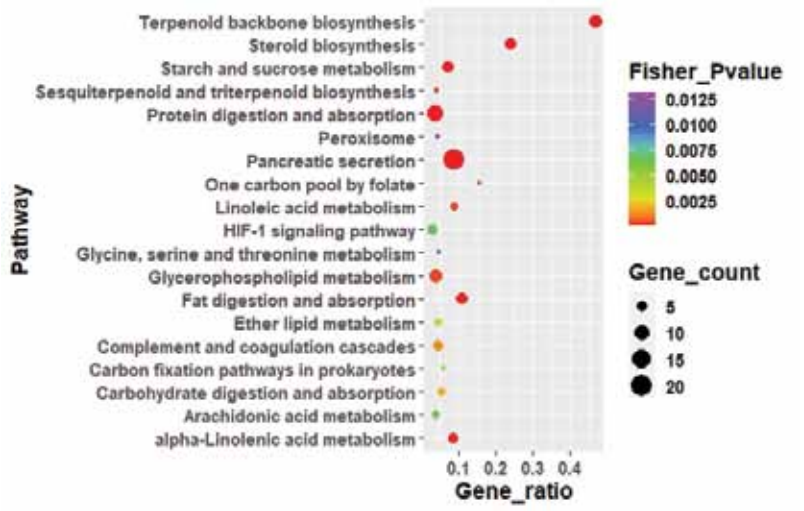


Fig.17. Down regulated KEGG pathways in zero fishmeal fed juveniles of milkfish

but it is not totally reflecting the dietary fatty acid profiles.

In the present study, whole transcriptome analysis was carried out to understand the molecular mechanisms of phenotypic observations of growth, digestive enzymes and fatty acid profiles. The quality analysis of the RNASeq raw data was done by using Trimmomatic and FasQC. The high-quality data were mapped with milkfish genome (Assembly: fChaCha1.1; Accession: GCA_902362185.1) by STAR aligner. Totally, 281 DEGs were found in juveniles fed with fishmeal replaced diet and also, 315 genes were found to be differentially expressed in fish oil replacement. Venn diagram indicated that 43 genes are down regulated and 88 genes are up regulated both in fish meal and fish oil replacement. Analysis of KEGG pathways have clearly indicated that the total replacement of fishmeal has significantly reduced the digestive capability of the juvenile milkfish and that has been reflected with lower digestive enzyme profiles and ultimately growth. Milkfish has conserved the essential fatty acids whenever the dietary essential fatty acids are lower by lowering the linoleic acid, Alpha linolenic acid and arachidonic acid metabolisms.

Fatty acid profiles of different organs of adult *Siganus javus* collected from wild and cultured

Adult *Siganus javus* fishes are collected from both wild and cultured sources and its nutrient profiles are analysed in order to develop the functional brood stock diet for successful maturation and spawning. Wild fishes have higher fatty acid profiles of eicosapentaenoic acid and docosahexaenoic acids in muscle (161.9 and 136.2 mg/
100 g) and liver (387.1 and 543.5 mg/100 g) compared to muscle and liver (133.07, 81.53; 323.4, 331.24 mg/100 g, respectively) of cultured fish. Whereas, the ovary of cultured adults are having higher EPA and DHA (245.9, 207.6 mg/100 g) compared to wild adult (176.28 and 183.5 mg/100 g), respectively.

Solid state fermentation of the feed ingredients

The prepared inoculum (1% of

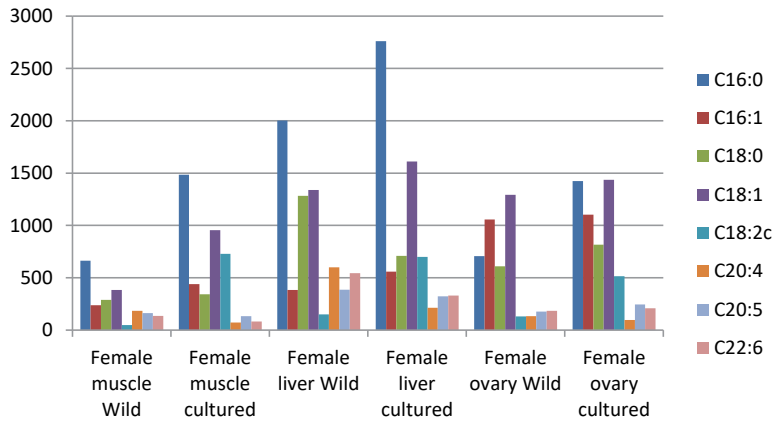


Fig.18. Comparative fatty acid profile of different organs of wild and captive S. javus

Fig.19. Solid state fermentation of plant proteins using Aspergillus niger in pilot scale fermentor

the feed ingredient) was added to the different feed ingredients by usage of septum and peristaltic pump to avoid contamination. The feed for solid state fermentation was prepared by adding water to increase the moisture content of the feed 35-50% followed by autoclaving in the SSF (@ 121°C, for 20 min). The feed ingredients were maintained at a temperature of 28-35°C. The pressure of the fermenter was maintained between 0.5-1 kg/cm2 and agitation of 30 rpm. The fermentation continued for 3 days (72 hours) after the addition of inoculum. The fermented feed was harvested after sterilisation of the fermented feed @80oC. The cooled feed ingredients was harvested and kept for sun-drying for 3 days.

Monitoring of microbial growth during fermentation

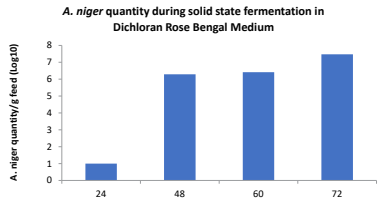
Aspergillus niger growth analysis during fermentation

The samples were taken from the SSF at intervals of 24 hrs, 48 hrs, 72 hrs (before sterilisation & after sterilization) and were used for quantification. The selective medium Dichloran with Rose Bengal and Dichloran Glycerol Medium were used for quantification of *A. niger*. The Dichloran base with Rose Bengal was prepared as per manufacturer's (Hi-Media) instruction. *Aspergillus niger* quantification was carried out by serial 10-fold dilution in NSS. In brief, 1 g of feed after fermentation was transferred to 9 ml of NSS. This was vortexed for few second and subsequently transferred the 1 ml of this inoculum to fresh 9 ml NSS. Finally, 100 µL of diluted inoculum was transferred to Dichloran Rose Bengal and Dichloran Glycerol Medium. Medium was incubated at 30°C for 3 days before counting. The result is presented as Log10 colony forming units.

The results suggest that *A. niger* spores started germinating from 24 h post incubation reflected by a lower value of 1 log population. By 48 h and 72 h, *A. niger* count increased to 6 and 7 log, respectively. Both, Dichloran Rose Bengal and Dichloran Glycerol Medium were found effective in *A. niger* quantification and produced similar result. Fermentation process has been standardized with *Bacillus* sp. and yeast also.

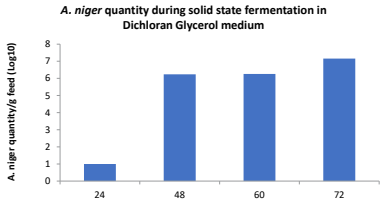
Aspergillus niger spores inactivation

The inactivation of *A. niger* was carried out by heat treatment of fermented feed ingredients at 80°C for 1 h followed by sun-drying for 3 days. Quantification

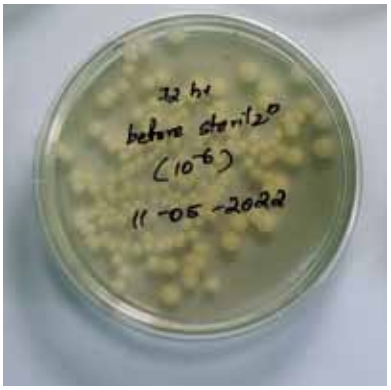


A

B



C



D

Fig. 20 (A) Quantification of Aspergillus niger in Dichloran Rose Bengal medium; (B) growth of Aspergillus niger in Dichloran Rose Bengal medium plate (C) Quantification of Aspergillus niger in Dichloran Glycerol Medium (D) growth of Aspergillus niger in Dichloran Glycerol Medium plate

was carried out in selective medium Dichloran Rose Bengal and Dichloran Glycerol Medium as described earlier. The result suggested that heat inactivation at 80°C reduced the *A. niger* by 4 log or efficient to kill 99.99% of the *A. niger* spores. The results further suggest that temperature and humidity parameters further need to be standardised to reach 100% spores inactivation.

Screening of potential microalgae for nutraceutical properties and their application in brackishwater aquaculture

Microalgae are a source of nutraceuticals because they can produce several bioactive compounds which are helpful for human and animal health and development. However, so far, very few species are only studied extensively for nutraceutical properties and their application in aquaculture. Using various isolation techniques species like *Thalassiosira weissflogii, Chaetoceros gracilis, Tetraselmis* sp, *Isochrysis galbana, Nannochloropsis oculata, Chlorella marina* and *Arthrospira* sp. were isolated from Muttukadu estuarine ecosystem and screened for nutraceutical properties and evaluated their application in brackishwater aquaculture.

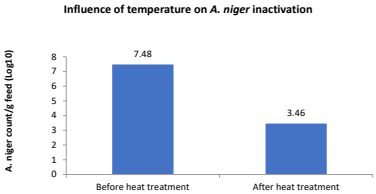


Fig. 21 Influence of temperature on Aspergillus niger inactivation

The study isolated *A. maxima* from Tamil Nadu coast for the first time. Morphological features and molecular characterization were used for the identification of microalgae species. The scanning electron microscopic images showed that the *Arthrospira* sp. is having larger diameter and with the trichomes having no or very little constriction at cross-walls. On solidified media it displayed higher gliding motility (Fig). The state-of-the-art microalgae repository at Muttukadu Experimental Station (MES) is having pure cultures of various microalgae used in aquaculture.

The highest protein content (%) was noticed in *A. maxima* (62.46±3.45) followed by *Chlorella marina* (49.48±3.8) and *T. weissflogii* (43.07±1.78). Significantly, higher ($P < 0.05$) lipid content (%) was observed in *I. galbana* (33.08±2.18) compared to others and followed by *T. weissflogii* (20.11±1.02) and *N. oculata* (18.35±1.02).

The fatty acid profiling (% of fatty acids) of selected microalgae showed that *A. maxima* with the highest percentage (69.51) of polyunsaturated fatty acids (PUFA) compared to other algae. The high percentage of PUFA was due to linoleic acid, gamma-Linolenic acid (GLA, γ-linolenic acid), and Dihomo-gamma-linolenic acid. *Tetraselmis* sp. has a PUFA content of 56.32%, and this was mainly contributed by linoleic acid and gamma-Linolenic acid (GLA, γ-linolenic acid). The higher percentage of eicosapentaenoic acid (EPA) was noticed in *N. oculata* (25.2), followed by *T. weissflogii* (17.77). The highest percentage of

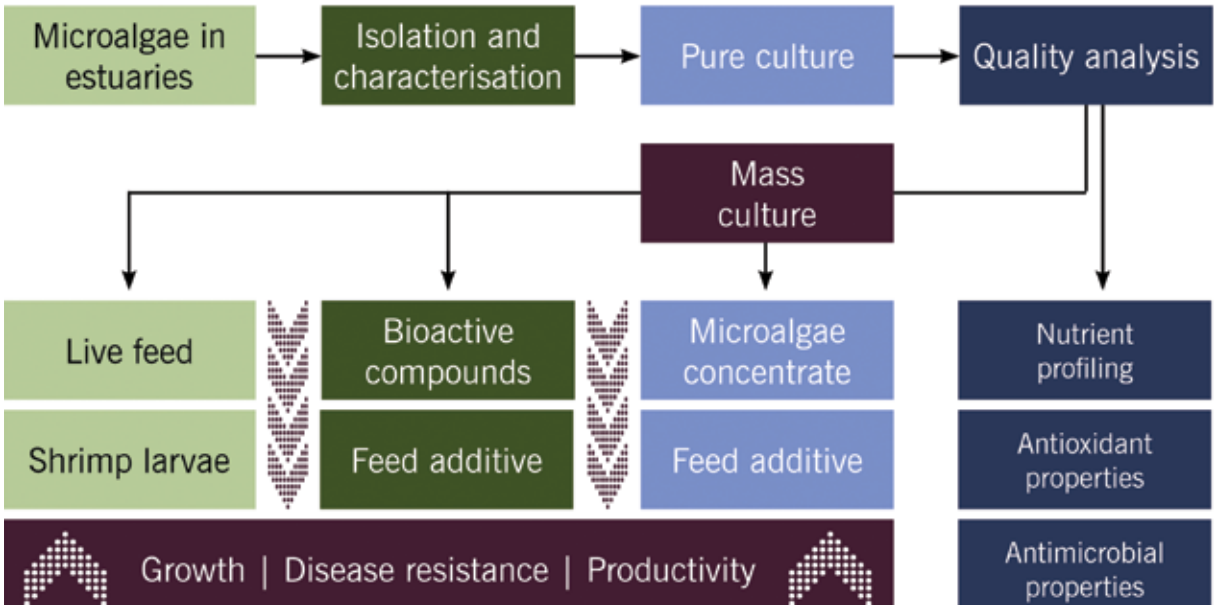


Fig. 22. Schematic diagram of microalgae isolation and assessment of nutraceutical properties and their application in aquaculture

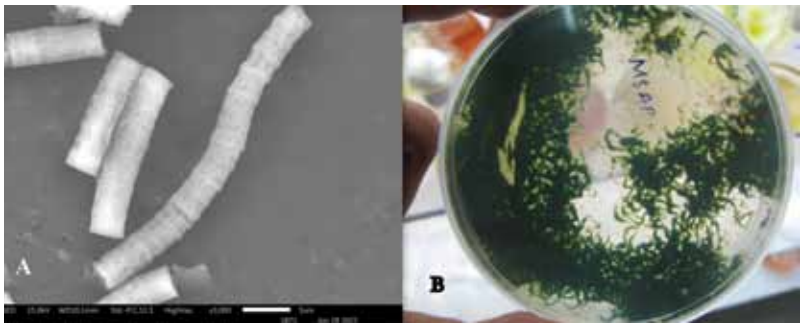


Fig. 23. Scanning Electron Micrograph of Arthrospira sp (A) and its growth in agar plates (B)

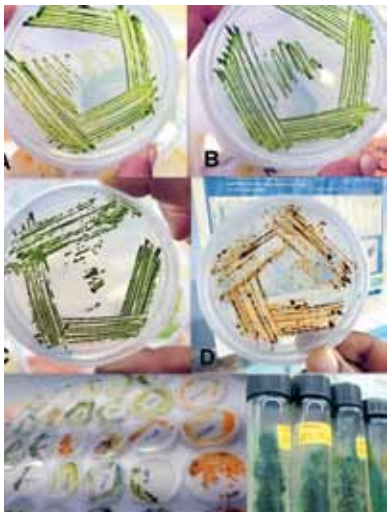


Fig. 24. Growth of microalgae isolates in agar plates and slants (A: Chlorella marina, B: Nannochloropsis oculata, C: Tetraselmis sp, D: Isochrysis galbana, E: Agar plates with different isolates, F: Agar slants with Arthrospira strains.

docosahexaenoic acid (DHA) was observed in *I. galbana* (9.19). Various phyco-chemical and antioxidant properties of microalgae were studied for screening (Fig 5). Methanolic extracts of *Chlorella marina* (48.85±3.18) and *T. weissflogii* (45.83±1.17) showed significantly higher ($P < 0.05$) total phenolic content (expressed as mg GAE g-1), followed by that of *A. maxima* (38.72±2.06). Methanolic extracts of *A. maxima* (8.92±0.92) and Tetraselmis (7.26±0.05) showed significantly higher ($P < 0.05$) total flavonoid content (expressed as mg RE g-1) than others. In case of total antioxidant activity (expressed as mg g-1), highest activity was exhibited by *A. maxima* (5.82±0.6) followed by *T. weissflogii* (4.9±0.02).

The antibacterial properties of various microalgae extracts were

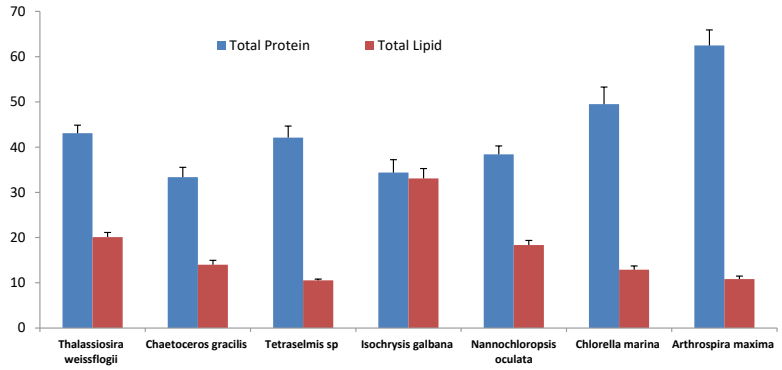


Fig. 25. Proximate composition of selected microalgae biomass (as % dry matter basis)

Fatty acids	*Chaetoceros gracilis*	*Thalassiosira weissflogii*	*Tetraselmis* sp	*Isochrysis galbana*	*Nannochloropsis oculata*	*Chlorella marina*	*Arthrospira maxima*
14:0	10.23	7.62	1.08	20.56	4.08	0.69	0.49
15:0	0.84	3.9	1.42	0.74	0.4	1.7	0.15
16:0	20.04	14.8	15.15	4.47	19.3	14.42	7.13
17:0	0.43	1.36	0.6	0.52	0.43	0.12	0.28
18:0	10.56	3.5	1.46	1.81	6.55	1.57	1.6
20:0	0.14	1.95	2.15	0.64	0.04	0.14	2.63
22:00	--	0.57	3.31	1.24	0.21	--	0.18
24:00	0.14	0.86	0.56	0.35	0.6	0.22	0.83
∑SFA	**42.38**	**34.56**	**25.73**	**30.33**	**31.61**	**18.86**	**13.45**
14:1n7	5.47	1.55	0.22	0.81	0.11	--	--
16:1n7	20.58	22.5	2.24	6.08	17.93	4.04	0.96
17:01	3.76	2.52	0.56	0.93	0.4	0.27	0.05
18:1n9	7.34	12.39	3.36	16.01	11.69	17.62	8.29
20:1n11	0.15	--	1.21	0.14	0.48	--	--
24:1n	0.22	0.48	--	0.41	0.36	--	7.31
∑MUFA	**37.52**	**39.44**	**7.59**	**24.38**	**30.97**	**21.93**	**16.6**
18:2n6	2.03	0.66	15.67	6.54	3.73	11.97	12.86
18:3n6	2.13	1.53	2.58	7.53	0.18	0.51	9.63
18:3n3	2.13	0.82	15.24	20.29	6.24	15.79	11.88
20:2n6	0.52	0.75	11.9	0.32	0.61	0.39	0.41
20:3n6	1.4	0.53	0.3	--	0.43	--	10.87
20:4n6	0.6	0.15	0.3	--	0.08	--	11
20:5n3	5.4	17.77	8.39	1.01	25.2	0.31	8.62
22:5.n3	--	0.78	0.39	0.41	--	--	0.41
22:6n3	0.96	2.25	1.55	9.19	0.95	0.3	3.74
∑PUFA	**15.17**	**25.24**	**56.32**	**45.29**	**37.42**	**29.27**	**69.51**

Table 5. Fatty acid profiles of selected microalgae (as percentage of total fatty acids)

also studied to screen the potential microalgae (Fig). The highest zones of inhibition was exhibited by CPC (C-Phycocyanin) against all three bacteria,
V. harveyi (20.52±0.35 mm),
V. campbellii (18.32±0.52 mm) and *V. parahaemolyticus* (19.48±0.84) and all the values were significantly higher ($P < 0.05$) than that of other microalgae extracts. The methanolic extract of *T. weissflogii* showed zone of inhibition against *V. harveyi* (15.66±0.18 mm), *V. campbellii* (14.47±0.78 mm) and *V. parahaemolyticus* (14.59±0.29 mm) and all the values were significantly ($P < 0.05$) higher than that of other microalgae extracts except that of CPC. It is evident from the results that the antibacterial activity of CPC against *V. harveyi, V. campbellii* and *V. parahaemolyticus* was significantly higher than all other

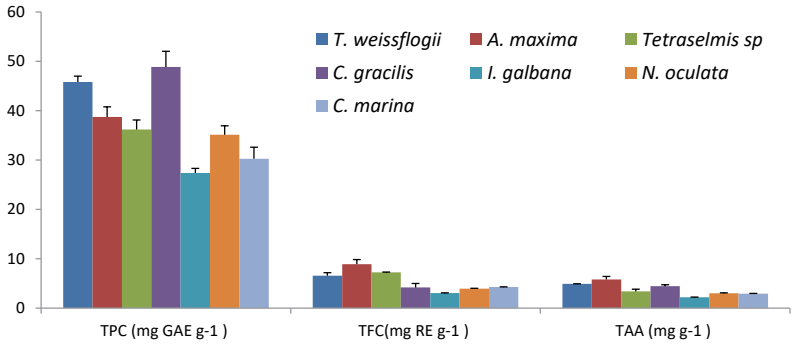


Fig. 26. Total phenolic content, total flavonoid content and total antioxidant activity of microalgae extracts

microalgal extracts and its utility against other aquatic diseases can be further explored.

Influence of dietary microalgal concentrates on growth, survival and health status of *Penaeus vannamei*

Marine microalgae are potential ingredient source and considered as an alternative to fishmeal in shrimp feed owing to their nutritional profile, palatability, and antimicrobial properties. The present study evaluated the nutritional value and antimicrobial activities of *Thalassiosira weissflogii* and *Tetraselmis* sp concentrates. This study also ascertained the effect of microalgae supplemented

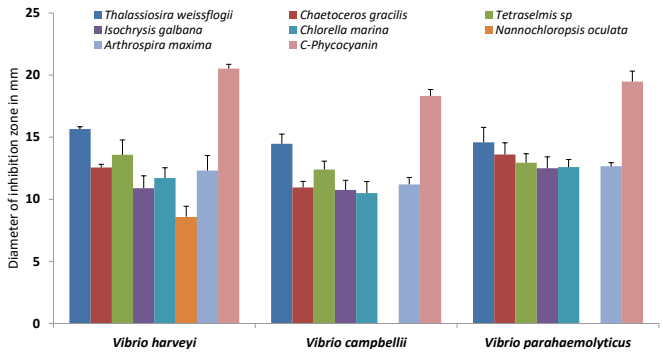


Fig. 27. Diameter of inhibition zone of microalgae extracts (200 µl/well).

diets on the growth and survival of *Penaeus vannamei* post larvae (PL 18, mean weight: 19.714±1.62 mg). The proximate composition showed no significant difference in the crude protein content between these species (*T. wesissflogii*: 43.07±1.78%, *Tetraselmis* sp 42.11±2.55%; p >0.05). However, the crude lipid content of *T. weissflogii* was significantly (p <0.05) higher (20.11±1.02%) than that of *Tetraselmis* sp (10.56±0.27%). Significantly higher (p <0.05) polyunsaturated fatty acid (PUFA) was found in *Tetraselmis* sp compared to *T. weissflogii*. Significantly higher inhibition against Vibrio parahaemolyticus was shown by the Tetraselmis extract compared to that of *T. weissflogii*. Further, a 42 days feeding trial was conducted with three different inclusions of *T. weissflogii* (THA) and *Tetraselmis* sp (TET) concentrates in *P. vannamei* nursery diet (0, 0.5, 1, and 1.5 g kg-1 of diet). Significantly higher (p <0.05) ABW was observed in $TET_{0.5}$, $TET_{1.0}$, $TET_{1.5}$, $THA_{1.0}$, and $THA_{1.5}$ compared to the control. Significantly higher (p <0.05) weight gain (WG) was observed in $TET_{1.0}$ (0.94±0.02 g) compared to the rest of the diets. The weight gain (WG) in treatments $TET_{0.5}$, $TET_{1.0}$, $TET_{1.5}$, $THA_{1.0}$, and $THA_{1.5}$ were significantly higher than the control. These results indicated the beneficial effect on growth and better antimicrobial property to withstand against the common pathogenic microbe and thus indicating the beneficial effect in the early life stages of shrimp post larvae. The feed containing these potential microalgae can provide nutrition and health benefits during the early stages of shrimp and can reduce the disease incidence and opens the new avenues as functional feeds in the early life stages of shrimp.

Effect of dietary taurine on growth and survival of milkfish larvae

A 45 days experimental trial was conducted to evaluate the effect of dietary taurine level in milkfish larvae by including it at varying level i.e., 0, 0.5, 1.0 and 1.5%. Final body weight, weight gain, specific growth rate were higher and feed conversion ratio was lower in *C. chanos* supplemented with 0.5% taurine. Survival (%) was significantly higher in all taurine supplemented groups. The digestive enzyme activities of dietary taurine supplemented groups were significantly (p <0.05) higher compared to the control group. Intestinal histology revealed that there was no abnormality among the supplemental groups but higher intestinal villi length, thickness and gap between the villi were reduced at 0.5 and 1.0% taurine supplemented groups. The results indicated that 0.52% taurine supplementation was found to be optimum in diet of *C. chanos* early life stages based on the broken-line regression analysis.

Effect of dietary squid protein hydrolysate on growth and survival of milkfish larvae

A feeding trial was conducted to study the effect of squid protein

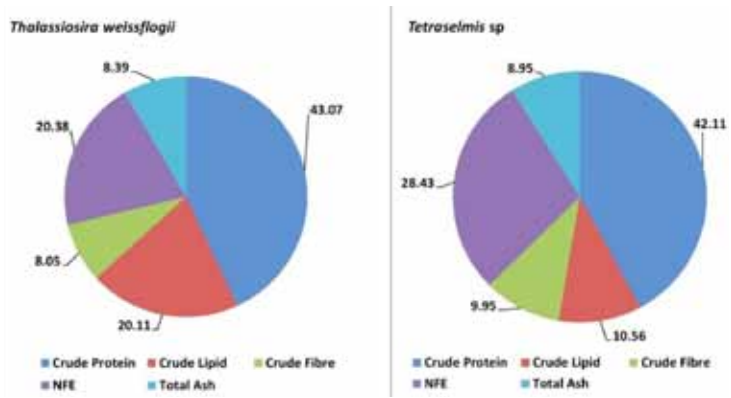
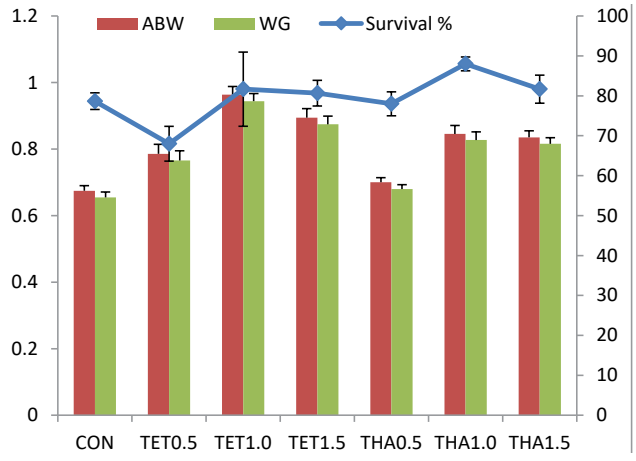


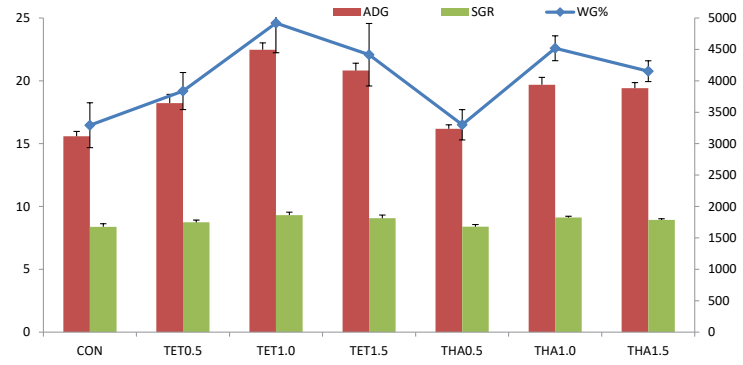
Fig. 28. Proximate composition of selected microalgae biomass (as % dry matter basis)

Fig. 29. Healthy P. vannamei juveniles fed with microalgae incorporated diet



ABW= average body weight (g), WG= weight gain (g)

Fig. 30. Average body weight, weight gain and percentage survival of P. vannamei fed with microalgae incorporated diet.



ADG= average daily gain, SGR= specific growth rate, WG%= percentage weight gain

Fig. 31. Average daily gain, specific growth rate and weight gain percentage of P. vannamei fed with microalgae incorporated diet.

hydrolysate (SPH) supplementation on growth and survival of the milkfish larvae for six weeks. A significantly higher final body weight, weight gain, specific growth rate and a better feed conversion ratio was observed in *C. chanos* supplemented with 1.0% SPH. Survival was maximum in group supplemented with 1.0% SPH. Intestinal digestive enzyme activities of dietary SPH supplemented groups were significantly ($p < 0.05$) higher Compared to with the control group. Second-order polynomial regression analysis revealed that 1.12% SPH supplementation was found to be optimum in diet of *C. chanos* early life stages. The results of the two feeding experiments ascertained the optimal additives for maximising growth and survival of milkfish larvae. The overall results would help in designing suitable larval diets for robust milkfish fry production.

Elucidate the ontogeny of digestive enzyme of milkfish larvae

The present study was undertaken with the main objective of elucidating the critical larval nutritional elements for the production of robust milkfish fry. In this context, we assessed the activity profile of key digestive

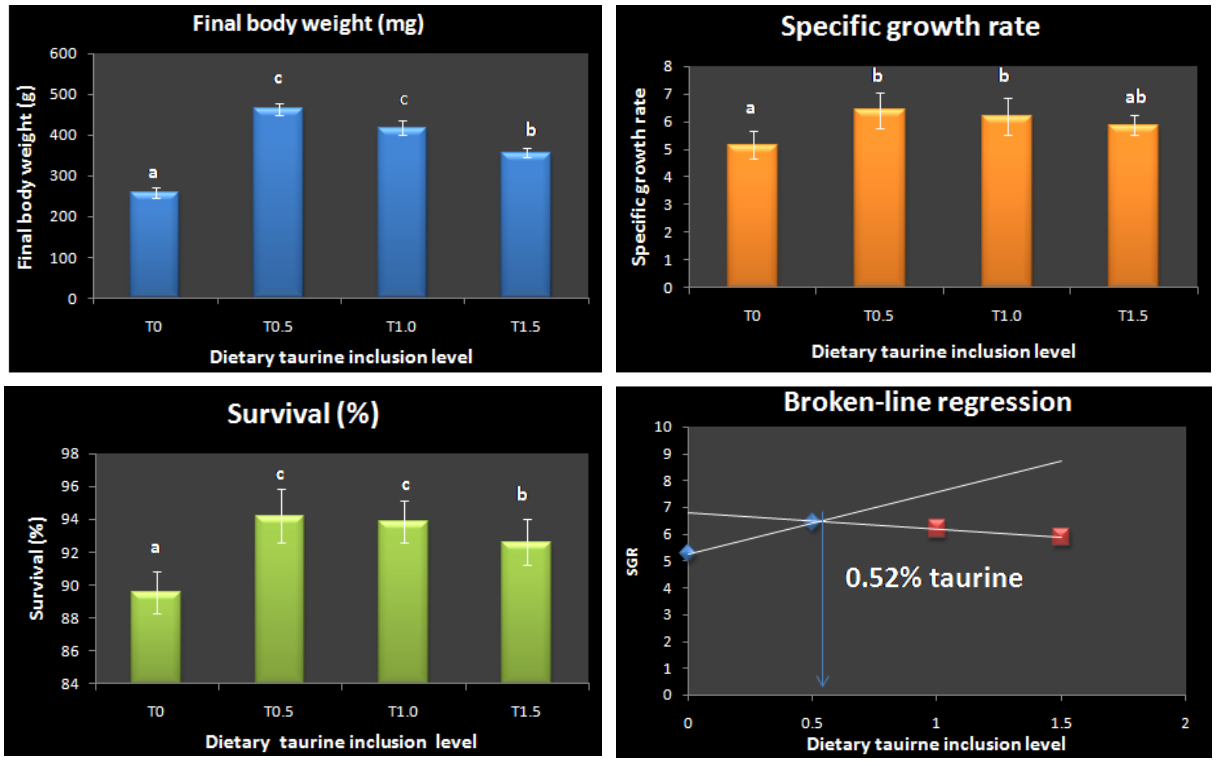


Fig. 32. Effect of taurine supplementation on growth and survival of milkfish larvae

enzymes viz., trypsin, chymotrypsin, leucine aminopeptidase, lipase, amylase and alkaline phosphatase during the early ontogeny of milkfish, *C. chanos* (0, 3, 6, 9, 12, 15, 18, 21, 25 and 30 days post-hatch). With respect to protein digestion, the specific activity of pancreatic enzymes trypsin and chymotrypsin, and intestinal brush border leucine aminopeptidase showed two peaks at 3 and 15 dph, following the introduction of rotifer and artemia nauplii. Similar bimodal peaks were observed for alkaline phosphatase, amylase activities, with first peak at 3 dph, and second peak at 18 and 21 dph, respectively. Whereas in the case of lipase, high activity levels were observed at 0, 3 and 18 dph, with subsequent decrease and fluctuations. Overall, as most of the enzymes were found to have peak activities at 15 to 21 dph, this period can be potentially considered as the developmental window for weaning larvae from live to artificial feeds in milkfish hatcheries.

Effect of dietary soy meal replacement with plant protein sources in juvenile specific pathogen free (SPF) *Penaeus monodon* diets

The soy meal is the major protein source used in shrimp diets. During last year soy meal price got increased up to ₹108 kg^{-1}. Shrimp industry was searching for alternative to soy meal to bring down the feed cost, which will reduce the production cost of the shrimp. The government of India took initiative to import the GMO soy meal for animal feed purpose to reduce feed cost. In this backdrop, an 8-week feeding trail was conducted to study the effect of soy meal replacement with combination of different plant protein sources (PPS). For this purpose four practical diets were prepared using 0, 50, 75, and 100% PPS (read as PPS0, PPS50, PPS75, and PPS100) replacing soymeal and tested in specific pathogen free (SPF) *Penaeus monodon* juvenile. Tiger shrimp juveniles (mean initial weight of 1.8±0.21 g) were stocked @ 20 nos in 350 L capacity FRP tank with flow through system with flow rate of 10 L min-1 and fed with experimental diets in triplicates following a completely randomized design. The group fed with PPS75 showed better growth and survival, but beyond 75% replacement of soy meal with plant protein sources resulted comparable growth and

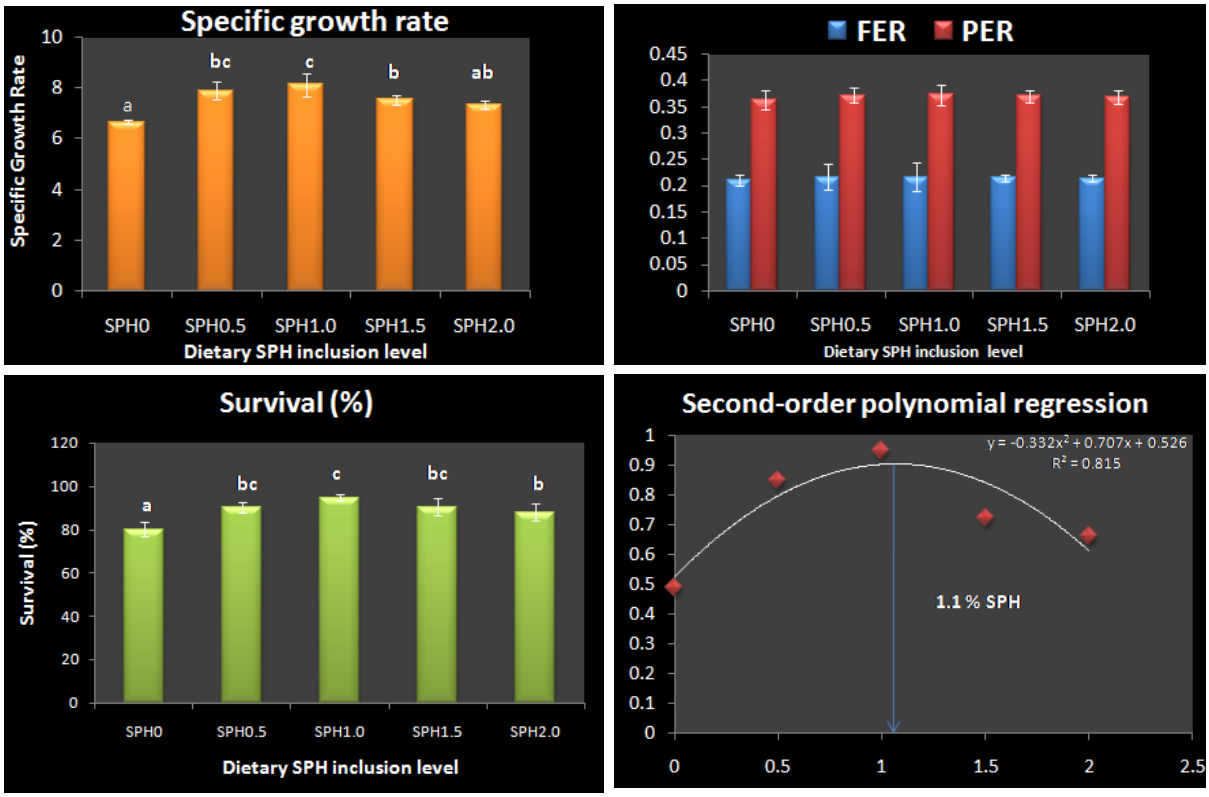


Fig. 33. Effect of dietary squid protein hydrolysate on growth, survival and feed utilization efficiency of milkfish larvae

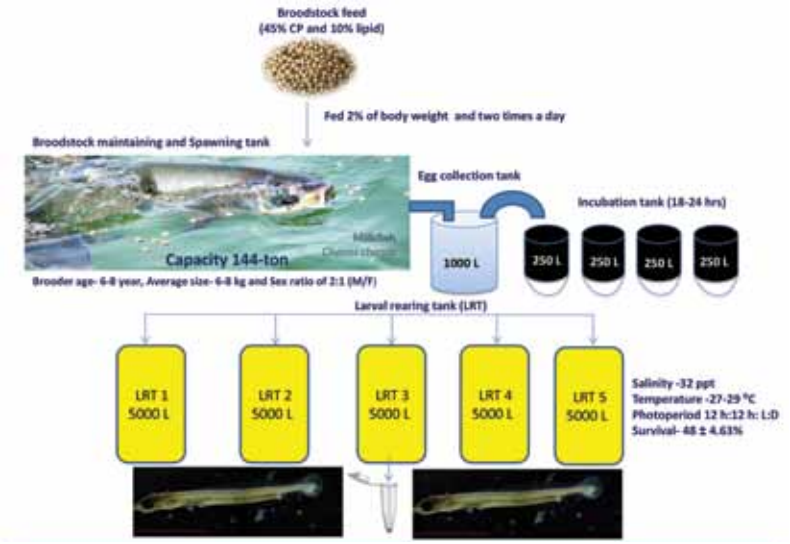


Fig. 34. Schematic representation of the milkfish breeding / hatchery conditions and experimental design (colours in the diagram indicates the original tank colours)

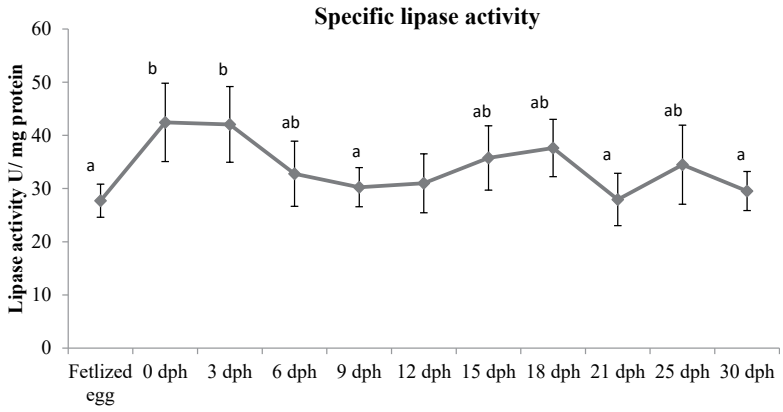


Fig. 35. Ontogeny of the specific activity of lipase in milkfish larvae, from 0 to 30 days post hatch. Enzyme activity are expressed as U mg^{-1} protein (mean ± SD; N=5). Different superscript letters at different time points indicate statistically significant differences (One-way ANOVA; P<0.05)

Fig. 36. Ontogeny of the specific activity of amylase in milkfish larvae, from 0 to 30 days post hatch. Enzyme activity are expressed asU mg-1 protein (mean±SD; n=5). Different superscript letters at different time points indicate statistically significant differences (One-way ANOVA; P<0.05)

lower survival compared to other treatment groups. The broken line regression analysis clearly revealed that the dietary plant protein sources can be incorporated up to 265 g kg^{-1} by replacing 75% soy meal in *P. monodon* diets. The results of the present study provide the baseline scientific information for formulation of cost-effective feeds with alternative plant protein source in place of soy meal for tiger shrimp, *P. monodon* juvenile.

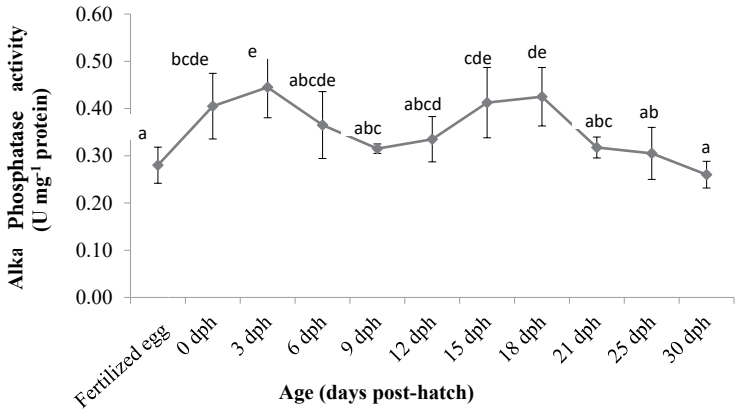


Fig. 37. Ontogeny of the specific activity of alkaline phosphatase in milkfish larvae, from 0 to 30 days post hatch. Enzyme activity are expressed asU mg-1 protein (mean±SD; n=5). Different superscript letters at different time points indicate statistically significant differences (One-way ANOVA; P<0.05)

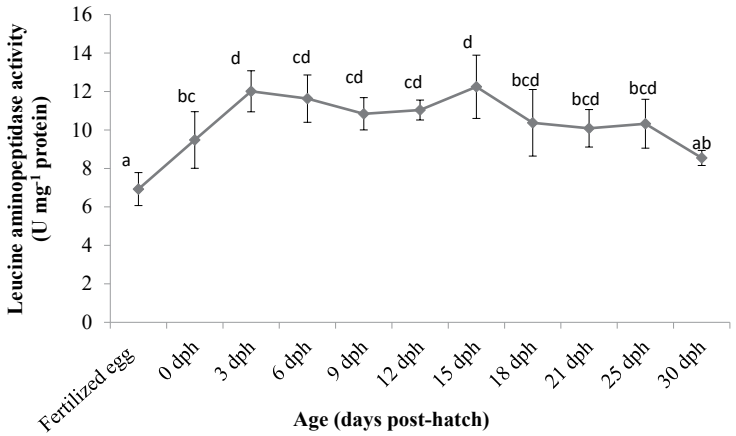


Fig. 38. Ontogeny of the specific activity of leucine aminopeptidase in milkfish larvae, from 0 to 30 days post hatch. Enzyme activity are expressed as U mg^{-1} protein (mean±SD; n=5). Different superscript letters at different time points indicate statistically significant differences (One-way ANOVA; P<0.05)

AQUATIC ANIMAL HEALTH MANAGEMENT

AQUATIC ANIMAL HEALTH MANAGEMENT

Disease surveillance in shrimp farms

Disease surveillance under NSPAAD Phase II was carried out from various shrimp farms during the year 2022 from the month September onwards. Around 94 samples have been collected from various shrimp farms located all over the country. It was found that the prevalence of WSD was found to be 3.22%, Hepatic microsporidiosis at 25.8%, IMN at 10.75%, while other diseases like IHHN, AHPND, DIV, YHD, TS were all found to be negative.

TiLV was detected in cultured

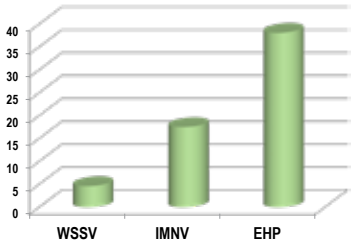


Fig. 1. Shrimp disease prevalence -2022

Oreochromis niloticus, both in apparently healthy (n=5) and diseased farm samples (n=4) indicating the prevalence of the virus in West Bengal. Disease conditions such as running mortality (n=5) and white faeces (n=11) were recorded in *Penaeus vannamei* farms in West Bengal. While EHP was detected 36% *Penaeus vannamei* farms exhibiting white faecal condition, the shrimp farms were found to be free from WSSV, IHHNV, HPV, DIV, TSV, CMNV, IMNV and AHPND disease conditions.

Standardization of molecular diagnostics for detection of *Scylla serrata* Reo Virus (SsRV)

Two sets of RT-PCR protocol with custom designed primers for detection of emerging viral pathogen SsRV in mud crab farming were standardised. The single step protocol yielded 372 bp length PCR products. Further nested

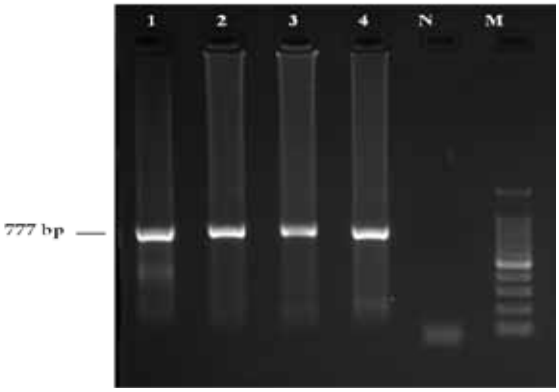


Fig. 2. First step RT-PCR detection of SsRV

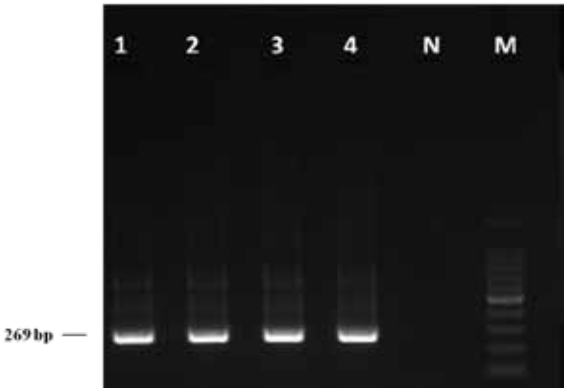


Fig. 3. Second step RT-PCR detection of SsRV

RT-PCR protocol with enhanced specificity was standardised for detection SsRV with expected amplicans of 777 bp and 269 bp. The PCR amplicans of single step PCR were submitted to NCBI under accession numbers OP191702 and OP191703. The phylogenetic analysis of sequences showed homology with other reovirus isolates available in NCBI public data base. Further work on cloning to develop as a ready to use kit is under progress. This technique can be used as routine disease diagnostic tool for MCRV as a part of biosecurity measures for regular screening.

Fig. 4. Phylogenetic analysis of sequences

Fig. 5. Shrimp challenged with SsRV

In vivo transmission studies on SsRV

Challenge experiments were carried out in mud crabs via injection, oral and cohabitation routes. The clinical signs varied with different approach of infection transmission. Mortality ranging from 95 to 100% in challenged animals was observed depending on mode of transmission. Further, experimental studies in shrimp with SsRV infected crab tissue caused 20% intermittent mortalities in injected animals and no mortalities by oral challenge. The carrier state was detected up to 48 days post challenge with no obvious gross changes in experimentally challenged animals. Further work on histopathology is under progress.

Etiology and pathobiology brackishwater ornamental fish diseases

A study on identifying the diseases affecting the ornamental fishes was taken up. Samples were collected from Tamil Nadu and the causative organisms were identified based on morphological, microscopical and molecular tools. *Monodactylus argenteus* suffering from disease condition (N: 15) were collected from pet aquarium shops, Kolathur. The animals exhibited haemorrhages, bleaching of body surface, excess slime and pale gills. Histopathological lesions were observed in liver, gills, kidneys, brain and eyes. The samples found free of VNN infection. Further work on identification of etiological agent and experimental challenge studies are in progress.

Investigation on shrimp white feces/gut syndrome (WFS/WGS)

Shrimp white faeces / gut syndrome is an emerging disease affecting the present culture practice in India and many other parts of the world. Due to considerable growth retardation and small scale mortality, farmers suffer huge economic loss from this problem. Though the microsporidian parasite, *Enterocytozoon hepatopenaei* (EHP) is invariably associated with WFS/WGS, EHP alone has failed to reproduce the disease. A recent report however, has shown that EHP together with *Vibrio parahaemolyticus* can reproduce the disease. Still the complexity of this syndrome is not well understood and a systematic investigation is required. In this regards, ICAR-CIBA, India along with CEFAS, UK carried out a project to have proper understanding

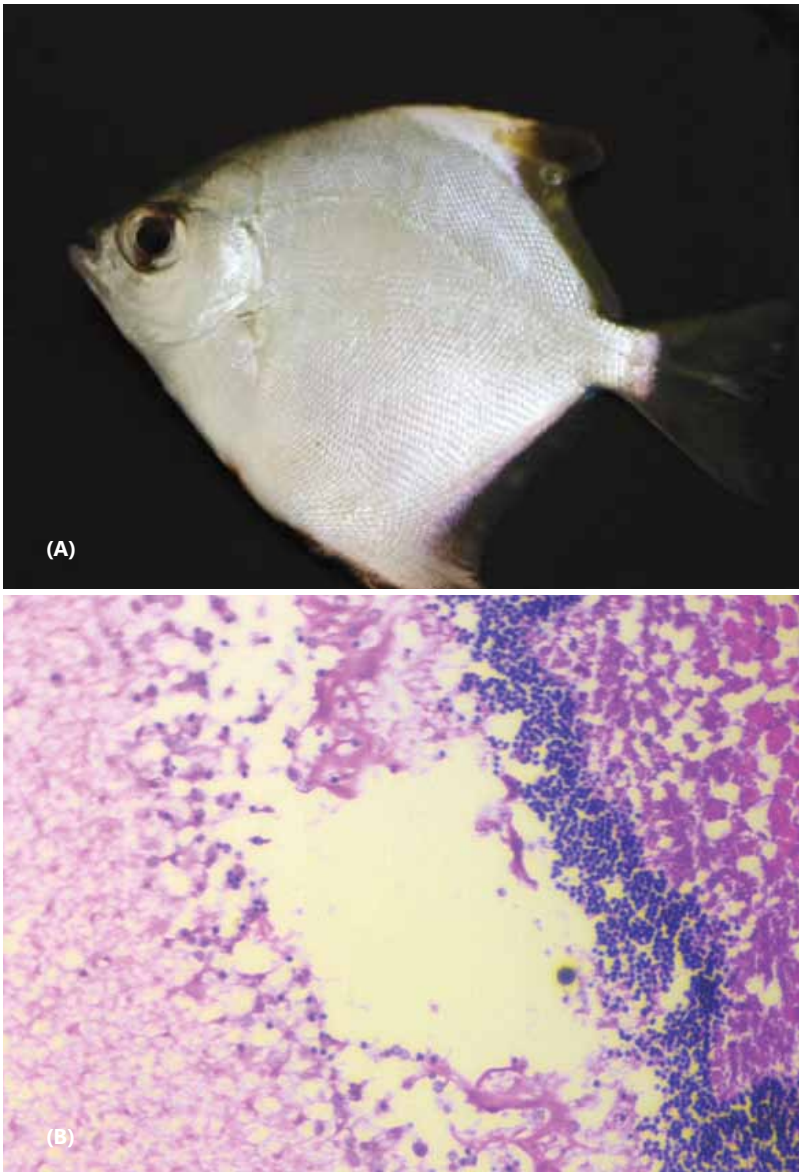


Fig. 6. Gross clinical signs (A) and histology of brain samples (B)

of WFS/WGS. Experiment was designed in which samples were collected from low saline ponds (<10 ppt) and high saline ponds (>10 ppt) for comparison. A total of 12 shrimps with obvious white gut and 12 apparently healthy shrimps from the same pond were collected. PCR for detection of pathogens (white spot syndrome virus (WSSV), infectious hypodermal and hematopoetic necrosis virus (IHHNV), infectious myonecrosis virus (IMNV), yellow head virus (YHV), Taura syndrome virus (TSV), decapod iridescent virus (DIV 1), necrotizing hepatopancratis (NHPB) and acute hepatopancreatic necrosis disease (AHPND)), histopathology, soil and water parameter analysis, transcriptomics and 16s metabarcoding were carried out on those animals.

Details of samplings and locations are presented below:

With respect to pathogen detection, shrimps were positive only for EHP and negative for rest of the pathogens tested. Interestingly, while all the WGS/WFS shrimps

were positive for EHP, about 60-70% of apparently healthy shrimps from same pond were also positive for EHP. Details regarding pathogen detection are presented in the table below:

For RNA-Seq, over 677 million read pairs were generated, with a mean number of ~28 million read pairs per sample (ranging from 11 to 46 million). Only sequence data from shrimp from low-salinity ponds were analysed.

All samples contained picornavirus sequences (similar to Wenzhou shrimp virus 8 [WZV8]), however, the total number of reads representing picornavirus (and as a proportion of all reads) were higher in samples affected from WFS.

Sl. No.	Location	Species cultured	DOC	Salinity (ppt)	Pond Area (acre)
1	Vellaikulam/Tamil Nadu (TN)	*Penaeus vannamei*	40	5	1.0
2	Vellaikulam/TN	*P. vannamei*	80	5	1.0
3	Nellore/Andhra Pradesh (AP)	*P. vannamei*	60	3	1.1
4	Nellore/(AP	*P. vannamei*	60	9	1.0
5	Nellore/ AP	*P. vannamei*	45	15	2.0
6	Nellore/(AP	*P. vannamei*	41	13	1.5
7	Nellore/AP	*P. vannamei*	65	13	0.5
8	Nellore/AP	*P. vannamei*	61	20	2.0

Table 1. Details of samplings from different ponds affected with WGS/WFS
In the same pond, shrimp had clear WGS/WFS where as some shrimps were still looking apparently healthy without any WGS/WFS

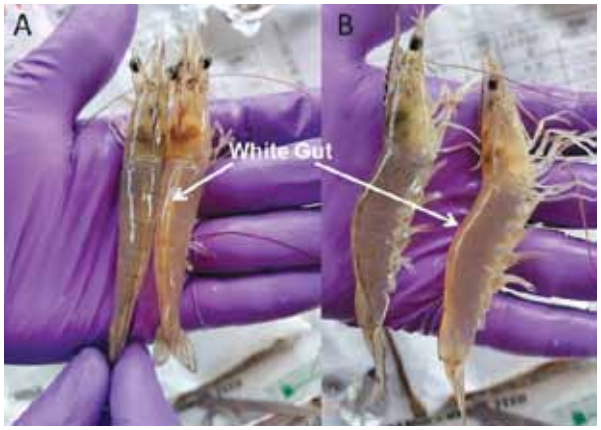


Fig. 7. Photographs showing shrimp without and with clinical signs of white faeces syndrome (WFS). A) Posterior view of individual shrimp without clinical signs of WFS (left) and with WFS (right). B) Lateral view of individual shrimp without clinical signs of WFS (left) and with WFS (right).

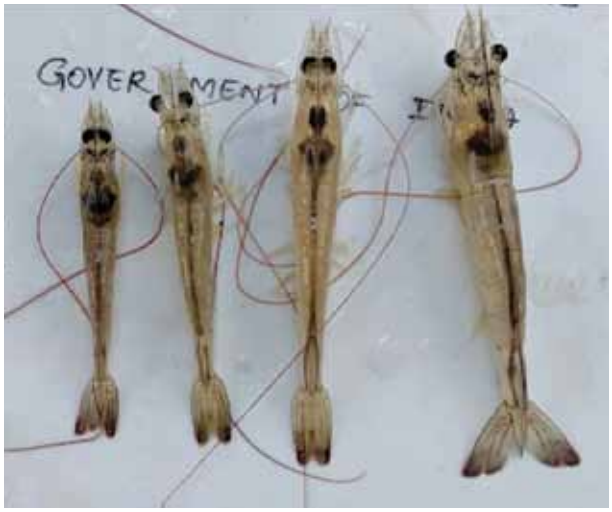


Fig. 8. Size variation of shrimp from a white faeces syndrome (WFS) affected pond

Pathogen	Detection Method	Status	
		With WG	Without WG
EHP	Nested PCR, Jaroenlak et al. (2016)	90-100 % 1st Step, Rest: 2nd Step	60-70% 1st Step, Rest: 2nd Step
WSSV	Nested PCR, Lo et al. (1996)	Negative	Negative
IHHNV	Single Step PCR, Nunan et al. (2000)	Negative	Negative
IMNV	Nested RT PCR, Poulos and Lightner (2006)	Negative	Negative
YHV	Single Step RT PCR, Mohr et al. (2015)	Negative	Negative
TSV	Single Step RT PCR, Navarro et al. (2009)	Negative	Negative
DIV1	Nested PCR, Qiu et al. (2017)	Negative	Negative
AHPND	Nested PCR, Dangtip et al. (2	Negative	Negative
NHPB	Nested PCR, IQ 2000 Kit	Negative	Negative

Table 2. Status of pathogen presence in different samples

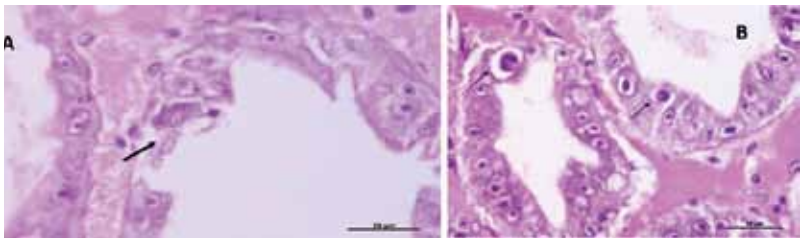


Fig. 9. Histopathology of WGS/WFS affected shrimps showing EHP spores (A) and inclusion bodies suggestive of picorna virus in the hepatopancreas (B).

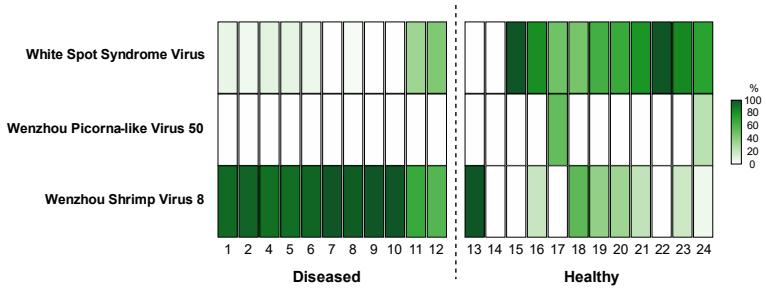


Fig. 10. Heatmap showing the abundance of viral reads assigned to White spot syndrome virus (WSSV), Wenzhou picorna-like virus 50, and Wenzhou shrimp virus 8 in WFS and healthy shrimp.

16s amplicon sequencing resulted in ~2.7 million read pairs (ranging from 67 to 138 million, with an average of ~114 million read pairs per sample) and ~3.8 million read pairs read pairs (ranging from ~106 to 215 million read pairs, with an average of 158 million per sample) for the low salinity and high salinity samples, respectively. Only data from the low salinity shrimp were used for further analysis.

Species accumulation curves suggested that the species richness was captured for all samples. A total of 895 low abundance features were removed based on prevalence. A total of 40 low variance features were removed based on interquartile range. The number of features remains after the data filtering step was 353.

Alpha and beta diversity were measured for WFS and healthy shrimp. Alpha diversity for WFS shrimp was lower than that of healthy shrimp, suggesting that species richness was reduced in the hepatopancreas of shrimp with symptoms of WFS. Beta diversity analysis showed significantly different diversity between healthy and WFS shrimp (p-value: 0.0003)

Water and soil samples were collected from low, medium saline and saline areas having salinity ranging from 3-5 ppt, 9-15 ppt and 20 ppt, respectively. In low saline areas, the pH of the water was low compared to the saline area. Total alkalinity was within the optimal range for shrimp farming. Total hardness values depended on the salinity and increased with salinity. In most farms, the Ca:Mg ratio varied between 1:1 and 1:2. In some farms, abnormally calcium concentration was high compared to magnesium and the Ca:Mg ratio was 8:1. In this pond, potassium concentration was very low. In all other ponds, K: Na ratio varied between 1:21 and 1:60. In the low saline region, it was around 1:36. Metabolites concentrations are within the optimum level except in one pond, which recorded the value of 9 and 5 ppm for TAN

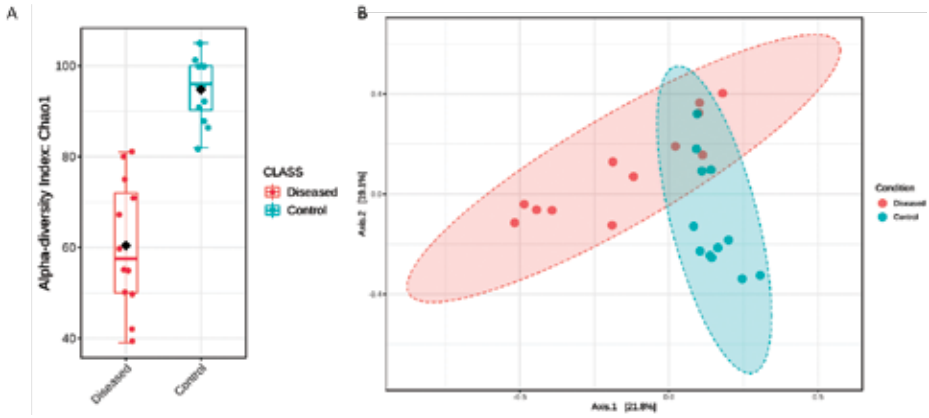


Fig. 11. Alpha and Beta diversity of bacteria present in healthy and WFS shrimp from a low salinity pond.
A) Alpha diversity measure using Chao1 at OTU level represented as boxplot. Each boxplot represents the diversity distribution of a group present within Condition class (Statistical significance: p-value: 0.00031001; [T-test] statistic: -4.3376). WFS shrimp represented by the red box and healthy shrimp represented by the blue box. B) PCoA plot using bray distance. WFS shrimp represented by the red points and healthy shrimp represented by blue points. The explained variances are shown in brackets.

and NO_2-N respectively. Nitrate and phosphate concentration was within the optimum level for plankton production. Chlorophyll-a concentration varied from 0.58 to 12.8 µg l^{-1}. Chromophoric dissolved organic matter (CDOM) varied between 1.34 and 11.27 ppb. There is an inverse relationship between salinity and CDOM. Soil pH varied from 6.42 to 10.02, but this is not influenced the pH of water. Electrical conductivity varied from 0.39 to 4.8 dSm^{-1}. Organic carbon content was lower than the optimum value.

Development of therapeutics for EHP control

Enterocytozoon hepatopenaei (EHP), emerging microsporidian parasite, has been reported in several shrimp farming nations. EHP is the causative agent of the disease hepatopancreatic microsporidiasis (HPM). EHP reported to be associated with stunted growth/ size variation, white feces syndrome (WFS) and reported to cause severe economic losses in shrimp aquaculture. At present the prophylactic and therapeutic protocols for treatment and control of *Enterocytozoon hepatopenaei* are very limited. The present study aims to develop prophylactics and therapeutics for the treatment of *Enterocytozoon hepatopenaei* (EHP). Different chemical drugs such as albendazole, nifedipine, verapamil, metronidazole, tinidazole, ketaconazole and natural plant derivatives such as carvocrol and naringenin were evaluated for anti-microsporidian activity.

To check the spore's viability, EHP spores 10^4 per ul was incubated with different chemical drugs such as albendazole, nifedipine, verapamil, metronidazole, tinidazole, ketaconazole and natural plant derivatives such as carvocrol and naringenin for overnight. Then the spore extrusion activity was evaluated. In which metronidazole at 0.0125%, albendazole 0.025% and naringenin at 1 mg/ml were found effective in the complete inhibition of spore extrusion (Fig. 12).

To check the effect of chemical drugs and natural derivatives in-vivo, naïve shrimps were fed with shrimp feed mixed with therapeutics and reared up to 30 days. After 30 days EHP load was quantified in all the treatment and control. Interestingly all the drugs had significantly reduced the EHP load when compared to control (Fig. 13).

However in light microscopy investigation of hepatopancreas (HP) severe necrosis, black discoloration, severe degeneration was observed in the hepatopancreas smear of all treatment including control except naringenin. Also in HP histological section severe necrosis, sloughed off epithelial cells, dilated epithelial cells, increased haemal sinus, EHP spore

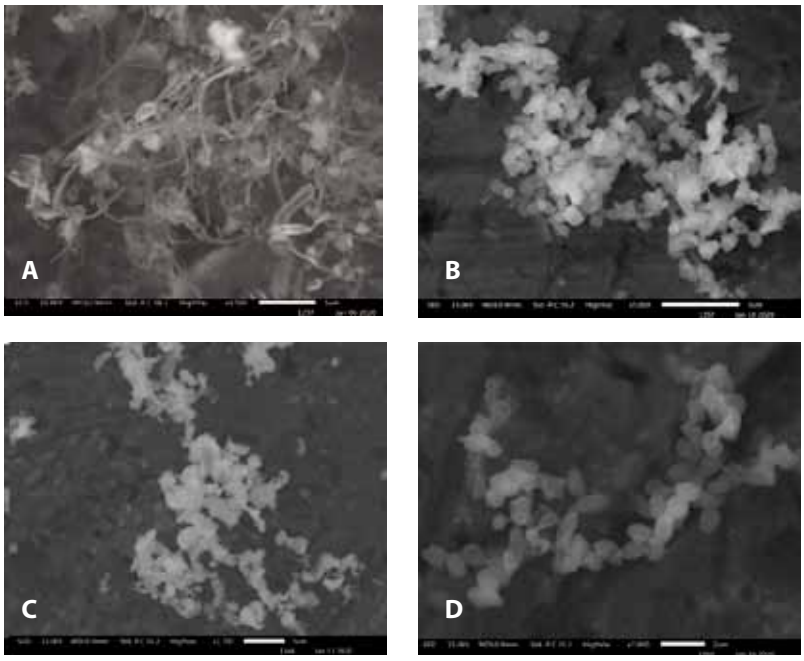


Fig.12. A- Control spores observed with sporulation, Spores treated with albendazole (B), metronidazole (C) and naringenin (D) observed with no sporulation.

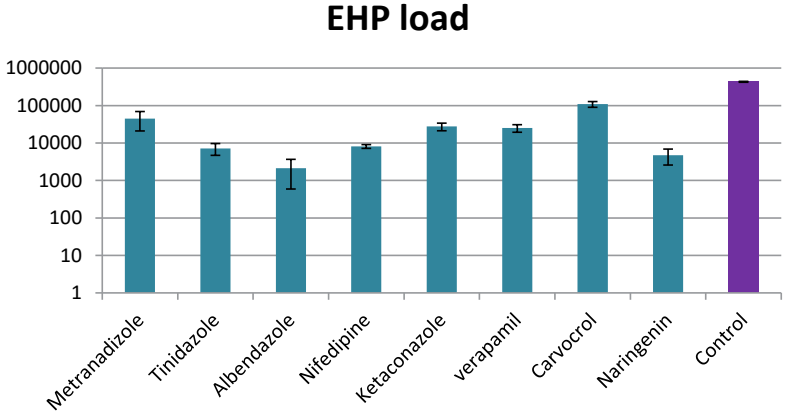


Fig. 13. EHP load of different treatment quantified by q-PCR

and developmental stages were observed all treatment including control except naringenin. In the naringenin treatment HP tubules were observed to be largely normal (Fig. 14)

However in the immune parameters such as the total haemocyte count of naringenin was significantly higher than all the treatment and control (Fig. 15A). The phenoloxidase activity of metronidazole, tinidazole, albendazole, and naringenin were significantly higher than the control and other treatment (Fig. 15B). Also, the catalase activity of metronidazole, albendazole, and naringenin were significantly higher than control and other treatments (Fig 15C).

In the growth parameter the average body weight of naringenin treatment was significantly higher followed by ketacanozole treatment and the survival rate of nargingenin treatment was significantly higher followed by carvocrol. Though the drugs such as albendazole, nifedipine, verapamil, metronidazole, tinidazole, ketaconazole and natural plant derivative such as carvocrol were significantly reduce the EHP load but largely failed to improve the growth and survival of EHP infected shrimp. While, the natural derivative naringenin at 1mg/ml significantly reduce the EHP load and improve the growth and survival of infected shrimp. Thus the natural derivative naringenin can be used as therapeutic/ neutriceutical for the treatment and control of EHP.

Investigation of vectors and carriers of *Enterocytozoon hepatopenaei* in shrimp farms

Enterocytozoon hepatopenaei (EHP), the emerging microsporidian is

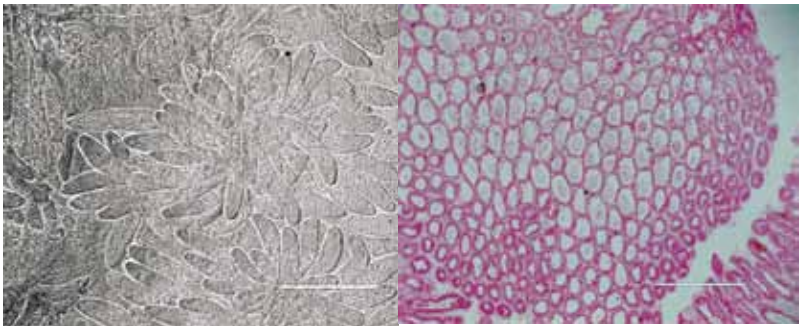


Fig 14. Light microscopic investigation of naringenin fed shrimp HP.

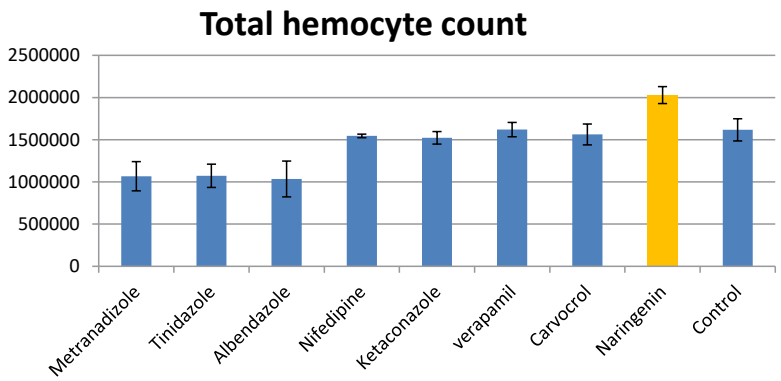


Fig. 15A Total hemocyte activity of all the treatments

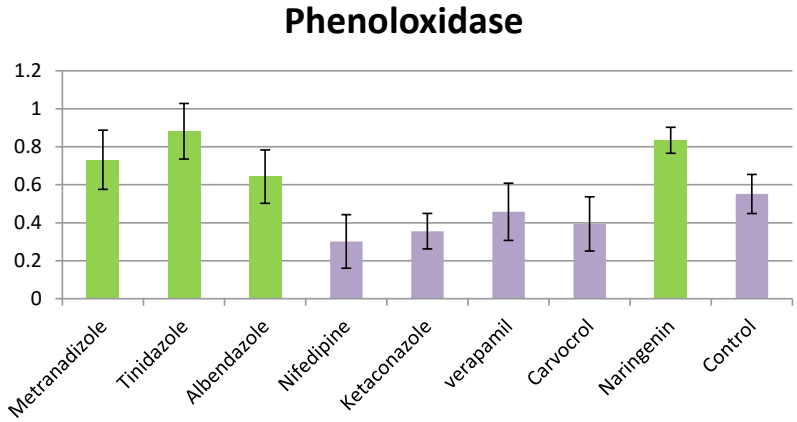


Fig. 15B Phenoloxidase of all the treatments

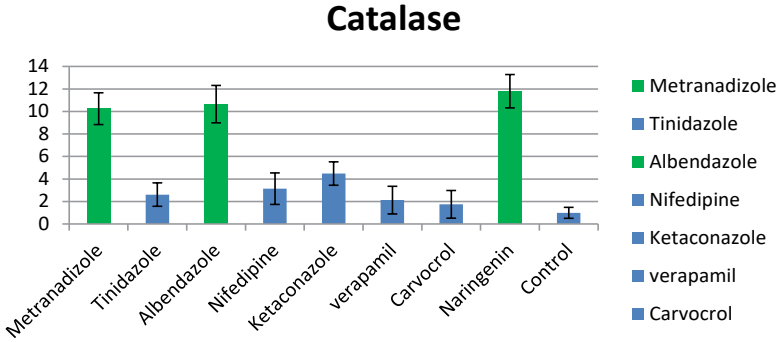


Fig. 15C Catalase activity of all the treatment

infecting penaeid shrimps and cause severe growth retardation/ size variation. EHP transmits the disease to the host horizontally without any intermediate host. Also the studies on vectors and carriers of EHP in shrimp farms are very limited. In the present study shrimp farms in Nellore and Thiruvallur were surveyed for the vectors and carriers of EHP. The possible vectors and carriers such as aquatic insects, mussel, clam and mysid shrimps were collected. In the preliminary investigation among the aquatic insects the *Gerrid* sp, *Belostoma* sp and the mysid shrimp were found positive for EHP at the nested level (Fig. 17). Further investigations are needed.

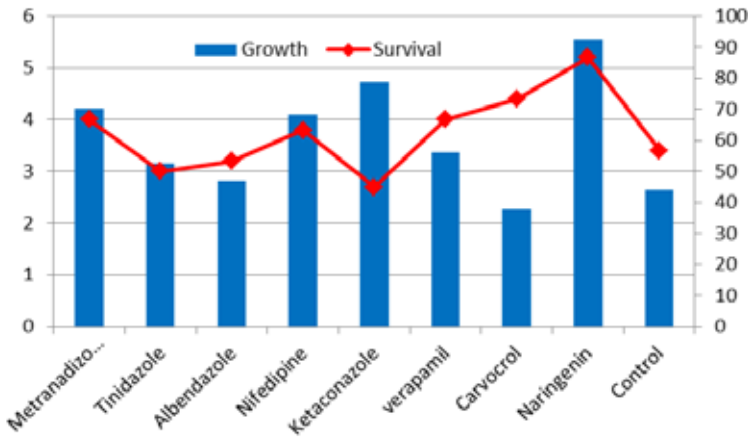


Fig.16. Growth and survival of different treatments after 30 days

Identification of suitable *in vitro* cell culture system for brackishwater finfish viruses and investigation of molecular interaction between virus and host cells

Asian seabass (*Lates calcarifer*), is one of the most preferred species for coastal aquaculture and open sea cage farming in southern part of India. The seabass culture is constantly increasing its production through intensifying the supply of nursery reared fingerlings from captive breeding stocks. Especially fingerlings and juveniles are facing the high incidence of diseases due to various etiologies. The foremost cause leading to heavy loss in hatchery and at farm level is of viral origin through horizontal and vertical transmission. The basic information of viral pathogen and its cell interaction can be effectively understood with the *in vitro* development of primary cells and cell lines from seabass. The seabass primary explant culture of muscle, brain, head kidney, spleen, liver and kidney tissue fragments were grown separately in L-15 medium supplemented with fetal bovine serum. The explant culture of muscle and brain tissues could establish in to a fibroblastic monolayer with 100% confluency in three weeks. The primary cell culture of muscle and brain cells were sub cultured at a ratio of 1:2 to a confluent monolayer of adherent fibroblastic cells in 5 days grown up to four passage level. The explant culture of head kidney developed with the proliferation of heterogeneous cells of adherent and non-adherent, both pigmented and non-pigmented, epithelioid round, fibroblastic cells appeared in two weeks, the adherent cells developed into fibroblast monolayer with 100% confluency in four weeks. The explant of spleen, liver and kidney could develop 10 to 15% confluency in four weeks of culture. The cell line of seabass developed for further pathogenicity studies and viral vaccine development.

Pathological changes observed during hepatic microsporidiosis infection with white spot syndrome disease

Occurrence of coinfection is

Fig. 17. Aquatic insects Gerrid sp. (A), Hydropsychid sp. (B), May fly (C), Belostoma sp (D).

Fig. 18. Morphology of primary culture of Asian seabass muscle cells in 12 days of explant culture under phase contrast microscope (4X).

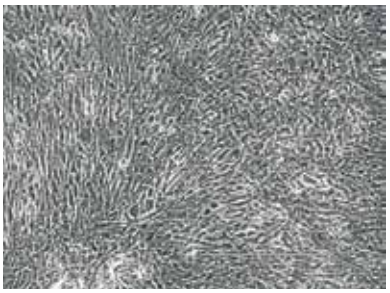


Fig. 19. Asian seabass muscle cells in third passage showing 100% confluent monolayer in 5 days of culture (40X)

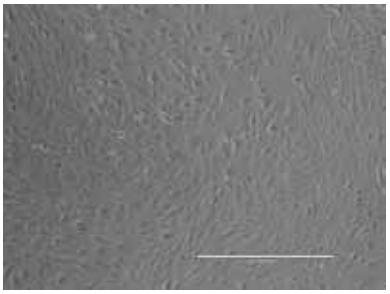


Fig. 20. Primary culture of Asian seabass brain cells at 5th passage showing uniform fibroblast and epithelial like cells (40X)

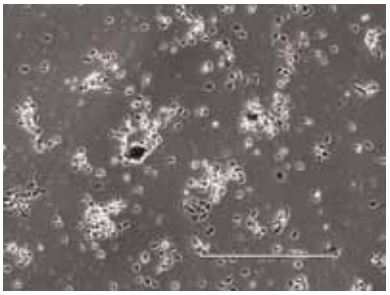


Fig. 21. Morphology of primary culture of Asian seabass head kidney cells in 12 days of explant culture with epithelioid round and fibroblastic cells under phase contrast microscope (40X)

increasing day by day in shrimp farms. Many research reports reveal the presence of multiple pathogens as a cause for shrimp mortality in

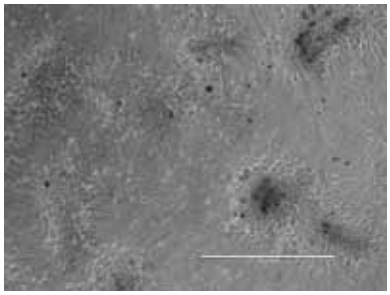
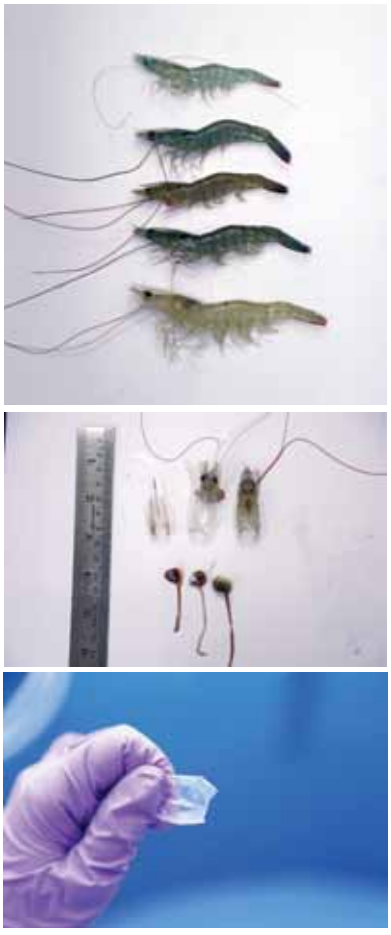


Fig. 22. Primary culture of Asian seabass head kidney cells at 4 weeks showing monolayer with fibroblastic cells (4X)

farms. To understand the pathology of hepatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) and white spot syndrome virus an experiment was conducted for 76 hrs in the laboratory with 168 *Penaeus vannamei* shrimp weighed about 8-10 gm. The shrimp were grouped into control and challenge group, which was fed with infected EHP for two days to induce EHP in the shrimp. Once the faecal matter showed the presence of pathogen, they were grouped into three groups of 28 @ challenge group and control group. Based on the biomass the challenge group shrimp were fed with WSSV infected shrimp tissues and the animals were samples at 4, 8, 28, 52, 56 and 76 hrs. From 4 hrs onwards the challenge group animals showed WSSV positive amplification in nested PCR and from 28 hrs onwards the challenge group were positive by first step PCR. Throughout the experiment the EHP copy number was found to be 105 in the challenge group of animals.

The gross observation revealed the presence of white spots in the carapace from 28 hr onwards. The histopathological changes were studied in mainly in the target organs like gill and hepatopancreas. The WSSV inclusion bodies were evident from 28 hrs of infection in the gill tissue. The gill tissue appeared normal in 4 hrs of infection whereas during 8 hrs of infection the heamal sinus space was found to increases with haemolymph as well as haemocytic infiltration was evident in the gill tissue. From 52 hrs of infection onwards gill tissue necrosis was observed.

The hepatopancreas of the challenged shrimp had EHP spores in the tubules and tubular



23. Challenge group of animals showing size variation as well as white spot in the carapace

necrosis as well as spores was seen in the tissue The immune genes like prophenol oxidase, SOD, lysozyme and crustin were studied in heamolymph, gill and in hepatopancreas. Prophenol oxidase and SOD expression was

found to be expressed more in hepatopancreas that too during later stage of infection. While lysozyme and crustin expression was found to be more in gill tissue compared to hepatopancreas and haemolymph.

The role of apoptosis was studied in gill, haemolymph as well as in hepatopancreas by profiling the expression of caspase genes and p53. Caspase 2 and caspase 5 expressions was seen in haemolymph while caspase 3 expression was found to be more in hepatopancreas while caspase 4 was found to be more in gill tissue. The expression of p53 was found in the later stage of infection that too during 52 as well as in 76 hrs of infection in haemolymph and gill tissue.

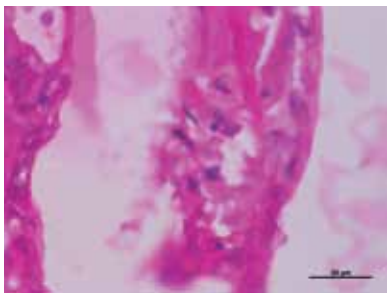


Fig. 24. WSSV inclusion bodies in the gill tissue – H & E (100x)

This study clearly shows that EHP can accelerate the infection in shrimp farms since the control animals were free from infection throughout the study. Hence

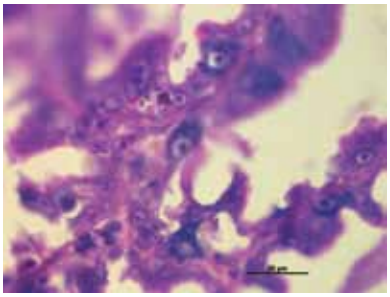


Fig. 25. Hepatopancreas of the challenge animals with EHP spores @ 56 hrs – H & E (100x)

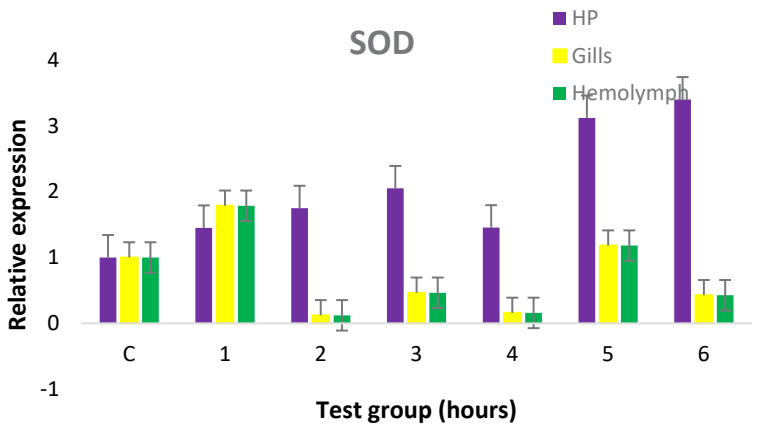


Fig. 26. Expression of SOD in various tissues in experimental shrimps

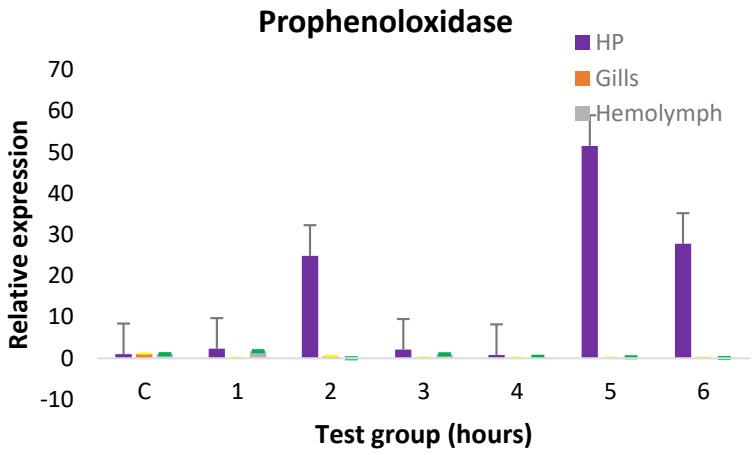


Fig. 27. Expression of prophenol oxidase in various tissues in experimental shrimps

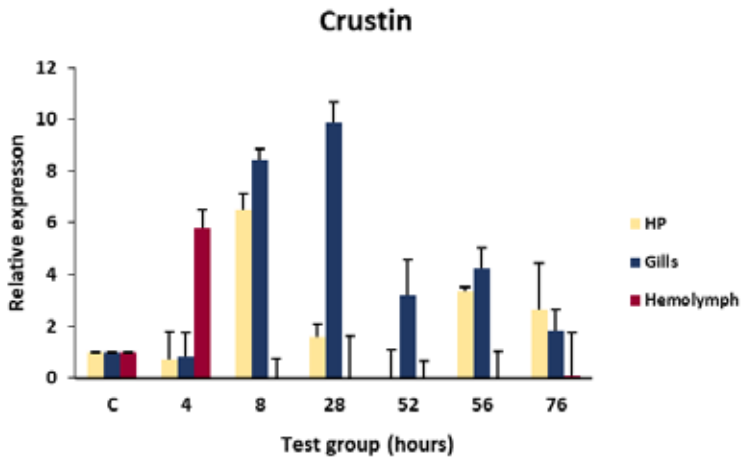


Fig. 28. Expression of crustin in various tissues in experimental shrimps

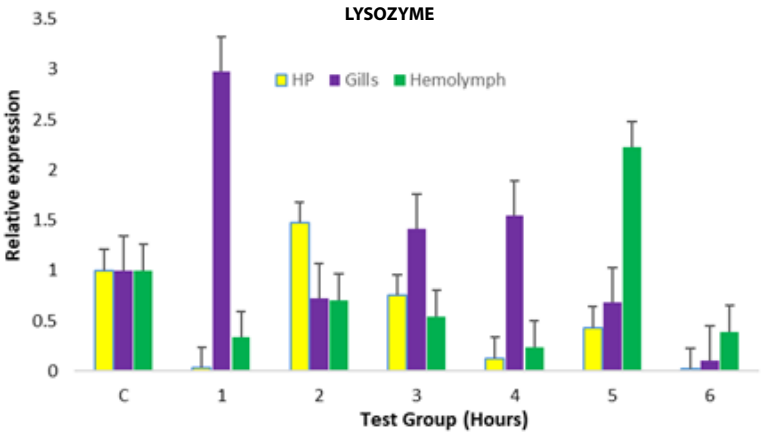


Fig. 29. Expression of Lysozyme in various tissues in experimental animals

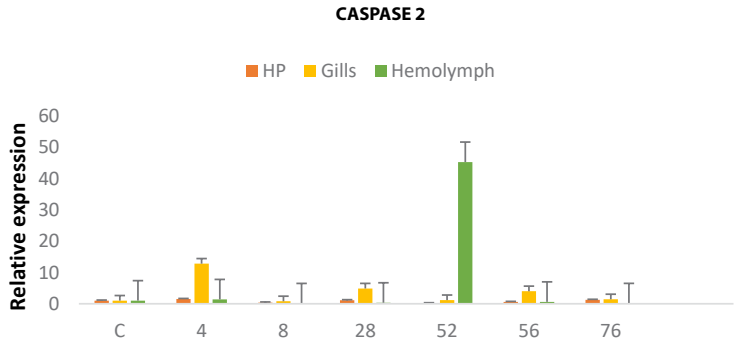


Fig. 30. Expression of Caspase 2 in various tissues in experimental shrimps

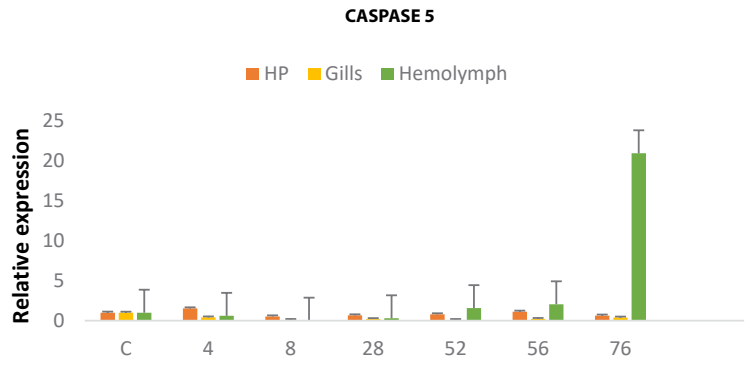


Fig. 31. Expression of Caspase 5 in various tissues in experimental shrimps

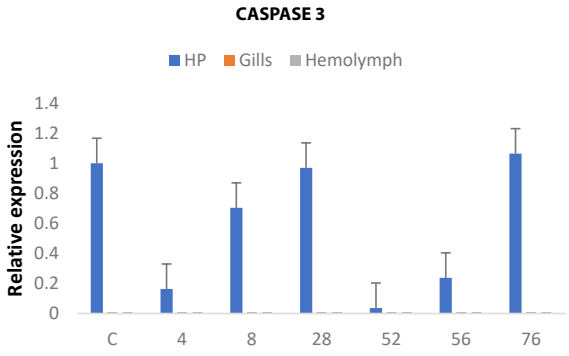


Fig. 32. Expression of Caspase 3 in various tissues in experimental shrimps

stocking of PCR tested negative seeds is highly essential to fetch a good crop.

In vitro transcriptome profiling of nervous necrosis virus infected Asian seabass primary brain cell culture

Viral nervous necrosis (VNN) caused by nervous necrosis virus (NNV) is a major disease as it causes massive mortality of more than 90% in the larval stage, and continues to be a threat for Asian seabass in the juvenile stage. Asian seabass primary brain cell culture was established and was experimentally infected with NNV. The samples were collected at day 0 (before infection), 1 dpi (days post infection) and 3 dpi in Tri reagent. RNA was isolated and RNA sequencing was carried out by Novaseq 6000 platform (2X150 bp) for 40 million reads. The raw reads were quality checked, trimmed and aligned to the total transcripts of Asian seabass. The mapping percentage of cleaned reads to the annotated Asian seabass transcriptome ranged from 67.2 to 69.1. We observed 4,130 upregulated and 4,430 downregulated genes in 1 dpi brain cells compared to uninfected cells whereas 2,864 upregulated and 2,741 downregulated genes were observed in 3 dpi vs uninfected brain cells (Fig. 35 and Fig. 36). The differentially expressed (DE) genes of 1 dpi vs day 0 represented seven prominent gene ontology terms, viz., ribonucleoside binding, nucleotide binding, guanyl ribonucleotide binding, guanyl nucleotide binding, purine ribonucleoside binding, purine nucleoside binding and GTP binding. Gene ontology classified DE genes of 3 dpi vs day 0 into several categories viz.,

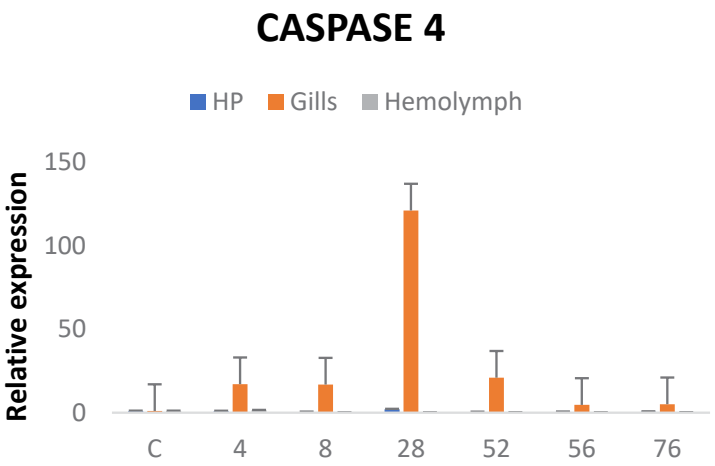


Fig. 33. Expression of Caspase 4 in various tissues in experimental shrimps

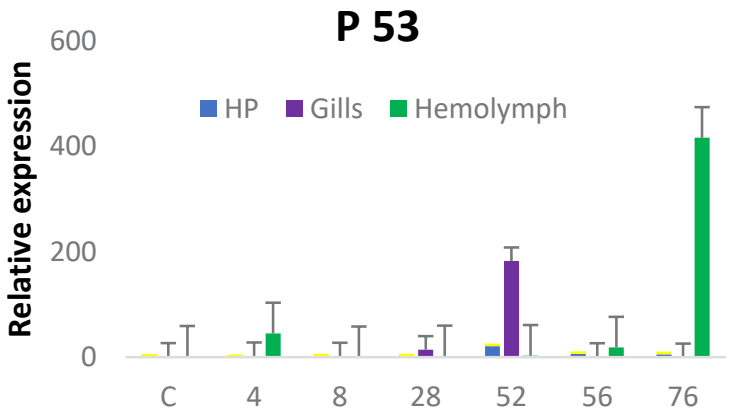


Fig. 34. Expression of Caspase p53 in various tissues in experimental shrimps

peptide metabolic process, amide biosynthetic process, peptide biosynthetic process, translation, cellular amino acid metabolic process and vacuolar membrane (Fig. 37). KEGG pathway analysis identified the DE genes of both the groups majorly involved in MAPK signaling pathway. The results offered vital information of novel genes and their molecular mechanism involved in Asian seabass-NNV interaction.

Comparative evaluation of the expression profile of immune-related genes in Asian seabass (*Lates calcarifer*) and milkfish (*Chanos chanos*) infected with nervous necrosis virus (NNV)

Nervous necrosis virus (NNV) produces significant mortalities in larvae and juveniles of many brackishwater fish species. Asian seabass (*Lates calcarifer*), a major candidate species in brackishwater aquaculture, is more vulnerable

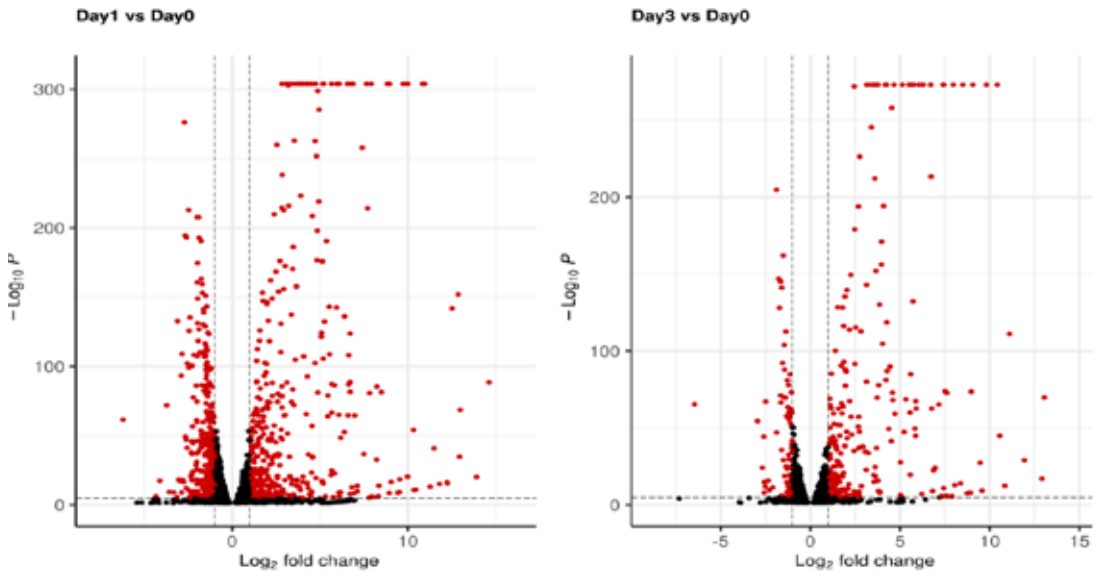


Fig. 35. Volcano plot displays differentially expressed genes

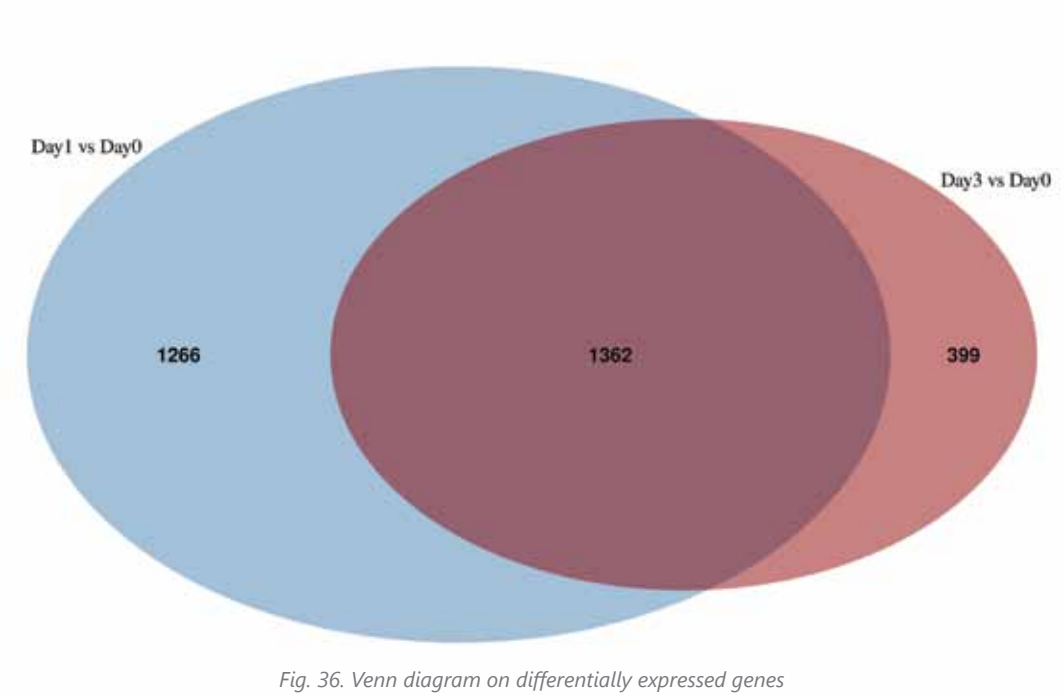


Fig. 36. Venn diagram on differentially expressed genes

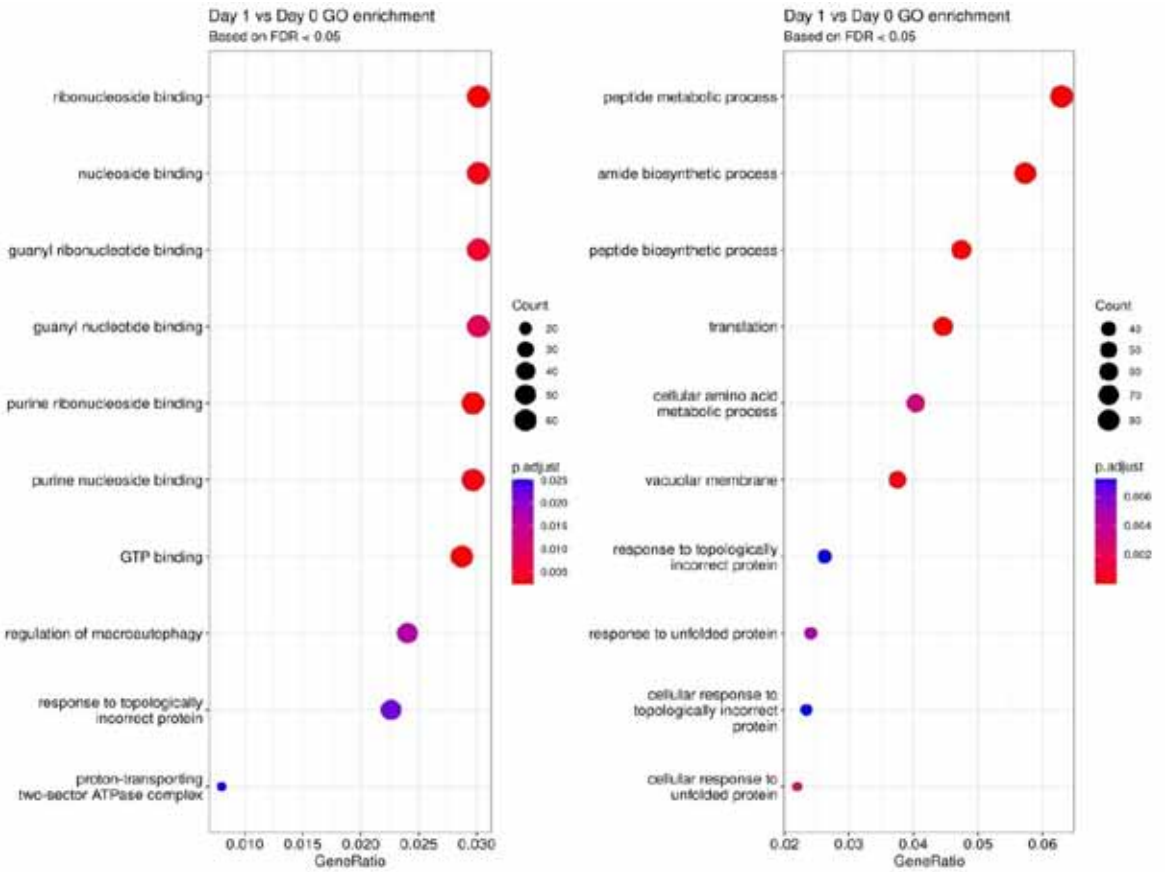


Fig 37. Gene ontology classification of DE genes

to diseases, whereas milkfish (*Chanos chanos*) is relatively less susceptible. The present study aimed to evaluate the effects of NNV infection in Asian seabass and milkfish by analyzing immune gene expression. Juveniles of both the species were infected with NNV by injecting 10^4 TCID50/ml per fish, and uninfected juvenile fishes were used as control. Brain, liver, spleen and kidney tissues were collected at 1, 3, and 5 days post-infection. Quantitative polymerase chain reaction (qPCR) was performed to assess the expression profile of immune genes such as Tol3, IL1, IL13, MHC, and CXC. All the genes exhibited higher expression in the kidney compared to other organs of Asian seabass. Similarly, a higher expression pattern was observed in IL1, IL13, and MHC in the kidney of milkfish, while Tol3 and CXC were highly expressed in the brain. However, the expression of different genes was higher in Asian seabass than milkfish, which could be related to the higher susceptibility of seabass to NNV. Variations in the expression of genes between the days post-infection (1, 3, and 5 dpi) were also observed in both the species. Although brain is the primary target organ for NNV infection, kidney of infected fishes displayed higher fold expression than other organs, and the liver had the least expression.

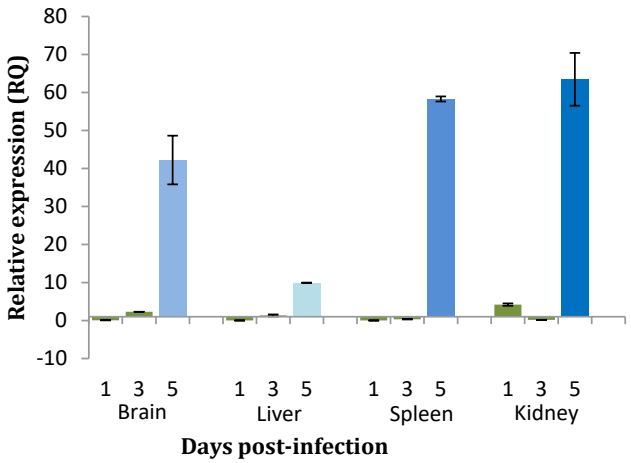


Fig. 38. IL13 expression in L. calcarifer. Mean ± SD

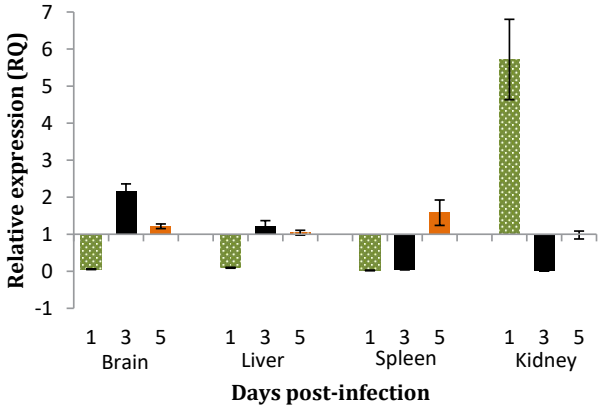


Fig. 39. IL13 expression in C. chanos. Mean ± SD (n=3)

Chromosome level genome assembly of pathogenic *Vibrio harveyi*

Vibrio harveyi is a Gram-negative, bioluminescent, marine bacterium causing serious infection in shrimp and fishes. A strain of *V. harveyi* named SB1 was isolated in 2020 from Asian seabass. During challenge study, the strain was found highly pathogenic to shrimp as well as Asian seabass. In the latter, it caused more than 50% mortality at the dose of 5 x 104 CFU from intramuscular route. To further understand the virulence, the strain was sequenced at illumina and pacbio platform. The assembly was carried out using flye assembler and further polished by Pilon using illumina data. The assembly quality was assessed by Busco score which was found 100% representing high quality assembly. The genomic assembly of SB1 contained two chromosomes and a plasmid. The genome size was 5.87 Mbp with the largest chromosome of 3.46 Mbp and plasmid of 161.5 Kbp. The genomic analysis suggests that plasmid of SB1 carries several pathogenicity island harboring genes associated with type 4 secretion systems. A very large pathogenicity island was also located on the chromosome 1. The functional annotation suggested that the genome has 5,391 protein coding genes and their rRNA genes are located at 3 regions. Further analysis of the genome is under progress.

Larval microbiome associated with pearspot (*Etroplus suratensis*) larvae reared in green and clear water rearing systems

Farming of marine and brackishwater fish species is gaining traction in India due to consumer

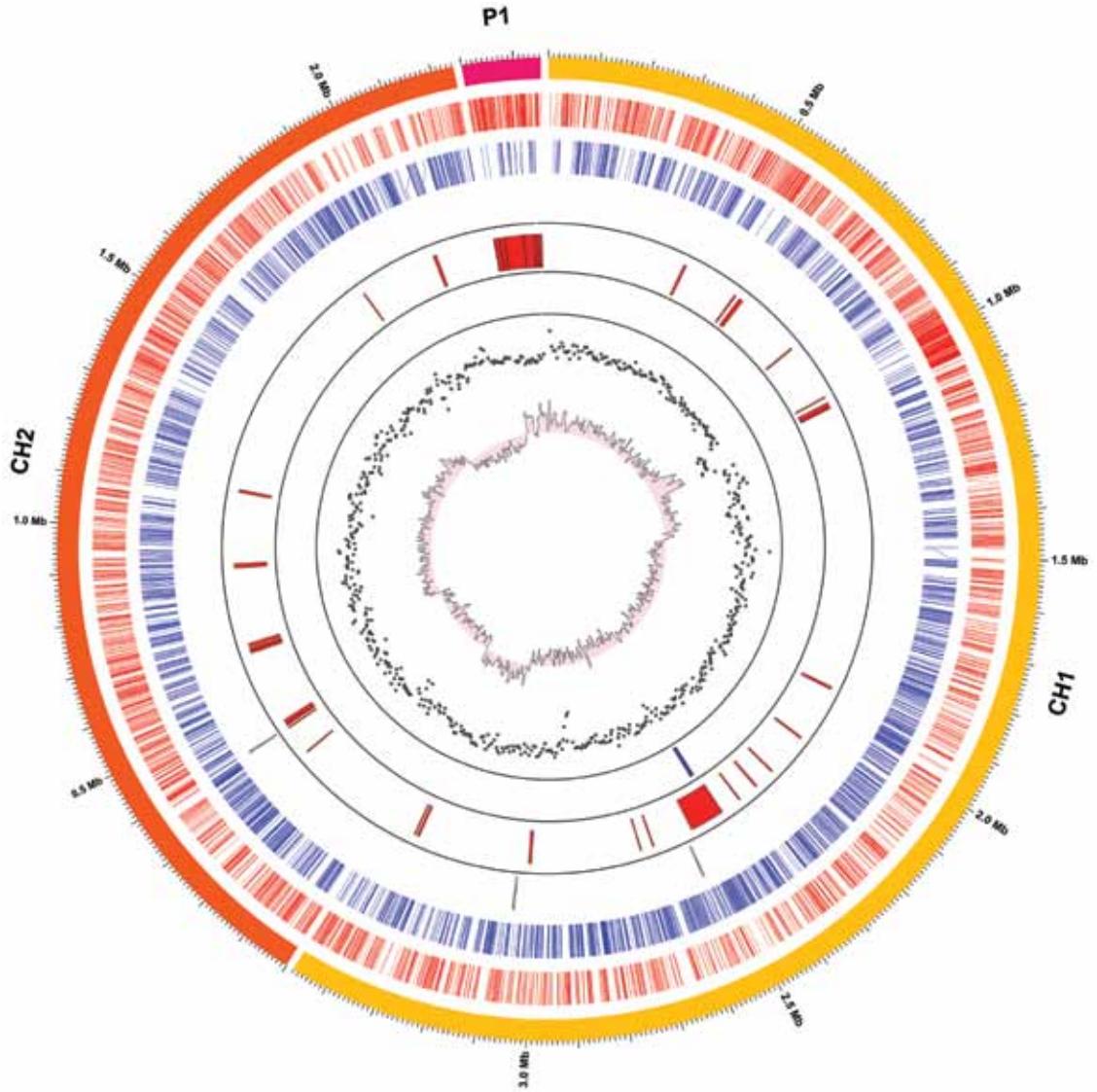


Fig. 40. Circos plot of Vibrio harveyi SB1

demand, and their high value. In order to ensure a steady supply of fish seeds, all fish farming nations engage in the commercial activity of breeding and seed production of fish and shellfish. Nevertheless, despite successful breeding, fish hatcheries have lower larval survival rates. The survival rate of larvae is largely influenced by the environment in which they are raised, their feeding habits, and the presence or absence of disease in fish hatcheries. NGS studies recently uncovered the complex functions of microbiomes in larval development, physiology, and immune competence. Hence to comprehend the larval microbiome associated with brackishwater larval development the present study was designed where the larval microbiome in pearlspot (*Etroplus suratensis*) larvae reared in green water and clear water system was investigated using next-generation sequencing.

Yolk-sac larvae of the pearlspot (5 days old, Average length-6.8

mm) in triplicates (n=30/replicate) were reared in clear (*Artemia*-0.5 to1 no/ml) and green water (green algae-10^3 to 10^4 cells/ml and *Artemia* 0.5 to1 no/ml) for 18 days. Larvae (n=3-5) were collected on days 0, 2, 8, and 18 of rearing. Total length of larvae was measured, specific growth rate was calculated, and the mean length was compared using one-way ANOVA in SPSS statistics version 29.0. Further, the genomic DNA extracted from the larvae (n=3-5) from 0, 2, 8, and 18th day from clear and green rearing water and was subjected to 16S rRNA V3-V4 based on next-generation sequencing in MiSeq Illumina platform. Raw reads were processed using Trimmomatic V0.38 to get high-quality reads and OTUs were picked up using sequence similarity within the reads using Greengens database Version 13_8 and taxonomies were assigned to the OTUs using UCLUST based on the threshold of 90% similarity. Diversity indices of the bacterial population at the species level were calculated and expressed as the Shannon alpha diversity index compared using one-way ANOVA in SPSS statistics version 29.0. Analysis showed that the growth of larvae raised in green was significantly different (Fig. 41 and Fig. 42 A, p value 0.005), with a specific growth rate of 3.4% compared to 2% in a clear water system. However, there was no discernible difference in alpha diversity between the associated microbiomes of the larvae raised in the two systems (Fig. 42B). The taxonomic analysis of the pearlspot larval microbiome revealed that Proteobacteria, Planktomycetes, Bacteriodetes, Firmicutes, and Actinobacteria were present in varying ratios, though their relative contributions varied between the two rearing systems. Specifically, Proteobacteria (27%), Planktomycetes (17%), Bacteriodetes (16%), Firmicutes

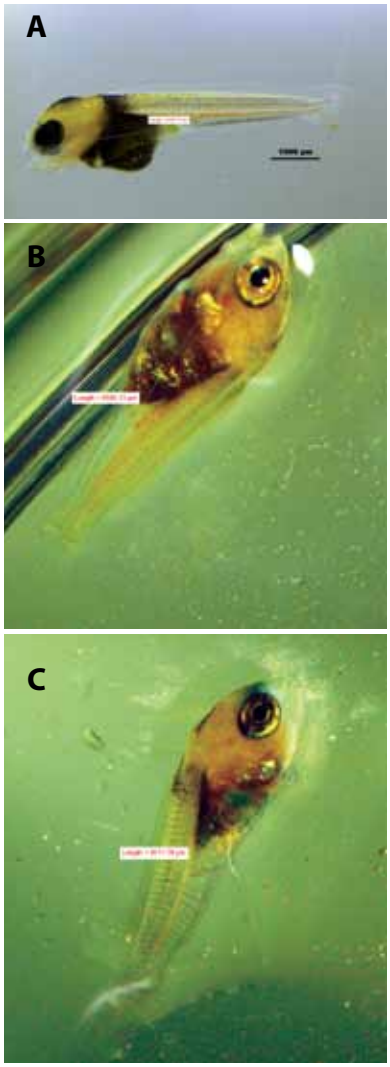


Fig. 41. A. Yolk-sac larvae of pearlspot B. Green water reared pearlspot larvae C. Clear water reared pearlspot larvae on 8th day of experiment

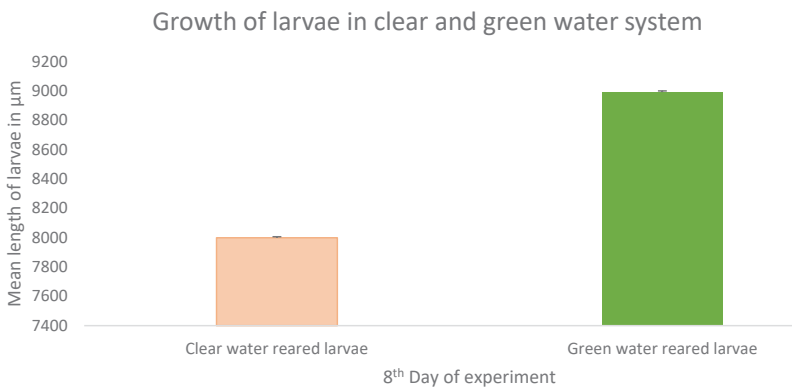


Fig. 42A. Growth of pearlspot larvae in clear and green water system

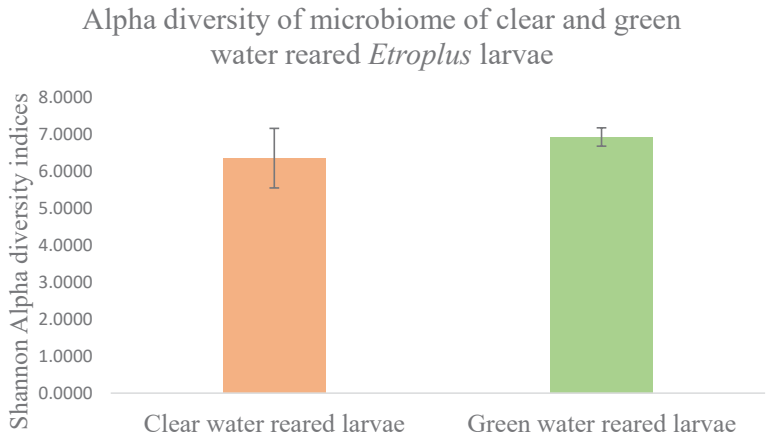


Fig. 42B. Shannon alpha diversity index of clear water and green water reared pearlspot larvae

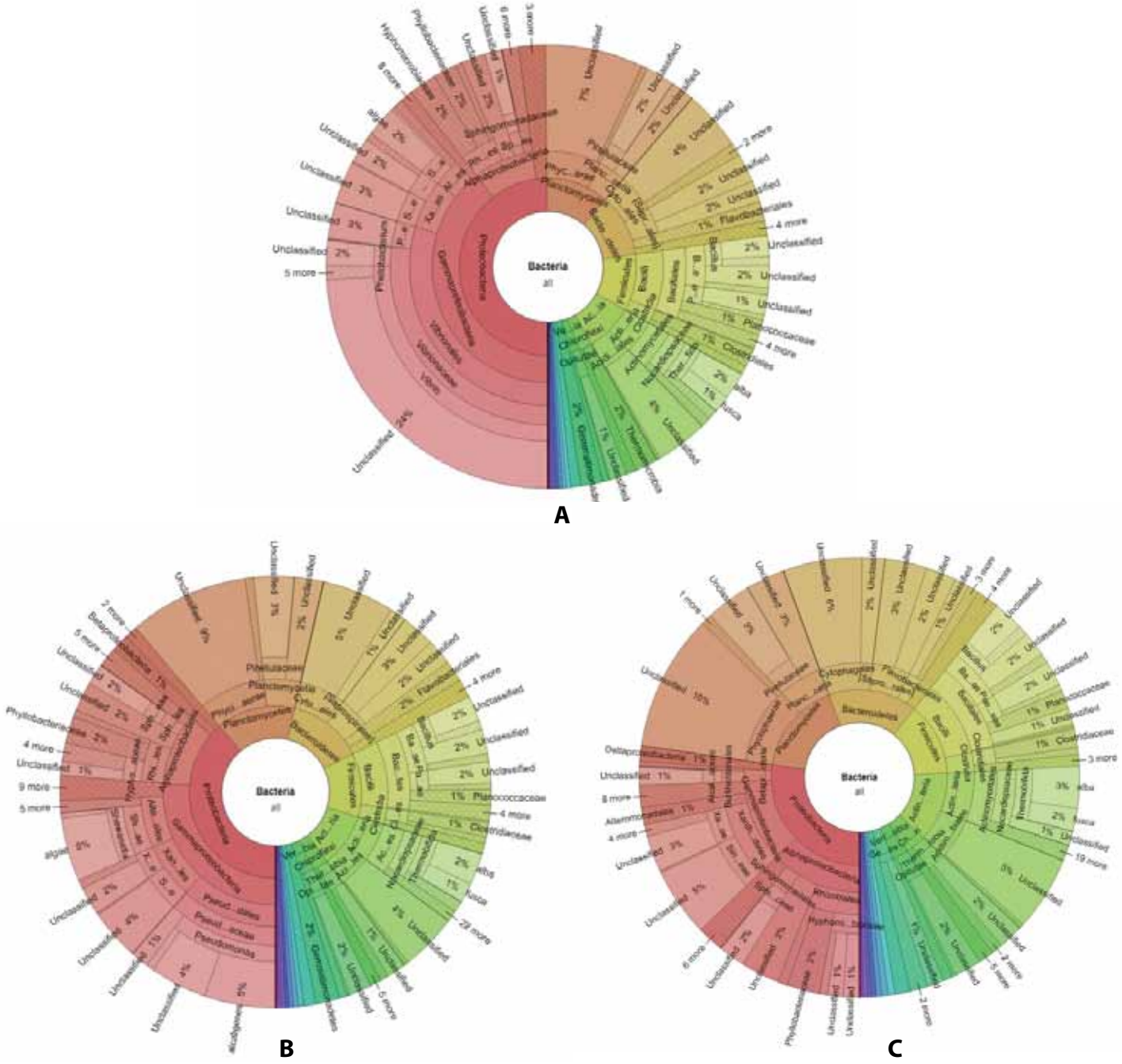


Fig. 43. Krona chart displaying the larval microbiome of pearlspot A. Microbiome of clear water reared pearspot larvae B. Microbiome of green water reared pearlspot larvae C. Microbiome of yolk-sac pearlspot larvae

(13%), and Actinobacteria (13%), contributed to the initial bacterial population of the yolk-sac larvae of pearspot. In contrast, after feeding, the percentage contribution of these bacteria decreased in larvae raised in clear water (Planktomycetes 11%, Bacteriodetes 11%, Firmicutes 10%, Actinobacteria 9%) and green water (Proteobacteria 39%, Planktomycetes 15%, Bacteriodetes 14%, Firmicutes 12%, Actinobacteria 10%) (Fig. 43).

Proteobacteria are a major bacterial phylum found in marine and brackishwater environments, including live feeds and marine animals represented by F. Vibrionaceae, F. Pseudomonadacea, and F. Pseudoalteromonadaceae. It was found that F. Vibrionaceae (27%) represented by the genus *Vibrio* dominated the bacterial family in clear water-reared larvae, whereas F. Pseudomonadaceae (11%) represented by the genus Pseudomonas dominated the bacterial family in green water-reared larvae. However, the

selective dominancy of bacterial families in larvae in green water and clear water systems needs careful examination. For this, the microbiome analysis of green algae and *Artemia* was also examined to comprehend their role in the development of the larval microbiome. The green algae microbiome was dominated by Proteobacteria, Myxococcota, and Bdellovibrionata, whereas the Proteobacteria represented by F. Vibrionaceae (99%) being the most dominant in the microbiome of *Artemia* and could be contributed to the microbiome of clear water reared larvae. However, despite feeding with *Artemia*, the representations of vibrios were low in green water reared larvae and needs further examination. Additionally, the analysis showed that despite having different rearing methods, the core bacterial population in pearlspot larvae was distinct and made up of Firmicutes, Bacteriodetes, and Actinobacteria, accounting for nearly 40% of the total bacterial population. The precise function of these organisms in larval development is still unknown. The knowledge produced by the present study will be useful for health management studies utilizing probiotic-mediated feeding strategies to control the bacterial population and microbial diseases in the systems supporting larval development.

Chromosome level genome assembly of *Vibrio campbellii* strains

Vibrio campbellii is a major bacterial pathogen affecting the mysis and early post-larval stages of penaeid shrimp. It closely resembles and often been misidentified in the past as *V. harveyi*. The detailed investigations of 30 *V. campbellii* strains suggested several differences such as pathogenic vs non-pathogenic, luminescent vs non-luminescent and bacteriophage susceptible vs phage resistant properties. Therefore, to understand these phenomenon six strains LB3, LB10, LB135, LB198, LB314 and LB503 were sequenced at illumina and pacbio platform. The Pacbio hifi reads had the total read length of 773948040 (LB3) to 1043975381 (LB503) with N50 length of 9,445 bp (LB3) to 13,049 bp (LB135). The assembly was carried out using flye assembler and further polished by Pilon using illumina data. All the six strains had chromosome level assembly with Busco score of 99 to 100% representing high quality assembly. The genome size varied between 5.62 to 5.74

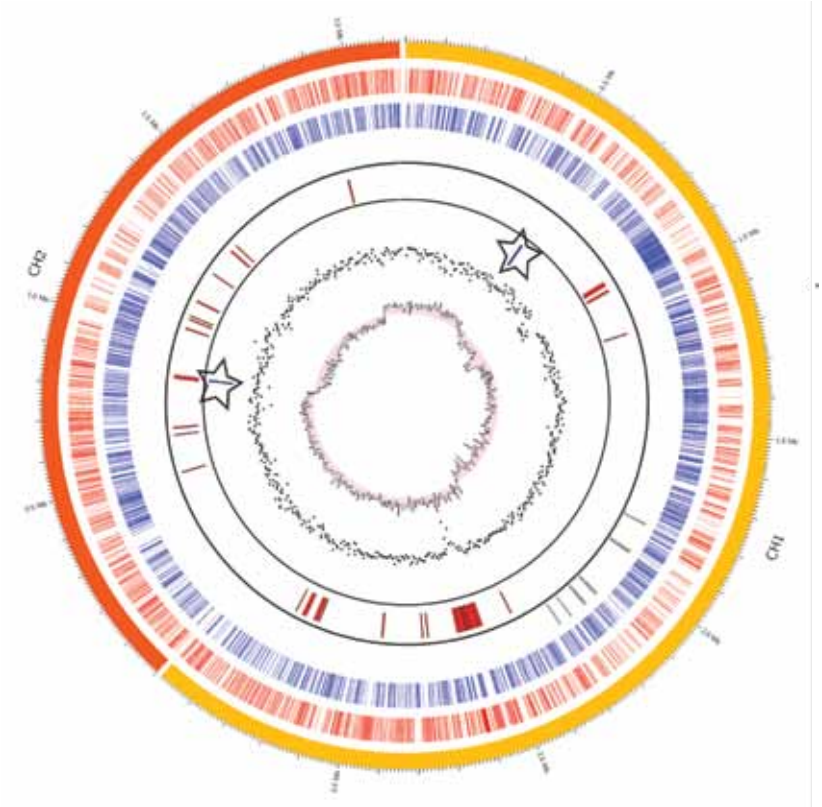


Fig. 44. Circos plot of Vibrio campbellii LB503

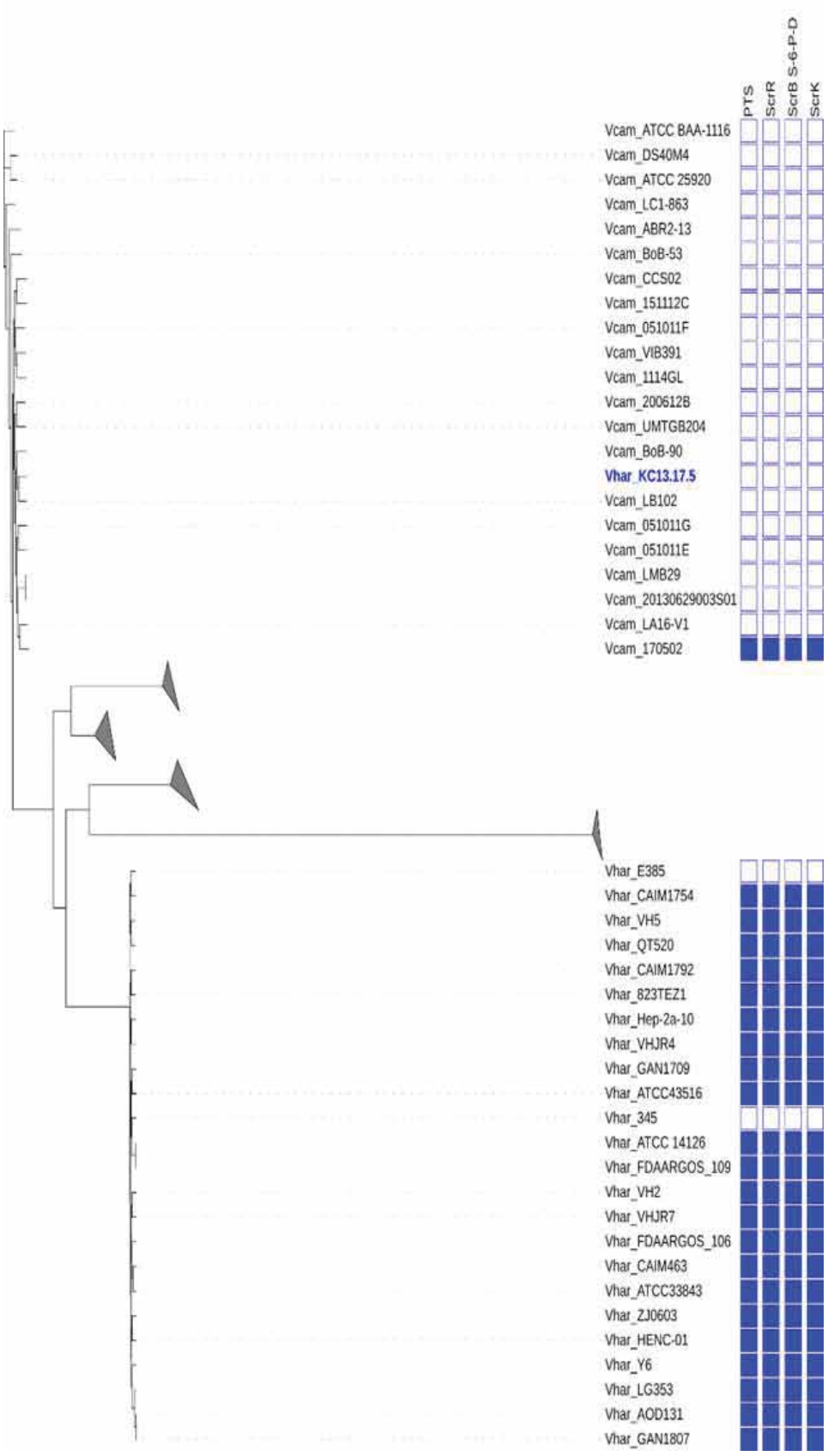


Fig. 45. Distribution of sucrose pathway genes in Vibrio campbellii and Vibrio harveyi

Mbp. *V. campbellii* LB503 which was highly pathogenic and luminescent carried two filamentous prophages with toxin coding genes. One of the prophage was located on chromosome 1 while the other was located within Pathogenicity Island of chromosome 2. Further analysis of genome is being carried out to understand the molecular pathogenesis.

Mapping of genes responsible for green yellow colony on TCBS agar in *V. harveyi* and *V. campbellii* suggest diagnostic potential

Vibrio harveyi has been widely reported from shrimp and finfish hatcheries and farms from several countries including India. Phenotypically it shares close relatedness from other pathogens such as *V. campbellii* and *V. owensii* leading to frequent misidentification. A myth among hatchery operators and aquaculturists prevails that green colored colony on TCBS agar are harmful and keeping their number under control is vital for hatchery operation. To find the truth, we re-evaluated confirmed strains of V. harveyi and *V. campbellii* for their growth characteristics on TCBS agar. Our analysis suggested that contrary to belief, all the strains of *V. campbellii* (n=30) form green colonies while *V. harveyi* (n=5) produced yellow colonies on TCBS agar. This was supported by genomic analysis of strains of

V. harveyi and *V. campbellii* available at the NCBI database (n=105). It was observed that above 90% strains of *V. harveyi* have operon for sucrose fermentation (responsible for yellow colored colony formation on TCBS agar) and more than 95% strains of V. campbellii lacked these genes (thus forming green colonies on TCBS agar). Our results strongly suggest that a luminescent green bacterium should be primarily identified as *V. campbellii* while luminescent yellow colony could be *V. harveyi*.

Differential pathogenicity and luminescent behaviour within Harveyi clade species (*V. campbellii, V. harveyi, V. owensii, V. rotiferianus* and *V. jasicida*)

To understand the comparative virulence and luminescent behavior total 17 strains comprising; *V. campbellii* (n=5), *V. harveyi* (n=5), *V. owensii* (n=2), *V. rotiferianus* (n=2) and *V. jasicida* (n=1) were compared for pathogenicity by challenge study. Among the studied strains, three *V. campbellii* (LB10, LB102 and LB503) and *V. harveyi* (LMG 7890, LMG 19643 and SB1) were highly pathogenic. However, all the strains of *V. owensii, V. rotiferianus* and *V. jasicida* were non-pathogenic. The luminescent properties were observed among few isolates of *V. campbellii, V. harveyi* and *V. owensii*.

Quantitative real time PCR developed for *Vibrio campbellii*

Harveyi clade species such as *V. harveyi* and *V. campbellii* are major pathogen in shrimp and finfish hatcheries. Earlier we developed differential and quantitative real time PCR primers for *Vibrio harveyi, V. owensii* and *V. rotiferianus*. To further boost the diagnostics against pathogenic *Vibrios*, a quantitative real time PCR primer were developed against *V. campbellii*. For identifying a novel marker, a differential pangenome analysis was carried out Based upon the result, *hdc, fatA* and *angR* were selected for primer design. Earlier, primers targeting fatA genes produced 95bp amplicon which was 100% sensitive and specific but had dimer formation. To solve the dimer related issues three more primers targeting *fatA* and hdc were developed which was 100% sensitive, 100% specific and were free from dimer related issues.

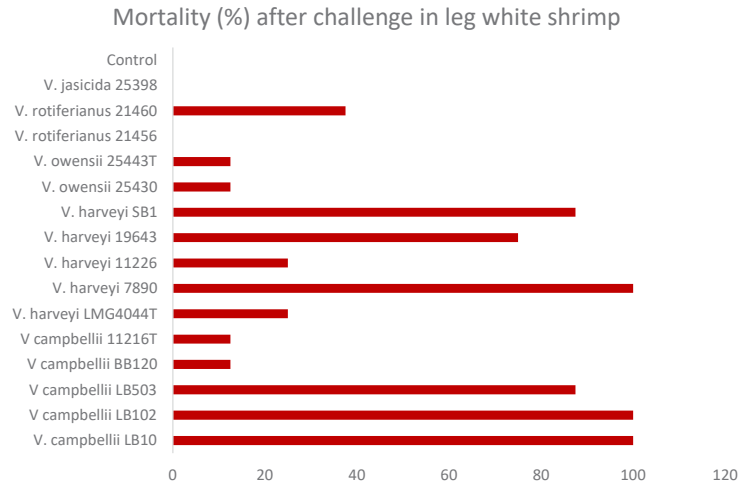


Fig. 46. Mortality pattern after challenge with different species of Harveyi clade

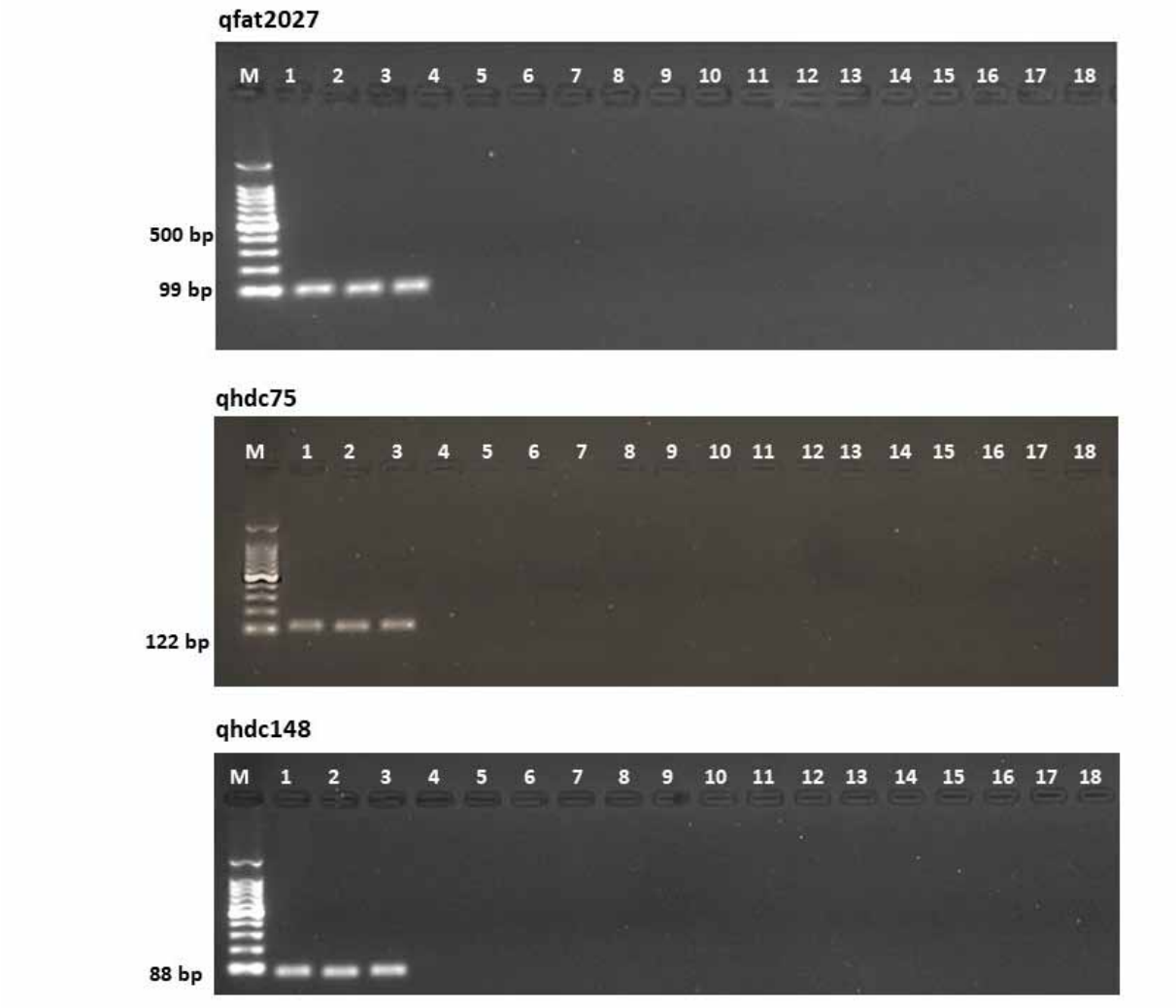


Fig. 47. Sensitivity and specificity of real time PCR primers for quantification of Vibrio campbellii

M – 100 bp ladder; 1-3 V. campbellii; 4-6 V. harveyi; 7-8 V. owensii; 9 V. jasicida; 10 V. rotiferianus 11 V. aliginolyticus; 12 V. parahaemolyticus; 13 V. fluvialis; 14 E. coli; 15 P. fluorescens; 16 Bacillus subtilis; 17 Lactobacillus lactis; 18 Negative Control

Isolation and identification of parasitic infestations in brackishwater candidate species

Parasitic infestations in wild and farmed fish species of were carried out in Tamil Nadu, Puducherry, Kerala, Andhra Pradesh and Maharashtra. Thirteen parasitic infestations were isolated and identified. Sea louse *Caligus minimus* was identified as major parasite in pearlspot, *Etroplus suratensis* by a combination of morphological analysis and molecular identification method targeting 18S rDNA gene fragment with custom designed primers (143F : 5′ – TGC CTT ATC AGC TNT CGA TTG TAG – 3′ and 145R : 5′ – TTC AGN TTT GCA ACC ATA CTT CCC– 3′). No parasitic infection was found in *Chanos chanos*, *Monodactylus argenteus* and *Lutjanus argentimaculatus*.

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

Several ectoparasitic crustacean copepods and branchiuran infestations have been effectively controlled by the in-feed lufenuron (LF) treatment in

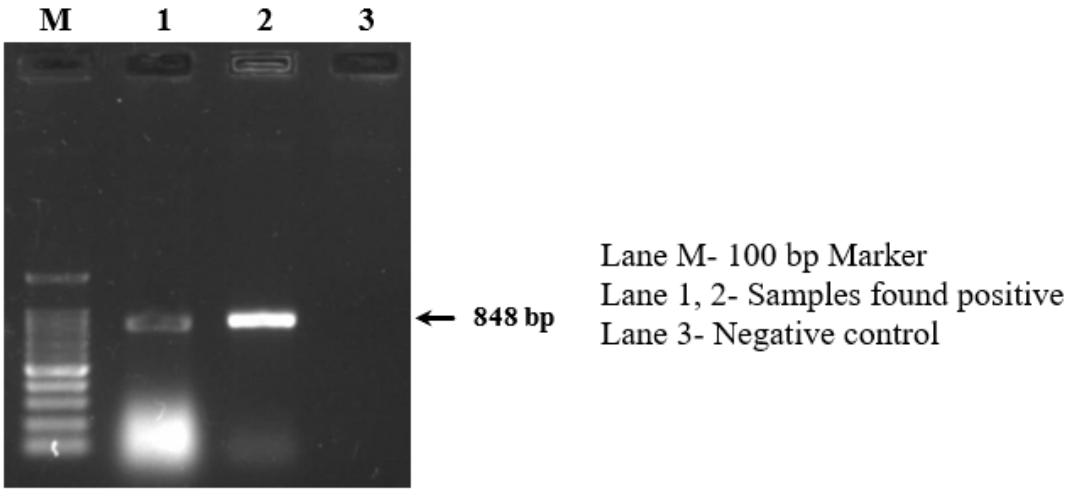


Fig. 48. PCR amplification of Caligus minimus 18S rDNA fragments

fishes. Pharmacodynamic study by QTRAP 4000 LC-MS/MS, to assess the safety of oral feeding was conducted in Asian seabass fingerlings (4.71±0.01g), at different doses 5, 25, and 50 mg kg-1 of fish BW day^{-1} for 21 days The samples were analyzed for hematology, histopathology and LF residues. It was found LF was biologically safe up to 10 times the recommended therapeutic dose and three times the treatment duration (Fig.). Pharmacokinetic studies showed that the level of LF in liver, kidney and muscle reached least by 28th day of last feeding with limit of quantification (LOQ) of

0.01 ppm. No significant difference was observed in the rate of LF leaching in guar gum and egg albumin coated feeds. Hence, usage of LF can be safe and effective as an anti-parasiticide in Asian seabass.

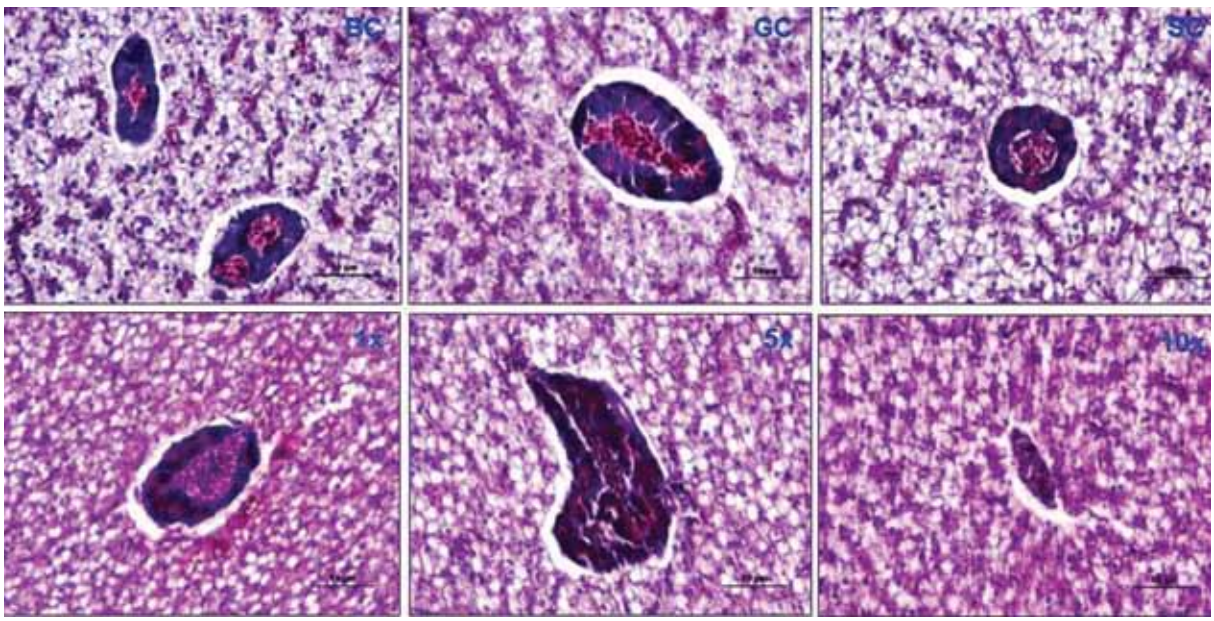


Fig. 49. Comparative histopathology of liver of control and anti-parasiticide, lufenuron fed Lates calcarifer fingerlings in different groups, blank control (BC), guar gum control (GC), solvent control (SC), 1x, 5x and 10x. Note normal central vein with pyramidal pancreatic acinar cells and radiating hepatocyte cord with normal polyhedral hepatocytes with central nuclei. Mild to moderate reversible fatty change is evident in all the treatment groups. H & E. Scale as depicted in the figure.

Identification of an antagonistic *Streptomyces griseorubens* CIBA-NS1 strain capable of excluding Vibrio in shrimp rearing system

Vibriosis is a limiting factor in shrimp hatchery operation that causes mass mortality of larvae. *Streptomyces griseorubens* CIBA-NS1 strain was isolated with promising antagonistic activity against *Vibrio campbellii*. The species is identified based on biochemical and morphological characteristics as well as 16SrDNA sequencing. To characterize the pattern of antibacterial activity, the active species is cultured in broth media. The culture media and bacterial cells were tested separately for antibacterial activity. The results show that the activity is found in the cell free broth with a zone of clearance of 20.16±1.6 mm diameter.

Fig. 50. Antagonistic activity of S. griseorubens against Vibrio campbellii

AQUACULTURE ENVIRONMENT

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Water quality parameters and ionic profile of inland saline groundwater samples in Haryana, Punjab and Rajasthan

Shrimp farming in inland states using saline groundwater is developing at a fast pace and further expansion of the same requires guidelines in the form of water quality variables and ionic profiles for site selection. Inland saline groundwater (ISG) samples collected from Haryana (n=52), Punjab (n=28) and Rajasthan (n=50) were analysed for major water quality variables and ionic composition. Based on the modified optimal ranges for ISGs, more than 90% of the samples in all states were within the suitable ranges of salinity. Total alkalinity was within the optimal range for all samples from Punjab whereas 8% and 12% of samples in Haryana and Rajasthan registered values over 400 ppm. Rajasthan had the maximum number of samples suitable for shrimp farming based on total hardness followed by Punjab and Haryana. In terms of Mg/Ca ratio, Rajasthan had the highest percentage of samples (86%) followed by Haryana (42%) and Punjab (28%). Potassium levels were extremely deficient in Rajasthan samples and moderately deficient in Punjab and Haryana. Overall, a greater percentage of ISG samples from Rajasthan fall within the optimal ranges for different ionic and water quality parameters indicating the state to be most suitable for further expansion of inland shrimp farming (Fig.1).

Effect of Sodium bisulphate to reduce total alkalinity: Investigations on water quality, animal growth, immunity and biochemical parameters

High total alkalinity (TA) is a major constraint faced by the farmers using borewell waters in inland areas. Preliminary experiments confirmed that sodium bisulphate ($NaHSO_4$) is the best

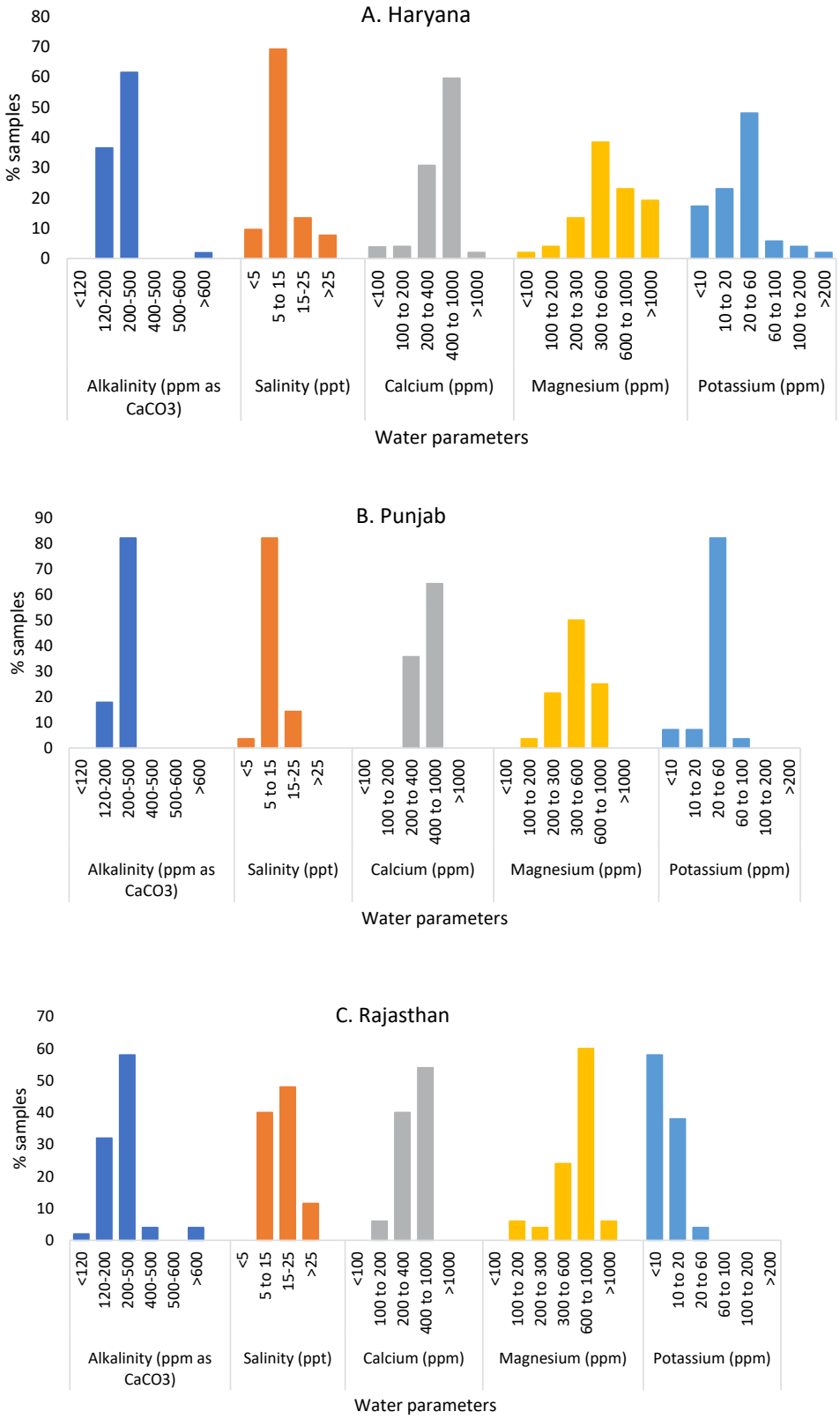


Fig. 1. Categorisation of inland saline ground waters of A. Haryana B. Punjab and C. Rajasthan

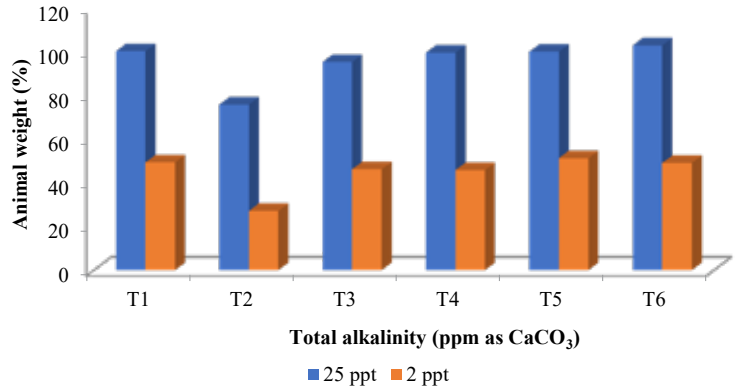


Fig. 2. Effect of $NaHSO_4$ manipulated alkalinity on shrimp growth rate

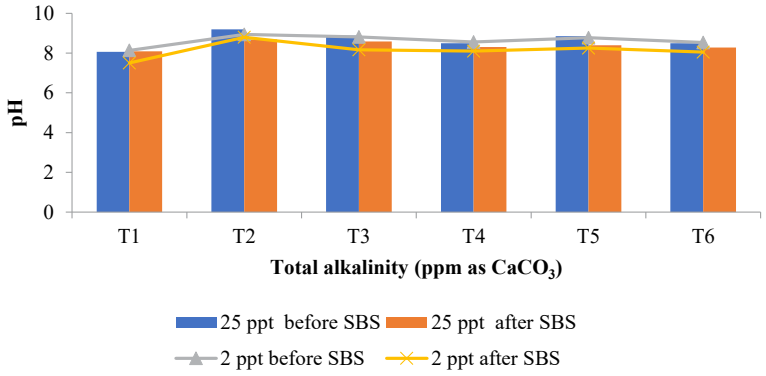


Fig. 3. Influence of $NaHSO_4$ on change in water pH

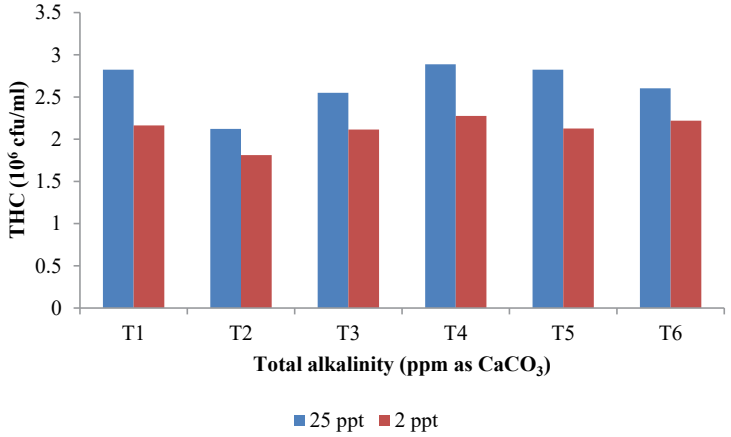


Fig. 4. Effect of $NaHSO_4$ manipulated alkalinity on THC (cfu/ml) variation

option to reduce TA, about 1.3 and 1.6 ppm reduces 1 ppm of TA under 2 and 25 ppt salinity, respectively. To understand the $NaHSO_4$ effect on water quality, growth and biochemical parameters, an experiment was conducted on *P. vannamei* with a stocking density of 80/m^2 for a month under six different treatments viz., control (T_1), 600 ppm (T_2), TA reduced from 600 to 300 (T_3), 600 to 200 (T_4), 300 (T_5), and 300 to 200 (T_6) under two salinities 2 and 25 ppt. Animal survival was good and the growth rate increase was 25.6 and 31.3% at high salinity, and 70.4 and 68.9% at low salinity in T_3 and T_4, respectively compared to T_2. There was no significant difference between T_5 and T_6 in both salinities. pH numerically decreased on $NaHSO_4$ application and returned to normal within a day. The addition of $NaHSO_4$ did not cause any significant changes in water quality parameters, protein, ash and fat content. Total haemocyte count was low under high TA and increased with $NaHSO_4$ addition. To conclude, $NaHSO_4$ may be recommended to remediate high alkalinity issues (Figs. 2-4).

Carbon budgeting in *Penaeus vannamei* culture with varying stocking density

To comprehend the concept of the contribution of carbon inputs and outputs in intensive and semi-intensive shrimp aquaculture systems to carbon budgeting, an outdoor yard experiment was conducted with *P. vannamei* at three different stocking densities (SDs), 20/m^2 (Low), 40/m^2 (Medium), and 60/m^2 (High) for 60 days. The data on carbon content in all the major inputs and outputs, and carbon fractions in pond water and soil during the culture were used for the estimation of carbon budgeting in varying SDs. Soil accounted for the highest carbon input in low (41.51%) and medium (33.40%) SDs, whereas feed accounted for the highest carbon input (33.57%) in high SD. In terms of carbon output, soil accounts for the highest fraction irrespective of the SD. The percentage contribution of soil to the total outputs was maximum for low SD (54.47%), and not much difference between medium (49.68%) and high (49.51%) SDs. Shrimp accounts for 18.30, 27.75 and 32.73% of the total output in low, medium and high SDs, respectively. The unaccounted carbon outputs were highest in low SD (11.22%) and the lowest in high SD (4.48%). The studies on carbon budgeting help in understanding the contribution of shrimp farming to global warming (Fig. 5-7).

Development of microbial enrichments for bioremediation of sulphide and ammonia

Hydrogen sulphide (H_2S) and

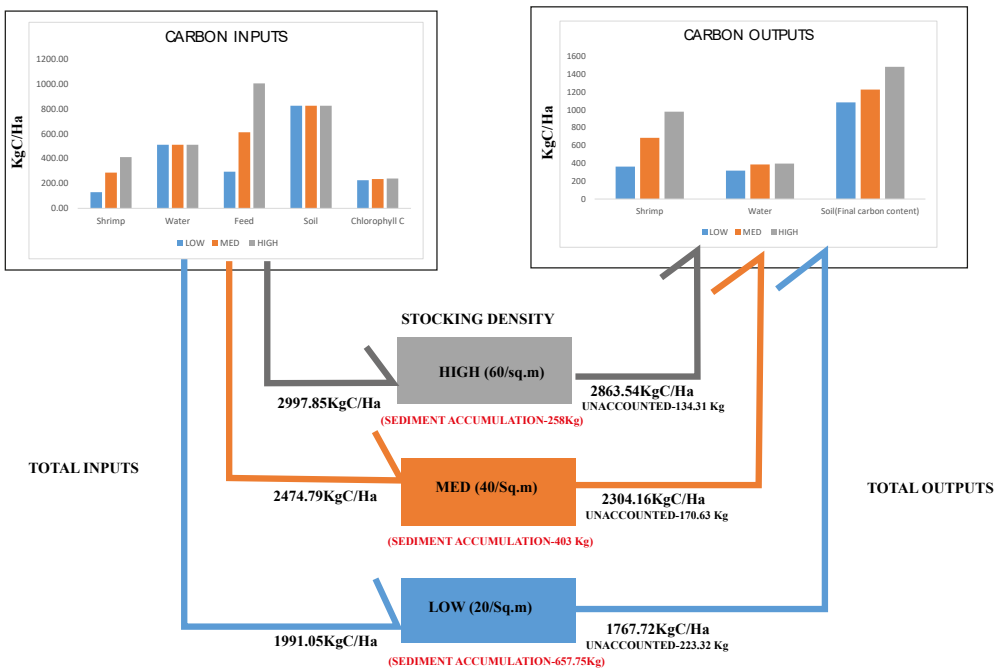


Fig. 5. Carbon inputs and outputs (Kg C/ha) in P. vannamei culture varying in stocking density

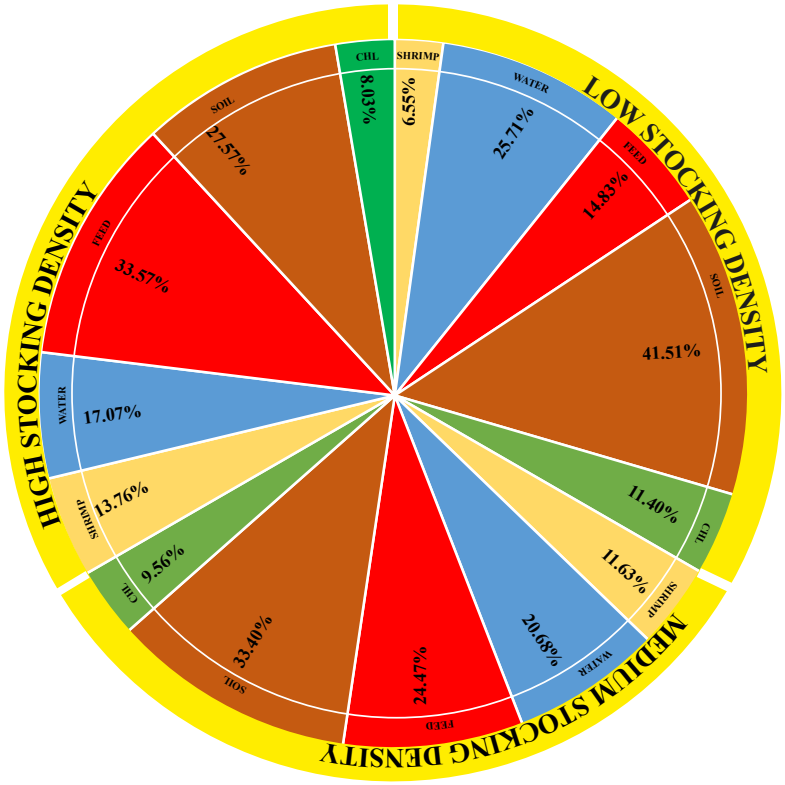


Fig. 6. Contribution of inputs to total carbon input in P. vannamei culture varying in stocking density

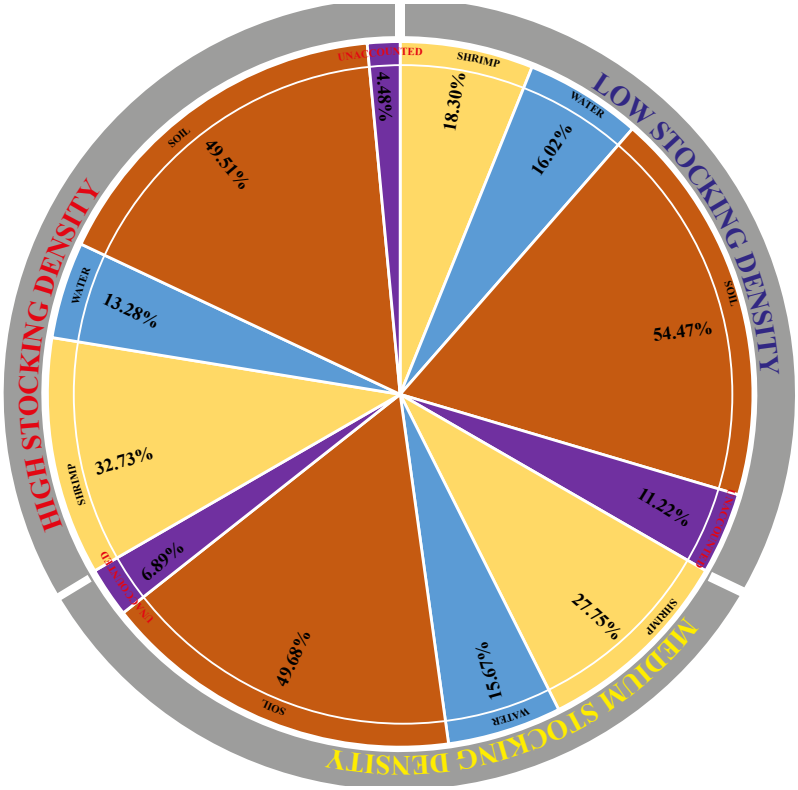


Fig. 7. Contribution of outputs to total carbon output in P. vannamei culture varying in stocking density

ammonia are considered the most toxic metabolites in brackishwater aquaculture systems that cause stress and mortality to culture animals. Any detectable level of H_2S is considered to be toxic for cultured shrimp, while higher than one ppm of ammonia causes stress. Six microbial enrichments for mitigation of sulphide toxicity (sulphide oxidation bacteria - SOB) were isolated from the brackishwater environment. The enrichments were assessed for their efficacy in H_2S reduction using the Starkey broth (inorganic) and Starkey broth with 0.1% yeast extract (organic). The bacterial growth and sulphide oxidation were higher in the organic media than in the inorganic media. The relative sulphide removal efficiency in 24 h period ranged between 45 and 57% against 26% in the control in the organic media, while it was between 20 and 26% in the inorganic media against 11% in control. Ammonia oxidation efficiency of these enrichments was also assessed in ammonia spiked media, which ranged between 33 and 86% in the 24 h period. The combination of enrichments of chemoautotrophic and heterotrophic bacterial consortia can be developed as a probiotic for effective bioremediation of sulphide and ammonia metabolites, respectively in a brackishwater environment (Figs. 8, 9).

Characterisation of lactic acid bacteria as potential gut and environmental probiotic

The gut-associated bacterial isolates were obtained from 10 *P. vannamei* culture ponds (25 shrimps per pond) with salinity

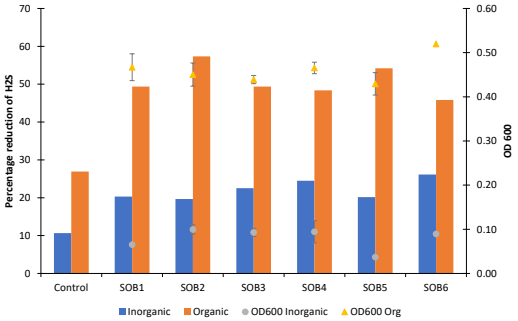


Fig. 8. Sulphide oxidation by SOB in organic (0.1% yeast extract) and inorganic media

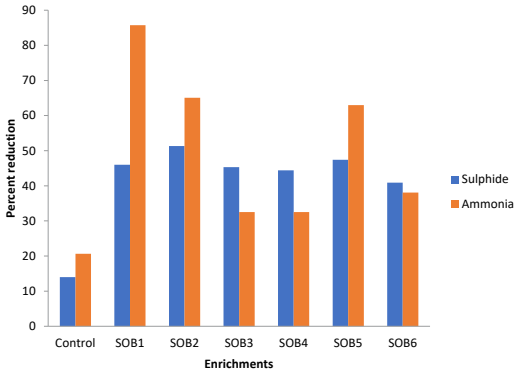


Fig. 9. Simultaneous oxidation of sulphide and ammonia by SOB

ranging from 5 to 25 ppt located in Kanchipuram, Chengalpattu, Tiruvallur and Villupuram districts of Tamil Nadu and characterised for their efficiency as indigenous gut and environment probiotic. Thirty lactic acid bacteria were isolated and identified using a 16S ribosomal DNA sequence. Six isolates viz., *Pediococcus pentosaceus* (LB1/ON495586), *Lactiplantibacillus plantarum* (LB2/ON491817), *Lactococcus lactis* (LB3/ON479264), *Enterococcus faecium* (LB4/ON478992), *Enterococcus hirae* (LB5/ON478991) and *Enterococcus durans* (LB6/ON564885) showed better enzyme activity, antibacterial activity against shrimp pathogens *V. campbelli, V. harveyi* and *V. parahaemolyticus* with the zone of inhibition ranging between 12.33 to 21.00 mm, better growth at pH 7.0, excellent auto-aggregative activity (74.45 to 91.14%) and hydrophobicity (77 to 99.93%). These lactic acid bacteria also have the potential as soil and water bioremediator by exhibiting the properties, breakdown of organic detritus and reduced water turbidity. No antagonist activities were detected among the strains, suggesting its use as the potential multiple cocktail gut and environmental probiotic in aquaculture production systems (Figs. 10-14).

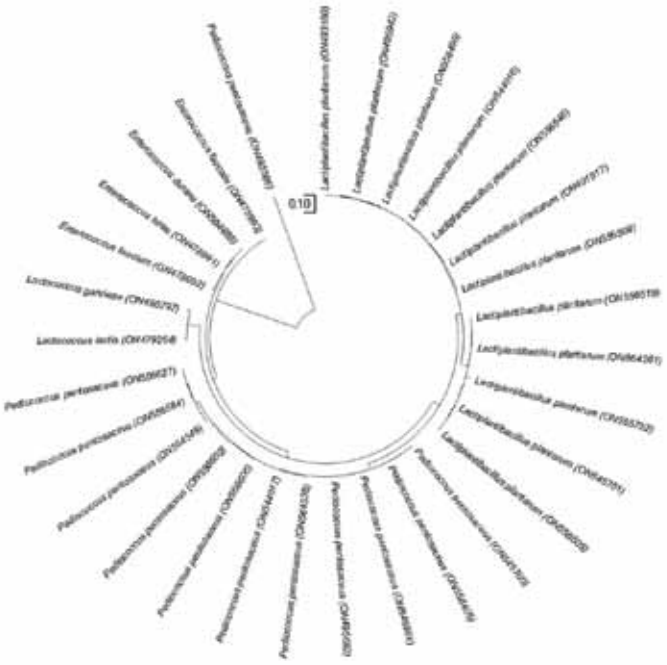


Fig. 10. Phylogenetic tree of the Lactic acid bacteria from the gut of P. vannamei

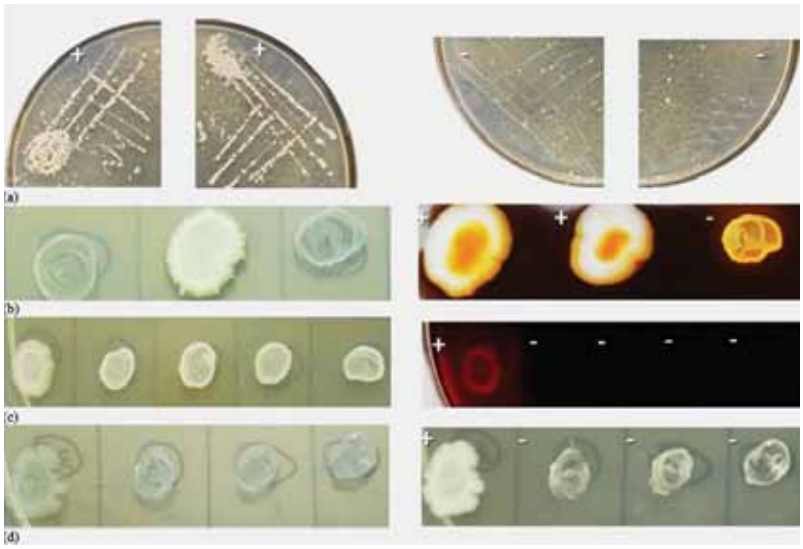


Fig. 11. Enzyme activity of the Lactic acid bacterial isolates

Panel (a): Growth of isolates on tributyrin agar plates revealed clearing around colony for lipase positive (Left) and negative (Right) isolates; Panel (b) Growth of isolates on starch agar plates for amylase activity (Left), Amylase enzyme positive bacterial isolates presented the transparent halo zone surrounding the colony when flooded with Gram's iodine solution after 24 h (Right); Panel (c) Growth of isolates on carboxy methyl cellulose agar inoculated with bacteria (Left), Cellulase activity of the isolates exhibited halo surrounding a colony and after addition of 1% Congo red in cellulase positive colony (Right); Panel (d) Growth of isolates on gelatin peptone agar inoculated with bacteria (Left), Protease activity of the isolates showed halo after flooding with 15% Mercuric chloride followed by washing with 1M NaCl (Right).

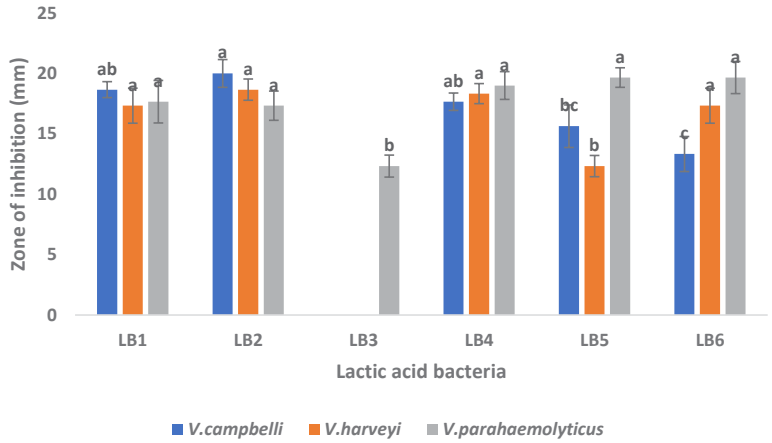


Fig. 12. Antibacterial activity of Lactic acid bacteria

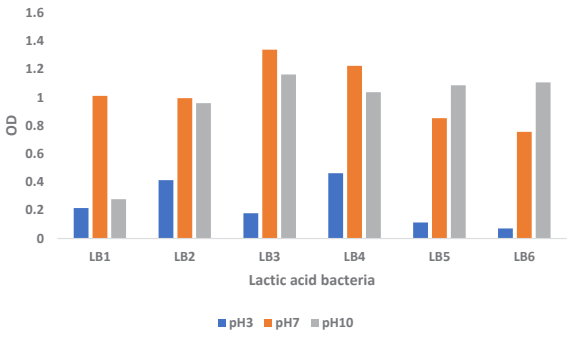


Fig. 13. pH tolerance of Lactic acid bacteria

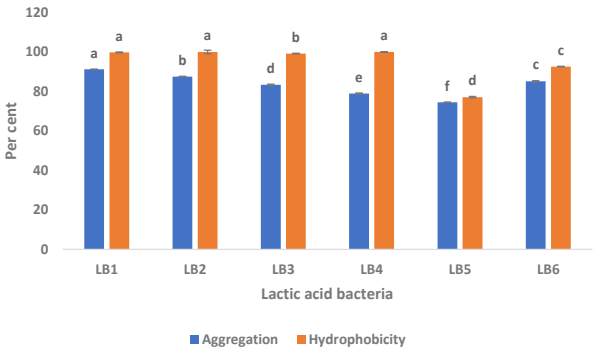


Fig. 14. Aggregation (24 hrs) and Hydrophobicity of the Lactic acid bacteria

Parameters	DOC 15		DOC 35	
	Control	*Sphingobacterium* sp. supplemented	Control	*Sphingobacterium* sp. supplemented
TAN (ppm)	0.131±0.005	0.096±0.014	0.120±0.010[a]	0.055±0.003[b]
Nitrite (ppm)	0.330 ± 0.035[a]	0.184±0.008[b]	0.483±0.027[a]	0.204±01010[b]
Nitrate (ppm)	0.134±0.010	0.139±0.003	0.138±0.005[a]	0.161±0.002[b]
pH	8.16±0.06	8.30±0.13	7.84±0.15	7.81±0.10
Alkalinity (ppm)	76.5±1.7	75.0±1.3	86.0±2.8	82.0±1.5

Table 1. Water quality parameters

Halophilic Sphingobacterium spp. SDKRC-13 was found to reduce toxic gases i.e ammonia and nitrite during indoor rearing of *Penaeus vannamei*

This particular study was conducted to isolate ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) from root of leguminous plants and mangrove soils of Sundarban area of West Bengal. A total of 28 samples including 22 soil samples and 6 leguminous plant samples were screened for that purpose. Total 132 isolates were recovered. They were screened for their ammonia and nitrite oxidizing activity by inoculation into defined bacteriological media containing ammonium sulfate and potassium nitrite, respectively. Only one isolate was found to reduce both ammonia and nitrite. That particular isolate was recovered from root of French bean (*Phaseolus vulgaris*) and was identified as *Sphingobacterium* sp. by 16S rRNA gene sequencing and designated as *Sphingobacterium* sp. SDKRC-13. The sequence was submitted to NCBI with Accession No. OQ396674. The isolate was found to be salt-tolerant and grew upto 10% NaCl concentration in Tryptic soya broth with 0.6% yeast extract (TSBYE).

Parameters	Control	*Sphingobacterium.* supplemented
THB (Log_{10} CFU ml^{-1})	5.809±0.066	5.788 ±0.191
TV (Log_{10} CFU ml^{-1})	4.125±0.457	4.025±0.208

Table 2. Microbiological parameters in rearing water

A trial study of 35 days duration with juvenile *P. vannamei* shrimp (ABW 4-5 g) was conducted to ascertain the effect of *Sphingobacterium* sp. SDKRC-13 on reduction of ammonia and nitrite in the rearing water. Eight aquaria (L × B × H = 60 × 30 × 40 cm) were used in this study containing approximately 50 L of brackishwater (salinity 7.2 ppt and pH 8.0). Four aquaria were used for each group (*Sphingobacterium* supplemented group and control). In the *Sphingobacterium* supplemented group, the appropriate amount of diluted overnight culture (5 × 10^4 CFU to make final concentration of 10^3 CFU ml^{-1}) of *Sphingobacterium* sp. was supplemented in the rearing water on days 0, 7, 14, 21, 28 and 35 (At the interval of 7 days). Supplementation of *Sphingobacterium* sp. SDKRC-13 was found to reduce the level of nitrites significantly both at DOC 15 and 35. It also significantly reduced the level of total ammonia nitrogen (TAN) at DOC 35. There was no significant difference in the level of pH, total alkalinity, total heterotrophic bacteria (THB) and total *Vibrio* (TV). However, at DOC 35, the level of nitrate was found significantly higher in *Sphingobacterium* sp. supplemented group. There was no significant difference in body weight gains between two groups ($p > 0.05$). Based on this study, it can be concluded that *Sphingobacterium* sp. SDKRC-13 isolate can act as a good candidate in formulation of water probiotics, which can reduce the level of toxic gases like ammonia and nitrites.

Characterisation of source waters and pond soils in brackishwater areas of West Bengal

Pond soil and source water samples from Namkhana (n=135) and Kakdwip (n=62) Blocks in South 24 Parganas District, West Bengal were characterised for physicochemical parameters. Clay loam (36%) and clay (43%) were the dominant soil texture categories in Namkhana and Kakdwip, respectively. About 58 and 62% of soils in Namkhana and Kakdwip were in the optimum pH range of 7.5 to 8.5. A large number of soils in both blocks were deficient in organic carbon,

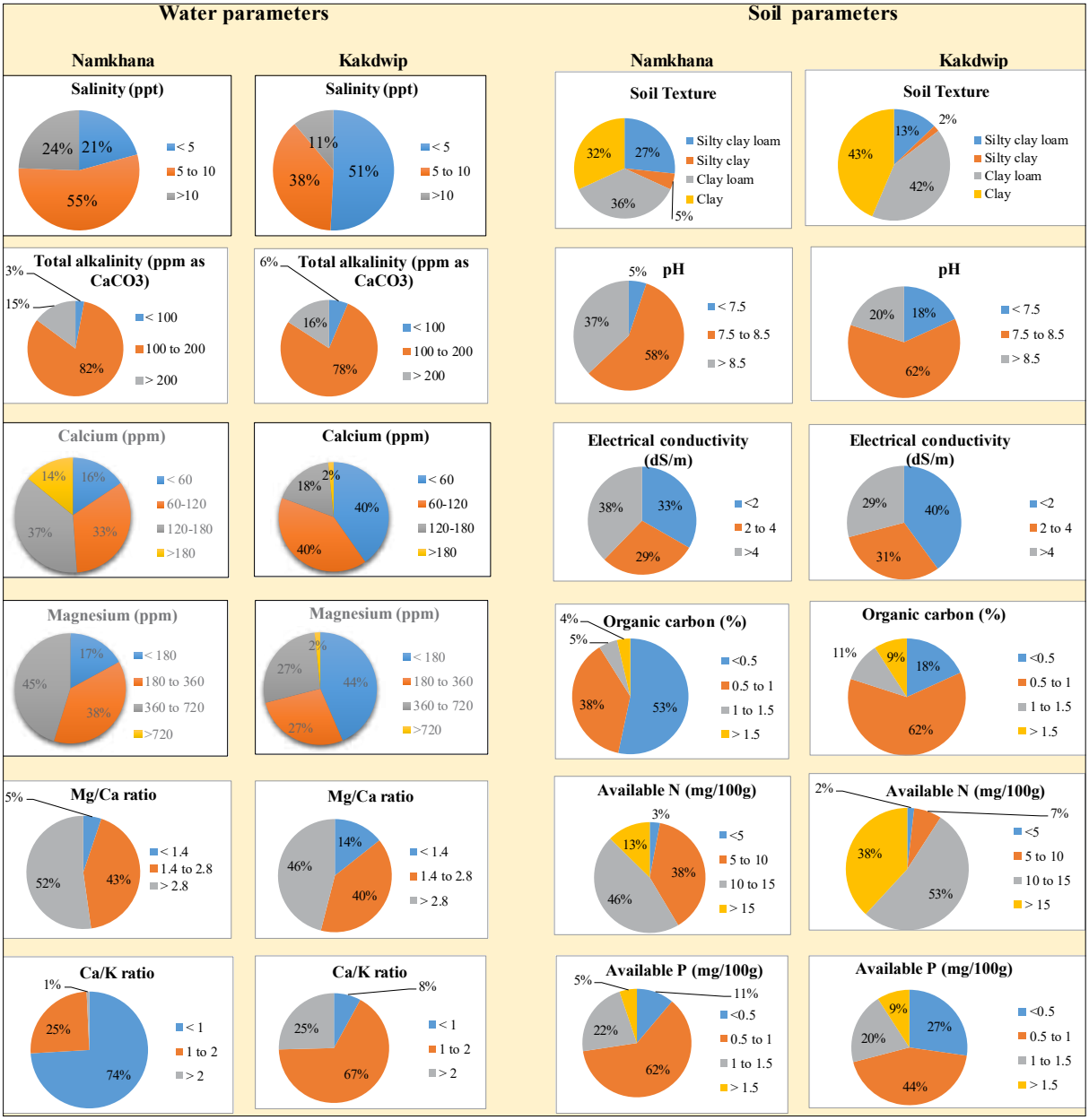


Fig. 15. Physicochemical characteristics of source waters and pond soils in Namkhana and Kakdwip Blocks of South-24 Parganas District, West Bengal

available nitrogen and available phosphorus. Most of the water samples in Namkhana (55%) were in the 5 to 10 ppt salinity range compared to 51% of samples under <5 ppt in Kakdwip. Most of the water samples in both blocks were in the optimum range for alkalinity. About 52% and 46% of samples were in the >2.8 Mg/Ca ratio category, and 25% and 65% were in the Ca/K ratio range of 1 to 2:1 in Namkhana and Kakdwip, respectively. Overall, all the areas are suitable for brackishwater aquaculture with the recommendation of manuring the soils once a year to increase the fertility status. (Fig. 15).

Spatio-temporal variation in water quality index of the sub-tropical estuary for cage aquaculture

Brackishwater estuaries are underutilized natural waterbodies for cage aquaculture. Water samples were collected from 11 sampling points in the Muttukadu estuary at the monthly interval and analyzed for physicochemical properties to assess the seasonal variation in water quality. Dissolved oxygen is

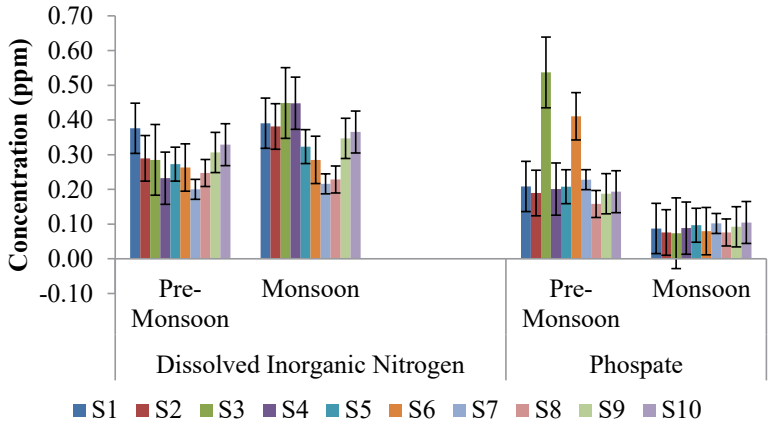


Fig. 16. Dissolved oxygen levels at different sampling points of Muttukadu estuary

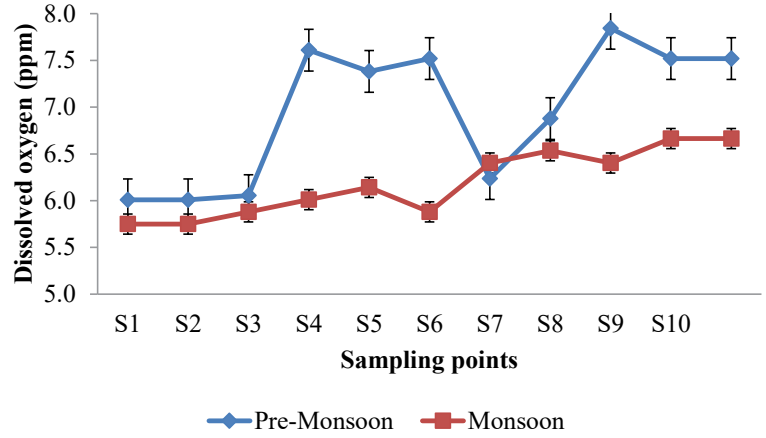


Fig. 17. Nutrient profile of Muttukadu estuary

one of the important parameters which determine the suitability of waterbody for aquaculture. Across the seasons, the DO levels were above 5 ppm and it is not a limiting factor for the site suitability and higher values were recorded during monsoon season. Seasonal variation in the water quality of the estuary indicated that nutrient levels (dissolved nitrogen and phosphate) were high during the monsoon season because of leaching from adjacent areas. The seasonal variation in the water quality of the estuary indicates that aquaculture could be carried out throughout the year. However, based on the seasonal variation in water quality cages should be installed without affecting environmental sustainability (Fig. 16, 17).

Adyar creek for Brackishwater Aquaculture

To study the seasonal influence on the water parameters of Adyar creek, samples were collected from different sampling stations at monthly intervals. The pH of the water was almost stable throughout the year (7.95-8.11), the salinity of water varied between 19-23 ppt and the hardness increased with the salinity. Metabolites concentrations are high, especially at the end of the creek length where the drainage water joins and away from the bar mouth and they varied with the tidal influx. Based on the key water parameters variation, a suitable season will be identified for cage/ pen culture by the communities in and around the creek. (Fig. 18).

Thermal tolerance of milkfish life stages

The thermal tolerance limits (CTmax - critical thermal maxima;

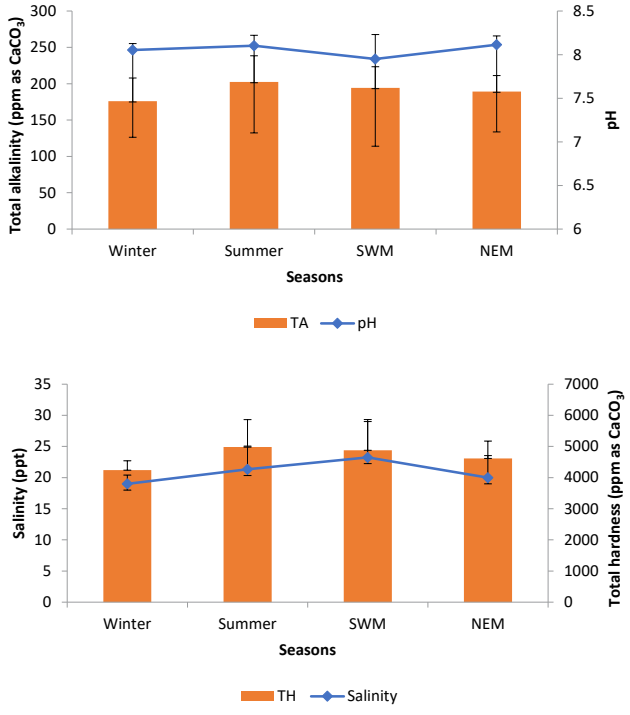


Fig. 18. Variation in Adyar creek water parameters under different seasons

LTmax - lethal thermal maxima) of milkfish life stages (larvae, fry, fingerling & stunted yearlings) were studied at the end of 30 days long temperature acclimation trial at 28, 30, 32 and 34°C. The loss of equilibrium was the endpoint for CTmax whereas the LTmax was the temperature above CTmax until the opercular movements ceased. Milkfish (except larval stage) which have a natural habitable temperature range of 25°C to 29°C, when exposed to higher acclimation temperature showed enhanced CTmax and LTmax values. The maximum CTmax for milkfish larvae was 35.26°C when acclimated to 30°C but they did not survive at a higher temperature for a longer duration. Stunted yearlings with maximum CTmax (40.7°C) and LTmax (41.4°C) values, and temperature tolerance period (TTp) of 21.6 min at 34°C are most resilient to temperature changes. Oxygen consumption (mg O_2/kg/h) of milkfish increased significantly with enhanced acclimation temperature. Based on the lowest temperature coefficient (Q10) values for oxygen consumption and acclimation response ratio (ARR) of larvae, fry, fingerling and stunted yearling, the final preferred temperatures (where a drop in the Q10 becomes apparent) are 28°C, 30°C, 30-32°C, and 34°C, respectively (Fig. 19, 20).

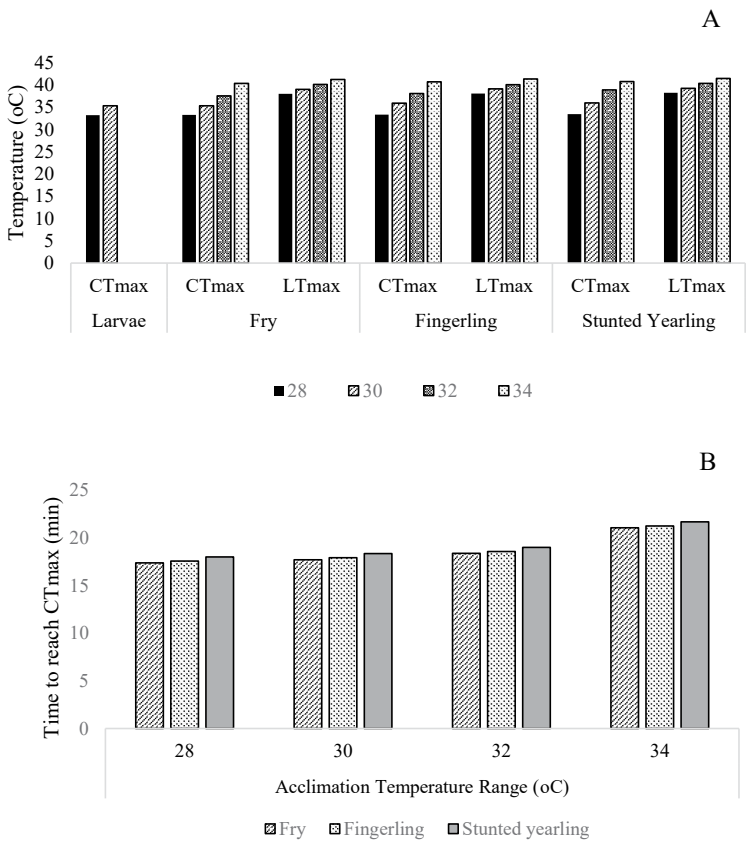


Fig. 19. Thermal tolerance of milkfish in different life stages (larvae, fry, fingerling & stunted yearlings) acclimated at 28°C, 30°C, 32°C and 34°C: (A). CTmax and LTmax values (B). Temperature tolerance period (TTp). Data expressed as Mean±SE

Life stages of milkfish	Maximum habitable temperature (° C)	SGR	b	r^2	L-W relationship (Log W=Log a+b Log L)
Larvae	28	2.45	0.82	0.98	Log W = 0.823 Log L- 0.1787
Fry	30	2.68	0.68	0.99	Log W= 0.6859 Log L- 0.3185
Fingerling	32	1.32	1.83	0.99	Log W = 1.8316 Log L- 0.3185
Stunted Yearling	34	0.01	1.37	0.99	Log W = 1.3775 Log L- 0.7274

Unit: Specific growth rate (%/day), b=regression slope, r^2=coefficient of determination, L=Length, W=Weight.

Table 3. Specific growth rate and length-weight relationship of milkfish under maximum habitable temperature

Ideal salinities for maturation, breeding and larval rearing of brackishwater catfish, *Mystus gulio*, a climate resilient fish

Mystus gulio (Ham.) is a commercially important climate-resilient species for brackishwater aquaculture due to its euryhaline and hardy nature can be easily farmed in different agro-climatic regions varying in salinities, temperature and hypoxic conditions. To understand the sexual maturation, breeding and larval rearing of *M. gulio* at different salinities ten males and five females (sex ratio of 2: 1, size 12-15 g) were stocked during the pre-spawning season (March) and reared in five

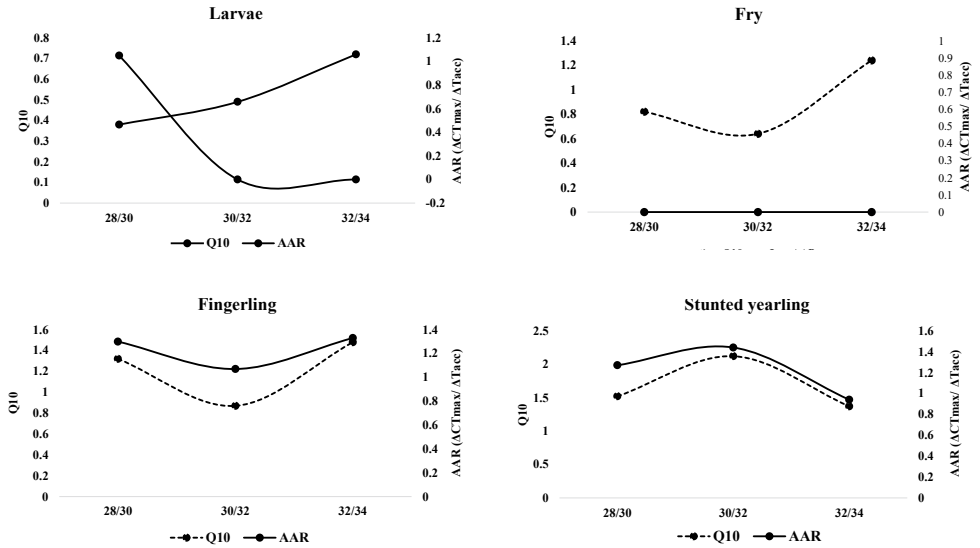


Fig. 20. Lowest temperature coefficient (Q10) values for oxygen consumption and acclimation response ratio (ARR) of larvae, fry, fingerling and stunted yearling of milkfish acclimated at 28°C, 30°C, 32°C and 34°C.

different salinities (0, 5, 10, 15 and 20 ppt) till spawning season begin (May), and induced to spawn in their respective salinities. There was a significant difference ($P < 0.05$) in the value of gonadosomatic index (GSI %), high at 10 ppt (25.3) and lowest at 20 ppt (16.1), and no significant changes for hepatosomatic index (HSI). Oocytes diameter (840-898 µm), fertilization (83-88%) and hatching rate (68-88%) were significantly maximum in 0, 5 and 10 ppt ($P < 0.05$). Larvae survival (25-28%) was significantly high in 5-10 ppt salinity ($P < 0.05$). It is concluded that though *M. gulio* attained sexual maturation and spawned between a salinity of 0-20 ppt, the ideal salinity for broodstock development, breeding and larval rearing is between 0-10 ppt. (Figs. 21, 22, 23).

Effect of lipid level on amelioration of temperature stress in shrimp, *Penaeus vannamei*

The rise in atmospheric and water temperature as a result of global warming will influence the growth, immune status and metabolic pathways in the cultured shrimp. To ameliorate the temperature stress, an experiment was conducted for 45 days with juvenile *P. vannamei* reared in three water temperatures

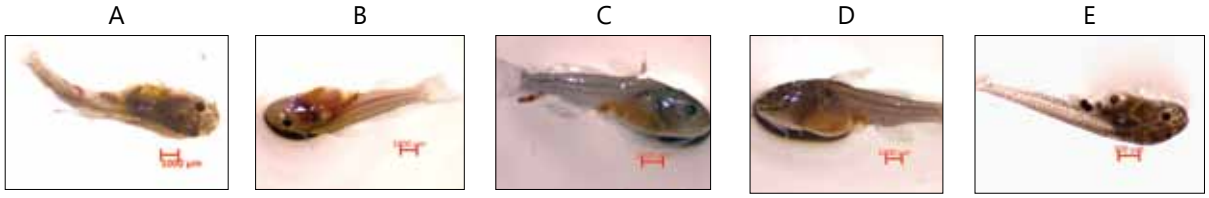


Fig. 21. M. gulio larvae at A. 0 ppt, B. 5 ppt, C. 10 ppt, D. 15 ppt, E. 20 ppt

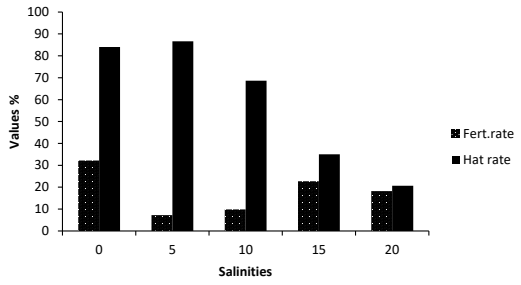


Fig. 22. Fertilisation and hatching rate of M. gulio

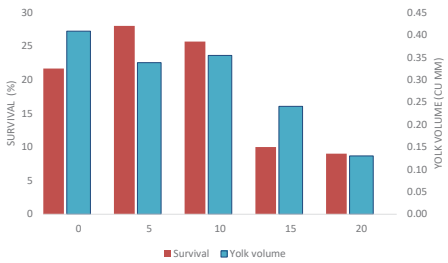


Fig. 23. Survival % Yolk sac volume of M. gulio larvae

(27, 30 and 33°C) in the RAS system with automatic temperature control. The shrimps were fed two diets varying in lipid content (5.3 and 7.8%). Higher lipid level (7.8%) had a positive effect on digestive enzymes, growth and fatty acid profile at 30 and 33°C, but at normal temperature (27°C). The hepatopancreas was analysed for whole transcriptome analysis to understand the metabolic pathways involved in temperature stress. The raw reads obtained were screened for quality using FastQC v0.11.9 and the low-quality reads and adapters were trimmed using Trimmomatic-0.39. High-quality trimmed reads were mapped to the *P. vannamei* reference genome (GCF_003789085.1_ASM378908v1) using STAR-2.7.10a (Spliced Transcripts Alignment to a Reference) and the assembled transcripts were quantified and normalized using RSEM-1.3.3 (RNA-Seq by Expectation-Maximization). Differential gene expression analysis and metabolic pathways by bioinformatics tools showed that higher lipid treatment has ameliorated the temperature stress by up-regulating the metabolic pathways involved in energy metabolisms like pyruvate metabolism, TCA cycle and AMPK signalling pathways. (Fig. 24-26).

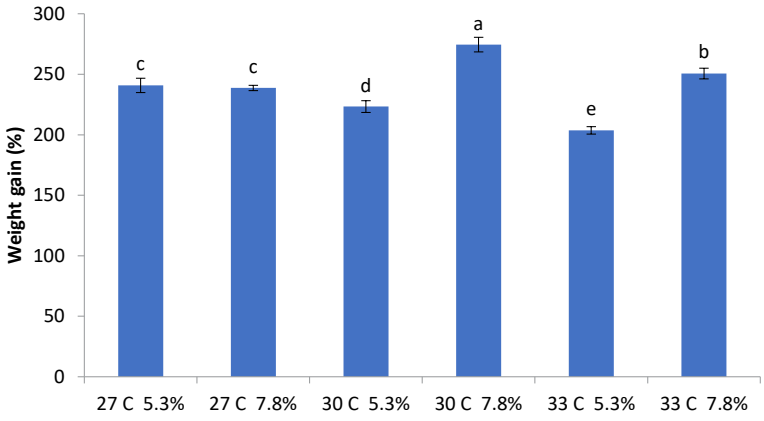


Fig. 24. Effect of dietary lipid level on shrimp growth (weight gain %) reared at different temperatures.

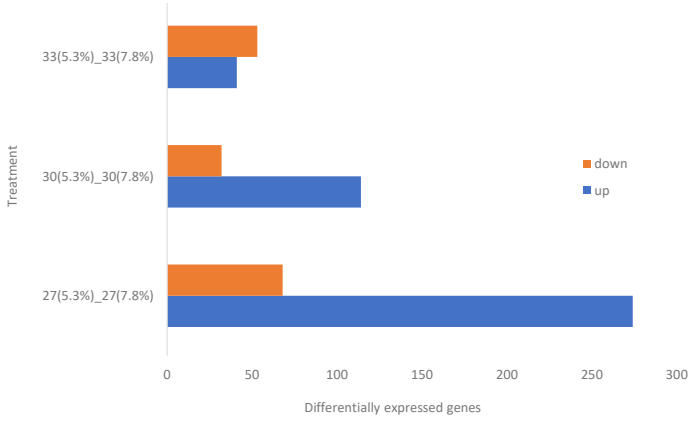


Fig. 25. Differential expression of genes in P. vannamei reared at different temperatures and fed with diets varying in lipid content.

Transcriptomic studies to understand the variability of physiological and stress responses to extreme climate under field conditions

Shrimp samples collected from different geographical locations in India (Haryana, Rajasthan, Andhra Pradesh, Kerala and Tamil Nadu) which had undergone sudden changes in their ecological

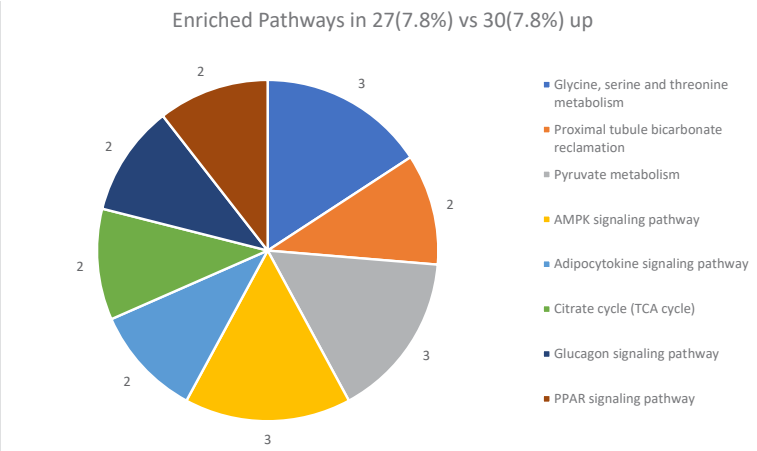


Fig. 26. Enriched pathways involved in 27 (7.8%) vs 30 (7.8%) upregulated.

environment such as drastic reduction in salinity and low temperature in ponds (Fig. 27). The gills, gut and hepatopancreas were dissected out and were subjected to transcriptomic analysis.

Tissue samples (n=171) of Pacific white shrimp, *P. vannamei* has been collected from the farmer's pond in different regions of India and stored for transcriptomic studies. These shrimps have been exposed to natural climatic stressors like sudden change in salinity and temperature. Out of 171 samples 36 samples have been subjected for transcriptomics and the results are being analysed.

Thermal tolerance ability of the diversified shrimp species

The ability of the various shrimp species for its tolerance to temperature has been studied under experimental conditions. In this experiment the critical thermal maxima and critical thermal minima of the commonly cultured shrimp species has been ascertained and the results are given below (Fig. 28, 29).

The results of the experiment revealed that highest value of CTMax was observed for *P. vannamei* (44.30°C) followed by *P. monodon* (42.80°C), *M. monoceros* (42.40°C), *P. indicus* (42.10°C), *M. dobsoni* (42°C).

The species which can tolerate lowest critical temperature value were observed as *M. monoceros* (10.8°C) followed by *P. indicus* (10.9°C) , *M. dobsoni* (12.7°C), *P. vannamei* (12.8°C), *P. monodon* (14.2°C).

Fig. 27. Field sample collection

Effect of salinity on growth, survival and osmolality of *P. indicus* and *P. vannamei*

A 30 days study was conducted to evaluate the effect of different salinity on growth and survival of *P. indicus* and *P. vannamei* juveniles. The animals were maintained in three different salinities (5, 30 and 40 ppt) in triplicates in 350 L FRP tanks. Fifteen animals of *P. indicus* (3.5 g) and *P. vannamei* (7.2 g) were stocked in each tank. Feed was provided 3 times a day at the rate of 5% of the body weight. Samples were collected once every week for growth assessment. The results for growth, survival and osmolarity at different salinity revealed that *P. vannamei* is versatile and adoptive to change in salinity while, *P. indicus* has shown better tolerance to higher salinity than lower salinity (Fig. 30).

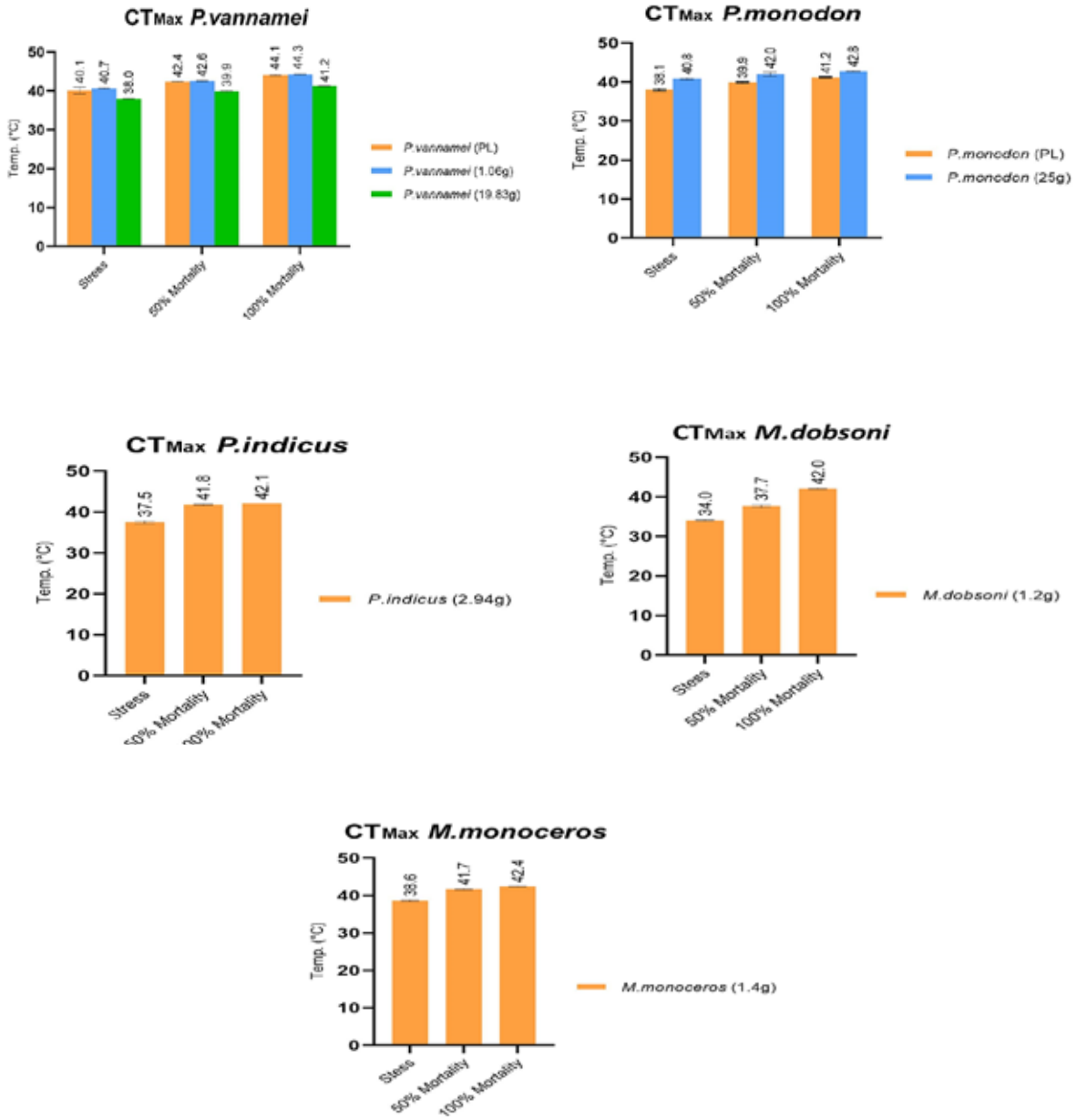


Fig. 28. Graphical representations of CTMax for different species

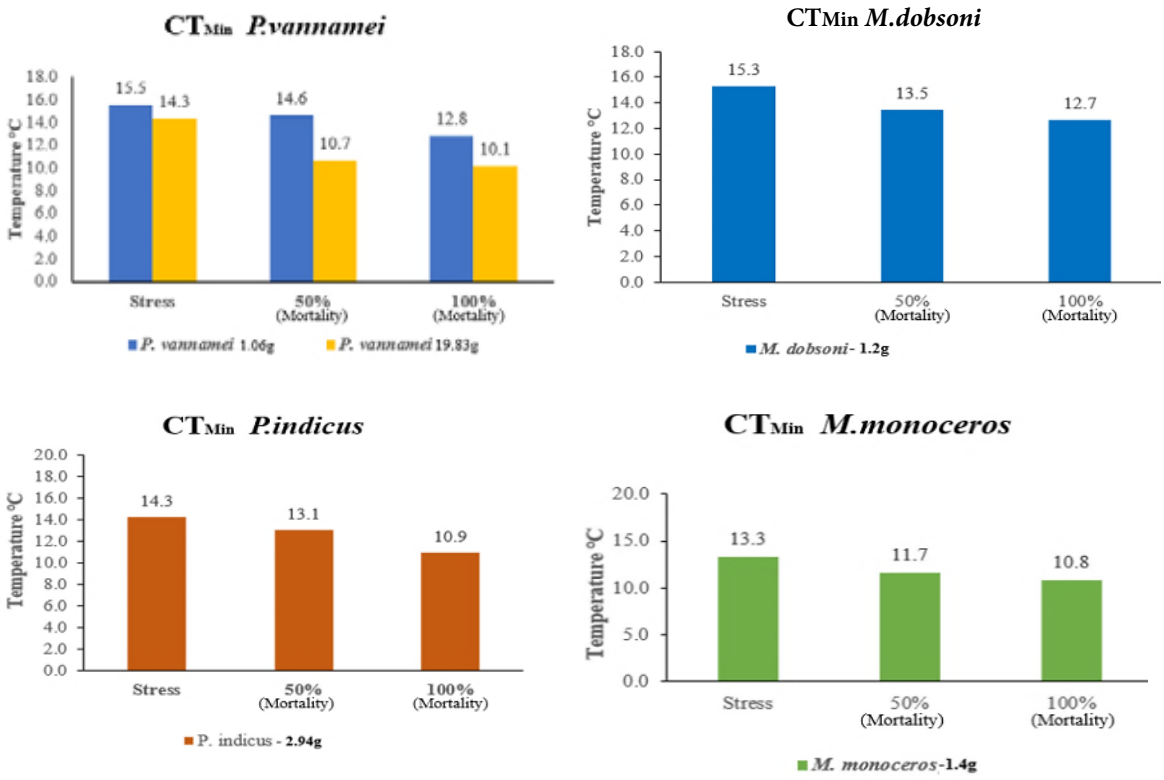


Fig. 29. Graphical representations of CTmin for different species

Effect of a sudden shift in salinity on EHP load in shrimp, *Penaeus vannamei*

Enterocytozoon hepatopenaei (EHP) is an intracellular microsporidian parasite that infects the hepatopancrease of shrimp and significantly retards somatic growth, resulting in economic loss. It was observed in our previous experiments that the infectivity and its effect vary with the salinity of rearing water. However, no information is available on the impact of a sudden shift in salinity as a result of extreme weather events on the EHP load in the shrimp. An experiment was conducted by suddenly shifting

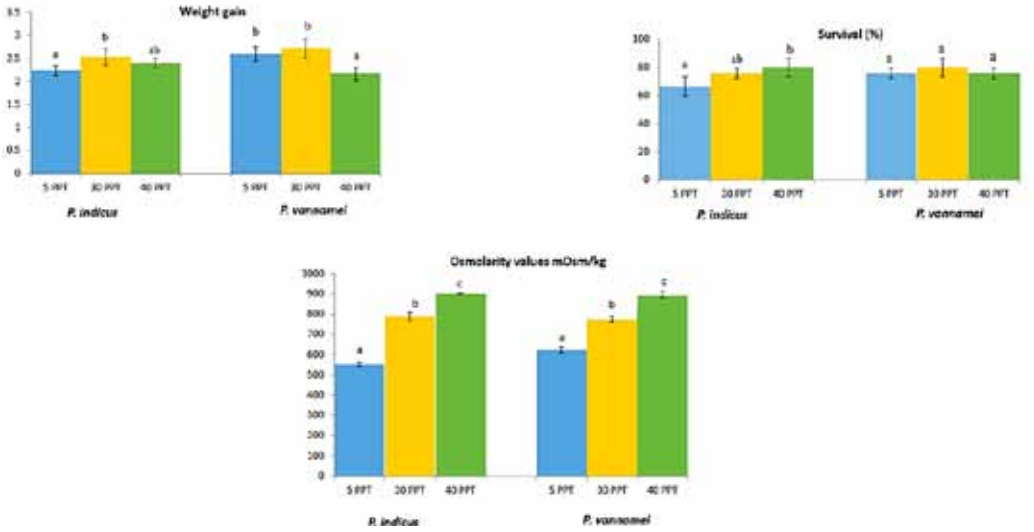


Fig. 30. Graphical representation of effect of salinity on growth, survival and osmolality of P. indicus and P. vannamei

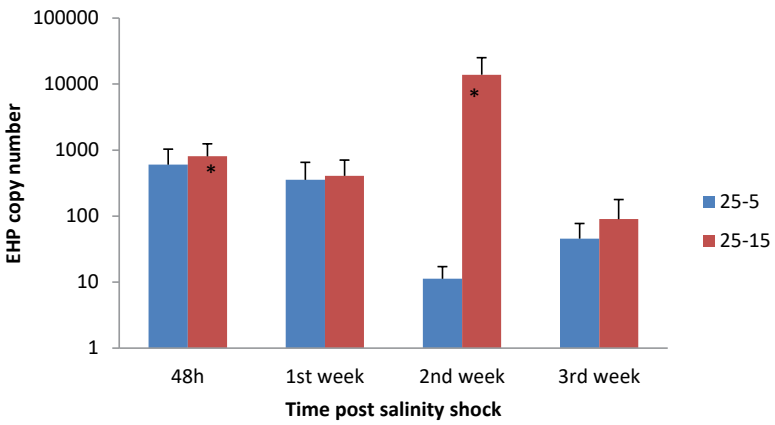


Fig. 31. Effect of a sudden shift in salinity on EHP load in shrimp

shrimp from 25 ppt to 5 and 15 ppt to assess its impact on EHP load in the hepatopancreas of shrimp. *P. vannamei* was orally challenged with EHP at 25 ppt for 4 days and maintained for 14 days before dropping the salinity (@5 ppt/h) to 5 and 15 ppt. EHP load in the hepatopancreas of the infected shrimp was assessed by qPCR at 48 h, 1, 2 and 3 weeks post-shift in salinity. A significant increase in EHP copy number in the group reared at 15 ppt was observed at 48 h and 2 weeks post salinity shock. The observations indicate the effect of a sudden shift in salinity on the EHP load in shrimp. (Fig. 31).

Building shrimp yield classification models

Soil and water parameters during shrimp culture have been collected from 12 shrimp farming areas covering both the east and west coast of India. Data on important water and soil parameters; climatic parameters: minimum temperature, maximum temperature and rainfall; and yield from respective areas have been included for modelling purpose. Based on the productivity of the farms they have been classified into low, medium, and high-yielding farms. For simulating the parameters to classify farms, data has been augmented based on the normal distribution. Mean and standard deviations of input parameters are used for generating a dataset of 1,000 observations using the R function for each class. Different machine learning models viz., logistic regression, multilayer perceptron, support vector machines, decision trees and random forest were applied to classify the data. Based on the accuracies obtained through tenfold cross-validation models and model output parameters, the Random forest model was observed to be best suited for the classification of aqua farms. This work demonstrates the suitability of the approach for developing aqua farm-based prediction models. (Fig. 32).

Contribution of shrimp farming to global warming potential: Life cycle assessment approach

To quantify and compare the total environmental impact of a product a standard benchmark including all relevant steps involved in the production cycle is required. Life cycle assessment (LCA) is an effective tool for generating detailed and integrative information with respect to impact categories like global warming potential (GWP), ozone layer depletion (ODP), and eutrophication potential (EP) of a given product within defined boundaries. It allows identifying impact peaks in the production chain as well as the detection of areas for improvement. LCA was used to quantify and compare environmental impacts associated with *P. vannamei* farming in India, with the system boundaries of the hatchery, feed mill and farming. The primary and secondary data were collected related to the entire individual processes including transport and energy use. The impact assessment was performed

Kappa statistic	0.941
Root mean squared error	0.161
TP Rate	0.961
FP Rate	0.020
Precision	0.961
Recall	0.961
F-measure	0.961
ROC	0.996

Output parameters of the Random forest model

using one of the most recent and up-to-date LCA methods, the ReCiPe 2016 Midpoint (H) V.1.02 with the SimaPro software. The global warming potential (GWP) of shrimp hatchery, feed mill and shrimp farming was 331, 704 and 3,230 kgCO_2eq, respectively indicating that farming is the key stage, significantly contributing to GHG emissions. The major hotspot contributing to GWP was the energy use in terms of electricity and diesel. (Fig. 33).

Alternate models to decrease global warming potential from shrimp feed mill

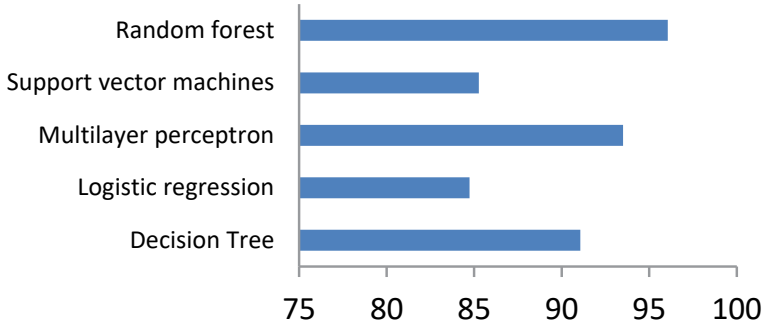


Fig. 32. Accuracy obtained for shrimp yield classification models

The carbon footprint can be reduced by employing energy-conserving technologies. The availability of fish meal is limited in the scenario of climate change and also its import is contributing to more feed production costs and GWP. Hence, alternate feed formulations were developed by replacing fish meal in the feed with plant protein sources. Four isonitrogenous and isolipidic diets were formulated by substituting fishmeal at 0% (control), 50%, 60%, and 70% (FR-0, FR-50, FR-60, FR-70, respectively) using fermented plant protein mix consisting of different proportions of fermented soybean meal, groundnut oil cake, sunflower and rape seed. While it is essential to test the efficiency of these feeds on shrimp growth, it is also pertinent to perform LCA to analyse the environmental impacts. The LCA of the feed mill was performed with the modified feed formulations. The GWP was 704, 660, 651 and 642 $kgCO_2eq$ with FR-0, FR-50, FR-60, and FR-70, respectively indicating the sustainability of feeds replaced with fish meal. (Fig. 34).

Adaptation measures to climate change events influencing the technical efficiency of shrimp farmers

It is pertinent to determine whether the adaptation strategies followed by farmers to overcome the negative effects of climate change (CC) help in improving their efficiency. Based on the farmer's (n=250, Nellore district, AP) perception of the likelihood, consequence and risk rating of CC events on shrimp aquaculture during the last 10 years along with socio-economics, and adaptation strategies followed, cyclone (CYC) and flood (FLD) were perceived by all, and irregular season (IRS), high temperature (HTEM), heavy rains (HR) and drought (DRT) by 206, 227, 239 and 147 farmers, respectively. The highest economic risk rating and maximum adaptation cost were for FLD followed by CYC. *Stochastic Frontier* and *Cobb*

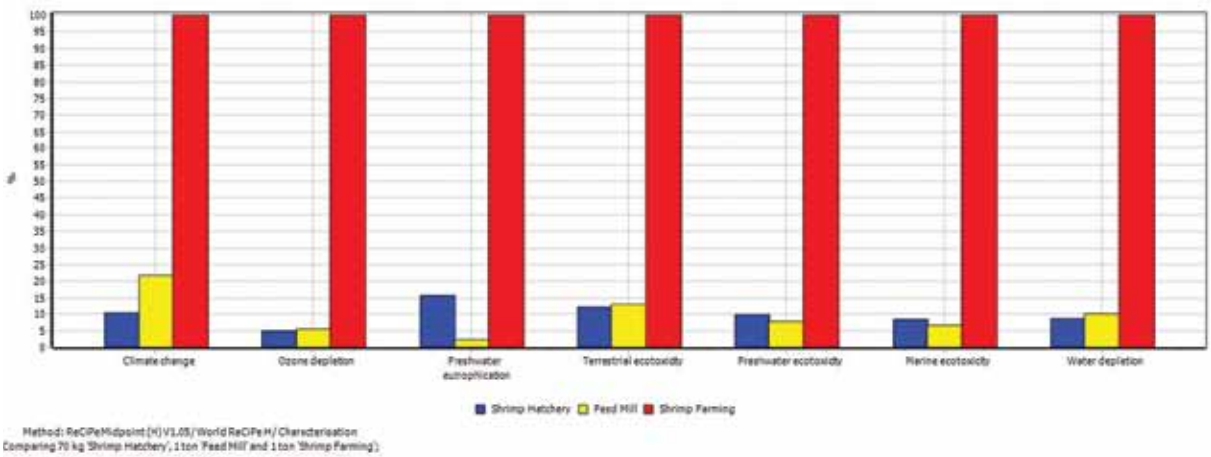


Fig. 33. Graphical representation of environmental impacts comparison during the life cycle of shrimp hatchery, feed mill and farming

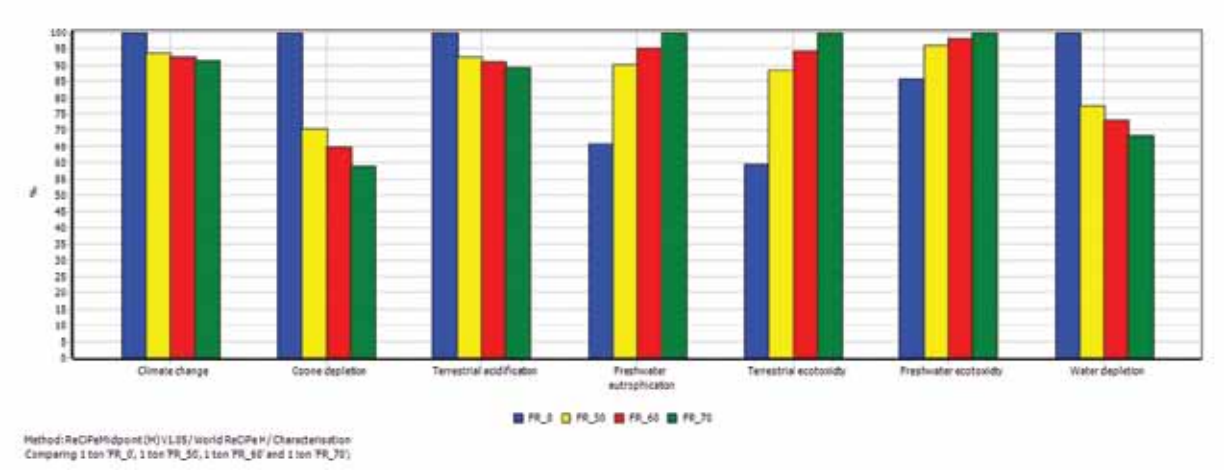


Fig. 34. Graphical representation of environmental impacts comparison during different models of shrimp feeds production.

Douglas functions were used to study the technical and economic efficiencies of the farmers by including both climatic and socio-economic variables. About 58% of farmers are more than 90% efficient due to the use of quality seed and feed, and the adoption of the latest technology in farming. Among the variables stocking density, farming experience, CYC-level of success and FLD/HR-level of success only had a significant influence on the efficiencies indicating that those farmers who had successfully overcome the negative effect of CYC and FLD had increased their efficiency levels.

	Coefficients	*t Stat*
Intercept	0.355	18.11
Water spread area	-0.0023	-0.762
Stocking density	0.0022	1.989*
FEXPYR	0.0007	1.821*
EDUL	0.0005	0.185
TRNATTND	0.0027	0.171
CYCLS	0.0161	3.421***
FLDLS	0.0124	2.732***
IRSOBSV	0.0055	1.057
LTEMOBS	0.0007	0.162
DRTOBS	-0.0018	-0.408
R2	0.89	
F-statistic	202.1	

*Significant at 10% level; *** Significant at 1% level

Table 4. Efficiency differentials across shrimp farmers in overcoming climate change events

FEXPYR - Farming experience in years; EDUL - Education level; TRNATTND - Trainings attended; CYCLS - Cyclone - Level of Success; FLDLS - Flood – Level of success; IRSOBSV - Irregular season observation; LTEMOBS - Low temperature observation; DRTOBS - Drought observation

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

A study was carried out for the identification of the potential areas in major riverine ecosystems of Kannur District, Kerala for their suitability to brackishwater aquaculture for a period of 18 months. The five major rivers studied are Perumba, Kuppam, Valapattanam, Anjrakandy and Kuyyali. The physio-chemical parameters, phytoplankton, zooplankton, benthic organisms, fish catch etc. were analysed during the study period. All the parameters were mapped in ArcGIS; results were generated using Analytic Hierarchy Process (AHP) and Multiple-Criteria Decision-Making (MCDM) methods. The river systems of Kannur were fresh (0 ppt) to saline

water (31 ppt) due to South West monsoon and various ecological factors. The estuarine river systems were classified into highly potential, potential, marginally potential and non-potential zones. Based on the ecosystem based analysis, about 48.2 hectares of brackishwater is highly potential for the immediate use in aquaculture. Valapattinam and Kuppam rivers are having more suitable area for initiating brackishwater aquaculture. Based on the parameters analysed the identified areas can be used for cage and pen culture of shrimp, crab and finfishes to enhance the aquaculture production in the district.

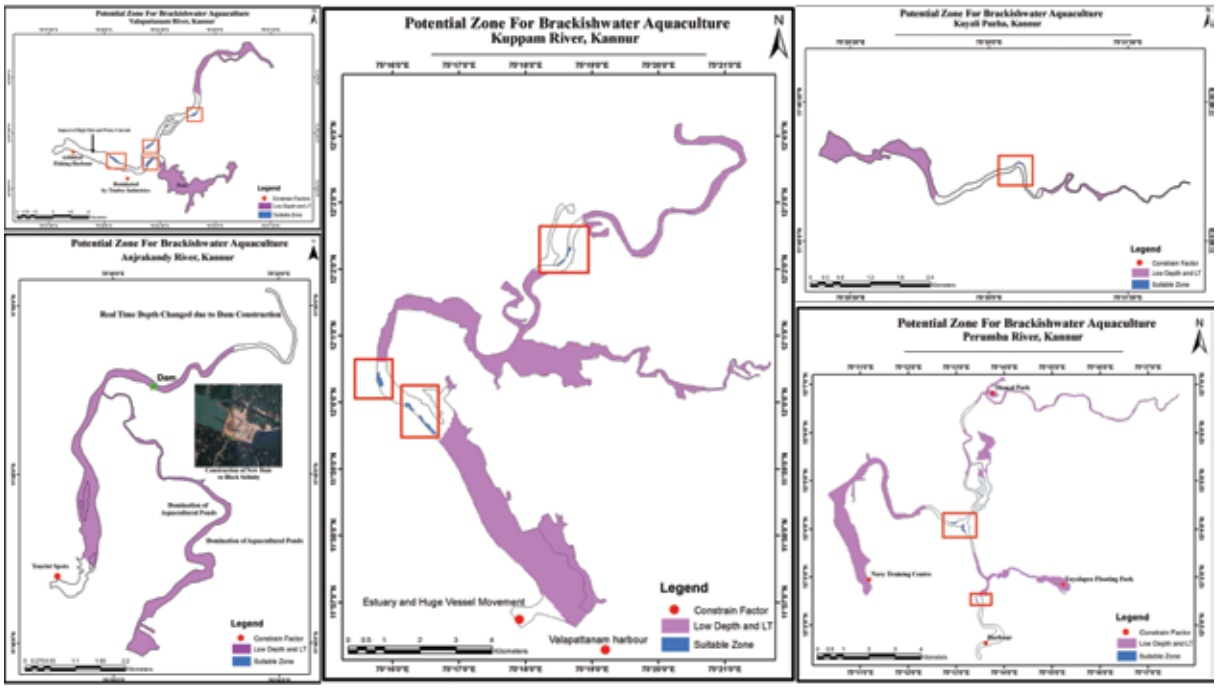
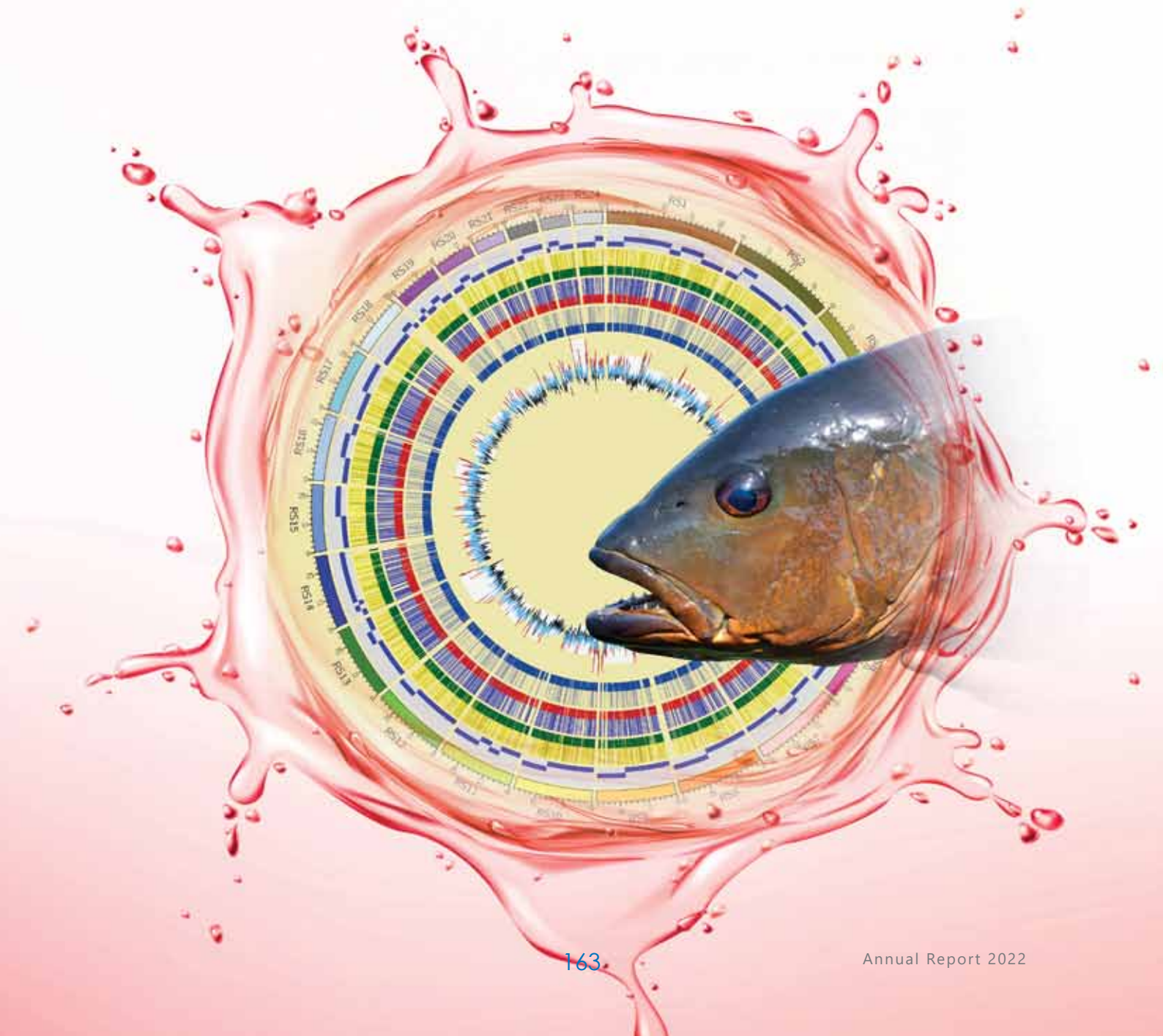


Fig. 35. Potential zones for brackishwater aquaculture in rivers of Kannur District, Kerala

GENETICS & BIOTECHNOLOGY



GENETICS & BIOTECHNOLOGY

Draft genome assembly of *Lutjanus argentimaculatus*

Lutjanus argentimaculatus, commonly known as mangrove jack or mangrove red snapper belongs to species of marine ray-finned fish of the family Lutjanidae. It is an important, fast growing, commercial food fish having good demand and fetches good price. The red snapper is a potential candidate species for aquaculture as it is a euryhaline fish with abilities to grow in fresh, brackish, and marine habitats and can be reared easily in captive conditions. The whole genome information data will provide a new perspective for the genomics research of *L. argentimaculatus*. The major findings of this study have potential applications in the conservation and the management of this species and future selective breeding programmes.

Genome length, bp	1,042,747,252
No. of contigs	699
Max. length, bp	38,328,485
N50 length, bp	12,244,877

Table 1. Red snapper genome assembly statistics

The expected size of red snapper genome was estimated based on k-mer profiles generated using Illumina paired-end sequence reads. The 21-mer histogram was generated in Jellyfish 2.3.0 and analyzed in Genomescope. The analysis revealed the genome haploid length to be 713 Mb and genome repeat length to be 91 Mb.

Genome haploid length, bp	713,827,565
Genome repeat length, bp	91,960,469
Genome unique length, bp	621,867,096

Table 2. Red snapper genome assembly statistics

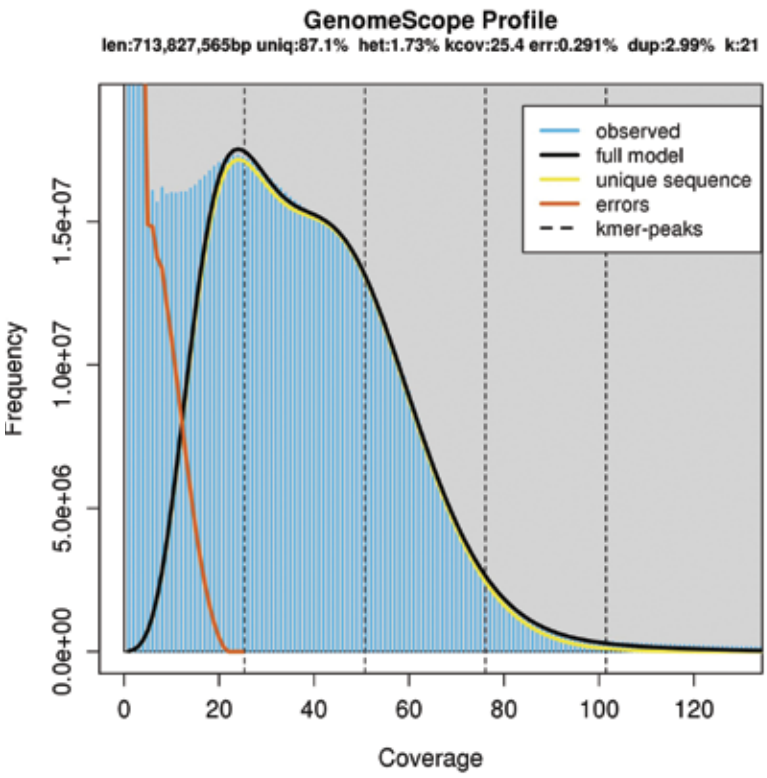


Fig. 1. The k-mer frequency analysis for red snapper genome

Steroidogenic enzyme gene expression in *Mugil cephalus*

Reproductive steroid hormones, produced from cholesterol by a suite of steroidogenic enzymes, play an important role in growth and maturation of the ovarian follicle in vertebrates. To understand the molecular aspects of steroid regulation of ovarian maturation in *Mugil cephalus*, a commercially important species that exhibits reproductive dysfunction in captivity, we examined the expression pattern of steroidogenic acute regulatory protein (*StAR*), a protein that regulates cholesterol transport for subsequent use in steroidogenesis and four key steroidogenic genes namely cholesterol side chain cleavage (*cyp11a1*), 3β-hydroxysteroid dehydrogenase (*3β-HSD*) and, 17α-hydroxylase/lyase (*cyp17*), and aromatase (*cyp19a*) in the ovaries of pre-vitellogenic (Stage I; Ova diameter 30-110 µm) and vitellogenic (Stage III; Ova diameter: 180-650 µm) females. The expression patterns of all these ovarian genes exhibited an increasing trend with advancement of maturation. The presence of all four steroidogenic enzymes in ovary and their positive correlation with higher plasma estrogen levels during maturation suggest ovary to be a prominent source of the circulatory E_2 levels in *M. cephalus*.

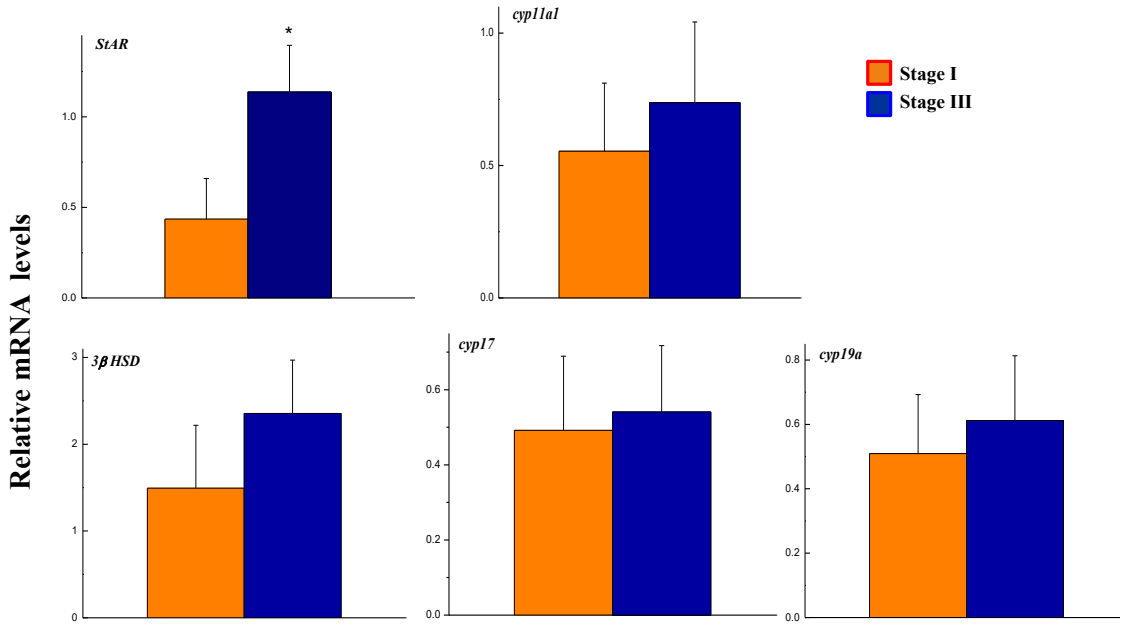


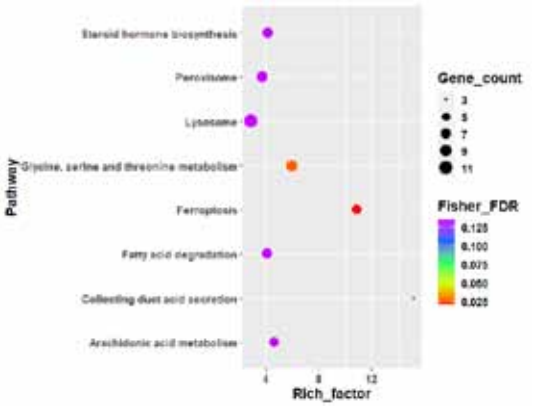
Fig. 2. Ovarian steroidogenic enzyme gene expression in Mugil cephalus

Comparative transcriptomic analysis of acute salinity and temperature stresses in *P. indicus*

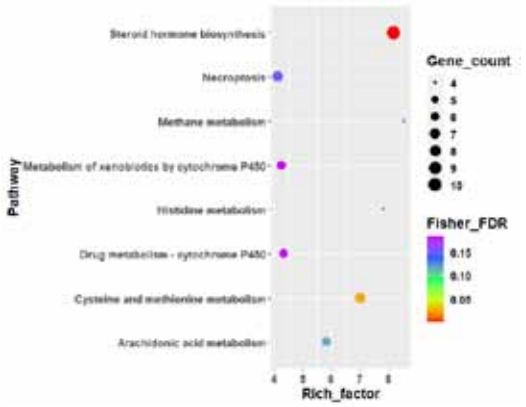
Abiotic and biotic stresses largely affect growth and development of culture animals. Among abiotic stresses, pond water salinity and temperatures are reported to be vital. Stress caused due to aberrations in optimal salinity and temperatures is a major factor of several diseases in aquatic animals. Sudden changes in these water quality parameters happen very often during the culture period due to surface weather parameters like rain fall, minimum and maximum temperature etc. Studying molecular mechanisms in shrimp due to changes in the growing environment could provide a basis for taking ameliorative measures. In the present study, it was intended to understand the molecular responses due to acute salinity and temperature stresses in *P. indicus* through RNAseq approach.

Shrimp cultured in indoor tanks were used for the study. For salinity experiment, acute salinity stress was induced by shifting the animals from control water salinities of 28 ppt to low and high adjusted water salinity tanks of 5 ppt and 45 ppt, respectively. Similarly, in temperature experiment, shrimp were shifted from control temperature of 27°C to low temperature tank and high temperature tanks with adjusted water temperatures of 22°C and 32°C, respectively. Animals were directly shifted to experimental tanks from the control tank without gradual acclimatization to experimental temperatures and salinities. No mortalities were observed during the experiment.

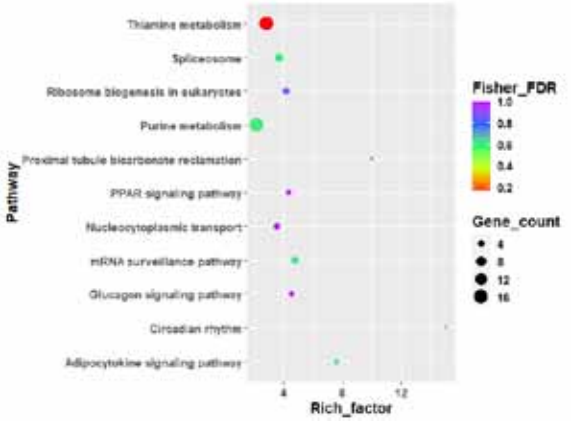
After 3 hours of creating acute stress in both experiments hepatopancreas tissue samples were collected and RNA-seq data was generated. Eighteen RNA-seq libraries were constructed from both the experiments generating 251.12 Gbp (131.53 Gbp + 119.6 Gbp) of sequence data. In the salinity experiment, 9 samples yielded a total of 871,053,274 raw reads, whereas 9 samples of temperature experiment yielded a total of 792,022,948 raw reads, which were then trimmed to remove



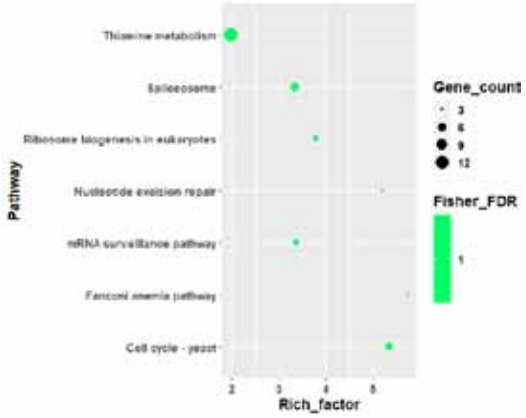
Enriched pathways in low temperature



Enriched pathways in high salinity



Enriched pathways in low temperature



Enriched pathways in high temperature

Fig. 3. Enriched pathways during acute salinity and temperature stresses in P. indicus

low-quality data. The percentages of Q20 and Q30 base were above 98.77% and 94.83%, respectively. Independent comparisons of groups, control (28 ppt) vs low salinity (05 ppt) and control (28 ppt) vs high salinity (45 ppt) were carried out to derive the differentially expressed genes (DEGs) in salinity stress. A total of 509 transcripts were differentially expressed in low salinity stress, out of them 260 were significantly upregulated and 249 were significantly down-regulated. Whereas, there were 284 DEGs in shrimp exposed to high salinity stress, in which 217 were significantly upregulated and 67 were significantly down-regulated. Similarly, in temperature stress, independent comparisons of groups control (27°C) vs low temperature (22°C) and control (27°C) versus high temperature (32°C) were made. Low temperature stress resulted in the differential expression of 348 transcripts, of which 247 showed a significant upregulation and 137 a significant downregulation. In case of high temperature stress, a total of 526 DEGs were identified of which 198 were significantly downregulated and 328 were significantly upregulated. DEGs were filtered by setting the log2Foldchange value above 2 and adjusted p-value below 0.05.

Annotation of DEGs were carried out in OmicsBox software, using blastx search against non-redundant (nr) protein database.

Clustering of differentially expressed genes resulted four clusters among upregulated salinity stress conditions. Carbohydrate & amino acid metabolism, cuticle protein, lipid metabolism and cellular processes were represented by cluster one, two, three and four respectively. While, signalling pathway and purine metabolism cluster was significant in temperature experiment.

Pathway enrichment analysis of salinity stress revealed up-regulation Ferroptosis and Glycine, serine and threonine metabolism pathways, Fatty acid degradation, Collecting duct acid secretion, Lysosome, Peroxisome, Arachidonic acid metabolism and Steroid hormone biosynthesis pathways, Cysteine and methionine metabolism pathways, Methane metabolism, Necroptosis, Histidine metabolism, Drug metabolism - cytochrome P450.

In case of temperature stress, Thiamine metabolism, mRNA surveillance pathway, Spliceosome, Adipocytokine signaling pathway, Purine metabolism, Circadian rhythm, Ribosome biogenesis in eukaryotes, Proximal tubule bicarbonate reclamation, Nucleocytoplasmic transport, Glucagon signalling pathway and PPAR signalling pathways, Fanconi anemia pathway, Nucleotide excision repair, were found to be up-regulated. Study documented important gene clusters, GO terms and metabolic pathways associated with acute salinity and temperature stress in *P. indicus*.

Building genome scale metabolic model for *Penaeus indicus*

Genome Scale Metabolic model (GEM) is a network-based computation tool used to simulate the metabolic interactions of an organism with the available known information such as genes, metabolites, reactions, enzymes, pathways, and the gene-protein-reaction associations. The collected information is compiled and transformed into a mathematical model in order to facilitate the mathematical calculation to predict the flow of fluxes through the reactions. The GEMs establish the relationship between the genotype and phenotype quantitatively by contextualizing the available Big-data. Here we aim to reconstruct the genome scale metabolic model of *P. indicus*.

As the first step in building GEM, genome annotation was performed with a blast search against the nr database followed by mapping, annotation, pathway analysis and Interpro analysis using the OmicsBox software. The reaction and metabolite information were retrieved from the KEGG database using the *KEGGREST* R package. The collected information was compiled together and transformed into a mathematical model using python scripts and the COBRApy python package. The generated draft model is composed of 3,015 genes coding for 6,222 reactions and 5,549 metabolites. Among these 6,222 reactions 6,039 are enzymatic reactions, 20 reactions which carry out the exchange of the essential amino acids, 5 of carbohydrate exchange, 23 of fatty acid exchange, 42 reactions were exchange reactions of vitamins, minerals and other micro nutrients, 91 transport reactions coding for the transport of the metabolites that are involved in the above stated exchange reactions. In addition, a biomass reaction as an objective function, was added to assess the overall biomass of the cell.

Chromosome-level genome assembly for pearlspot, *Etroplus suratensis*

The *Etroplus suratensis* (Bloch 1790), commonly known as pearlspot or green chromide, is a cichlid species

Assembly length, Gb	1.275
No. of Contigs	357
N50, Mb	31.42
Longest Contig, Mb	61.02
No. of scaffolds	344
N50, Mb	50.27
Genome length in 24 chromosomes, Gb	1.16 (91%)
BUSCO Completeness score, %	98.9

Table 3. Statistics of chromosome-scale genome assembly generated for pearlspot fish.

of high economic value as food fish. The pearlspot is particularly popular in the Indian state of Kerala where, it is referred to as Karimeen and enjoys the status of the 'State fish of Kerala'. The pearlspot displays tolerance to wide salinity range and hence is suitable for culture in fresh and brackishwaters. The growth rate of pearlspot in pond culture is observed to be low in comparison to cage culture. Low volume cage culture of pearlspot has been suggested as a viable livelihood for small-scale farmers. Availability of large number of seed is the major limitation for expansion of pearlspot culture in India. Deciphering of whole genome of pearlspot would lead to understanding of the genes and the molecular pathways that contribute to the species ability for salinity adaptation and species limitation in growth. Therefore, to have a better understanding of the salinity tolerance and growth of pearlspot, ICAR-CIBA has undertaken the activity of building complete genome and its associated molecular resources for pearlspot.

We have used the latest DNA sequencing technology to generate High Fidelity (HiFi) sequence reads on PacBio Sequel II sequencer using DNA of a single pearlspot fish. About 98 Gb of HiFi reads were used to generate 357 assembly contigs spanning 1.275 Gb with a N50 length of 31.4 Mb. These contigs were ordered and oriented with 4.39 billion Arima HiC reads to generate a chromosome-scale genome assembly containing 344 scaffolds of 1.275 Gb length and a N50 of 50.27 Mb. The software tools hifiasm and salsa2 were used for generating assembly contigs and scaffolds respectively. About 91% of the total genome length is contributed by only 24 scaffolds which is of significance since the pearlspot fish has 24 haploid chromosomes. As most of the assembly length is in 24 scaffolds, these could be considered as representing chromosomes. The genome was assessed to be 98.9% complete by benchmarking it with BUSCO actinopterygii_odb10 (2021-02-19) dataset. This high-quality genome would be used to understand the molecular mechanisms regulating salinity tolerance and slow growth in pearlspot fish after annotating the genome for protein-encoding genes.

Identification of microbial biomarkers for health state in *P. vannamei* through in silico meta-analysis

The diseases caused by pathogenic microorganisms are an important factor affecting the shrimp aquaculture production. Alternatively, microbes also promote the host's growth and health by acting as a probiotic. Therefore, documenting the potential, resident, and beneficial microbes crucial for improving shrimp health is important. Such information has potential to understand the health status of shrimp and prediction of disease incidence. The 16S rRNA based amplicon sequence data analyses have been reported in shrimp to document microbial profile and abundance. In recent years, the amplicon sequence datasets in public domain have increased enormously and this gave a possibility of undertaking a meta-analysis by combining all of them to document microbial biomarkers for health and disease states of shrimp. Further, the availability of genome sequences for various microbial organisms has prompted us to integrate genome-scale metabolic modelling in to meta-analysis to draw insights about the metabolic interactions influencing host health.

About 838 amplicon sequence datasets from 13 studies performed on diseased or healthy *Penaeus vannamei* have been collected from NCBI SRA database for this study. The linear discriminant analysis Effect Size (LEfSe) performed on sequence datasets identified 32 and 73 microbial species indicatives of health and disease states respectively for *P. vannamei*. Of these, the *Acinetobacter* and *Alteromonas* could be potential microbial biomarkers for health and disease states respectively (Figure 4). Further, genome scale metabolic models were built for all the indicator species to undertake *in silico* phenotypic growth predictions in pair-wise consortia in different nutrient environments. Here, we have looked for increase in growth rate of healthy species while the growth of disease species is limited. A total

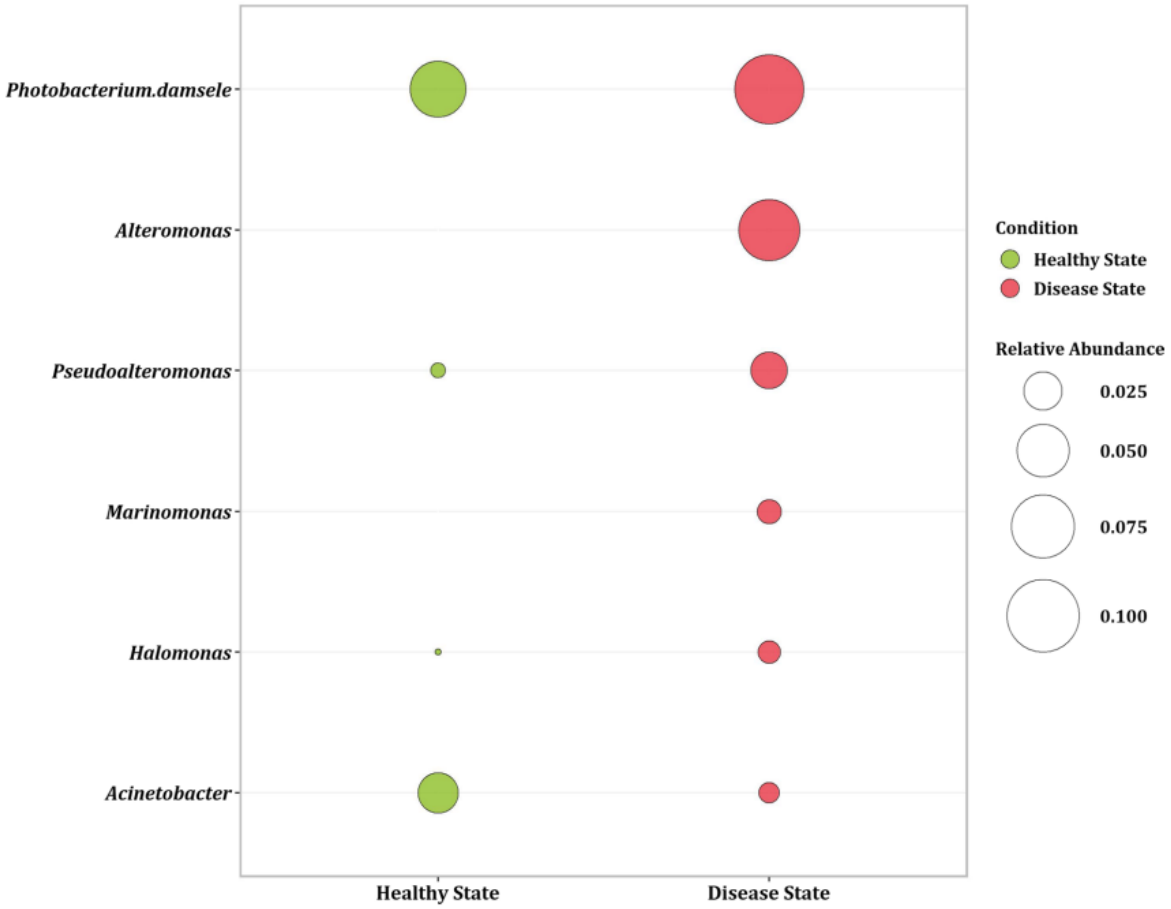


Fig. 4. Depiction of mean relative abundance of dominant biomarker genera in healthy and disease states of Penaeus vannamei. Size of the circle represents the mean relative abundance.

of 47 healthy species in 794 pair-wise communities have limited the growth of disease species. The growth of all the disease species was found to be limited by either one or the other healthy species except for the strain *Synechococcus*. Under majority of the nutrient environments, four genera namely, *Acinetobacter, Bifidobacterium, Brevundimonas,* and *Lutibacter* were found to be limiting the growth of many disease-related species.

Later, a flux variability analysis was performed to predict the acetate production/consumption behaviour in the community under diverse nutrient environments. The analyses revealed the role of *Acinetobacter* sp. in acetate production which might explain its potential role as a health indicator. Although, many beneficial or probiotic species are used in aquaculture, the lack of consistency and performance under different conditions is a major concern as microbial interactions vary in different nutrient environments. Therefore, it is crucial to capture the favourable environment that controls disease species growth. The flux variability analysis demonstrated that sucrose facilitates parasitic interactions (limits disease species growth). Overall, the study highlighted the role of sucrose and beneficial species towards improved health state for *P. vannamei* shrimp.

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

To sustain and prosper in aquaculture, development of genetically improved fish species are considered paramount important. Among brackishwater candidate species, pearlspot fish is selected for genetic improvement since they are euryhaline, omnivorous and they can be bred easily in captive conditions. Here, we have established six pealspot full-sib families on experimental basis and recorded their growth performance.

Among the fish families, within family selection will be implemented to generate next generation. The six full sib fingerlings were then stocked in six different cages fed at 5% bodyweight. The growth parameters were recorded in terms of total body length and body weight from 60 days of post-hatch (dph) to 360 dph. Body weight parameter had higher coefficient of variation (CV) than the body length. Complete mortality was observed on one of the families (6th family) after 120 dph due to water contamination in the pond. The mean body weight of the families ranged from 85 to 125 g on 360 dph. The recorded parameters will be utilised to compare with the next generation fishes to estimate response to selection and genetic gain which may tell us the efficiency of the selective breeding.

Effect of salinity on the stress-related gene expression in Indian white shrimp, *Penaeus indicus*

Recent studies on the response of *P. indicus* to salinity stress have primarily been focused on growth, survival, osmoregulation and immune response. Several important genes have been identified to be associated with salinity responses in shrimps. This study provides a better understanding of the genes involved and molecular mechanism underlying low-salinity adaptation in *P. indicus*.

The gene expression of Carbonic anhydrase (CA), Sodium potassium ATPase (Na+/K+-ATPase), Crustin, Prophenol oxidase (PPO), Peroxinectin , Beta glucan binding protein (BGBP), Super oxide dismutase (SOD) and Hemocyanin were measured by qRT-PCR at low salinity stress (5 ppt) for a period of three weeks. Shrimps reared at 30 ppt were taken as control.

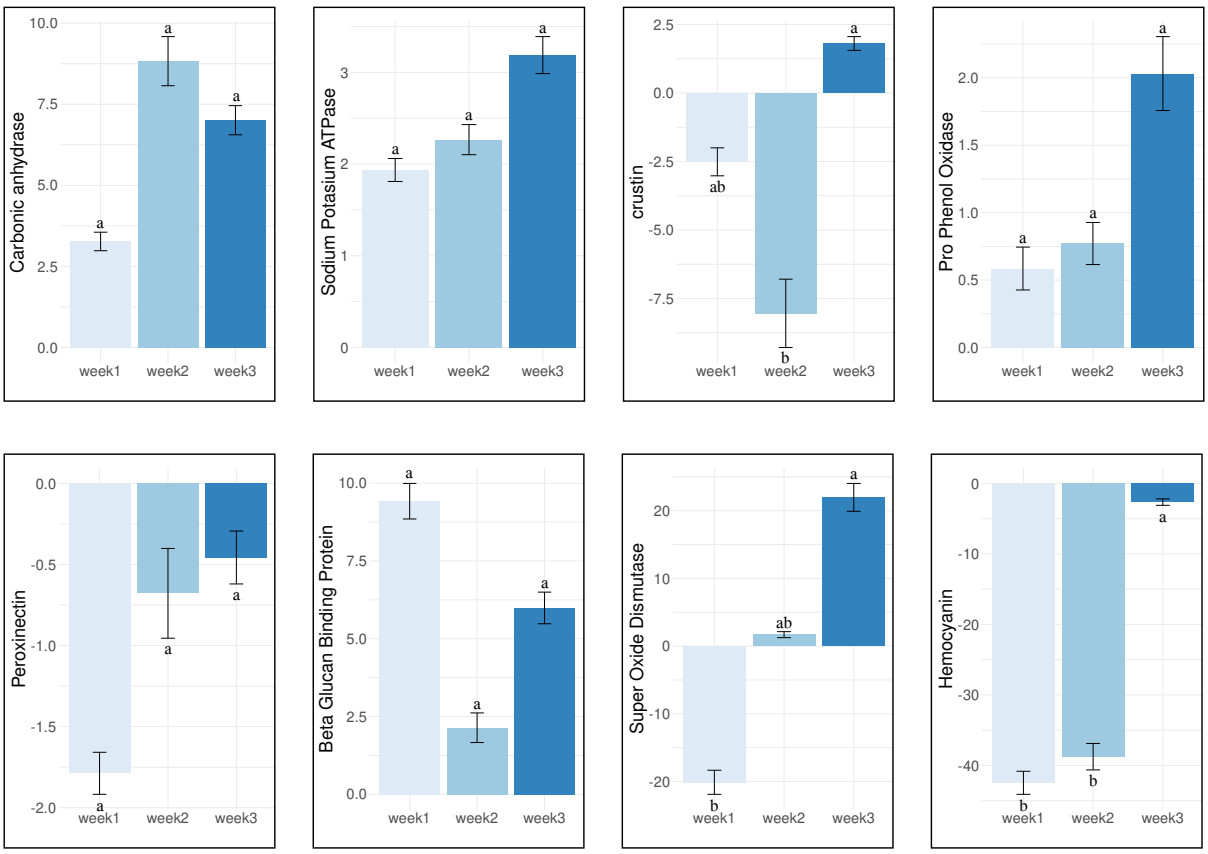


Fig. 5. Gills relative stress-gene mRNA levels at low salinity. Bars bearing different letters are significantly different, same letters indicate no differences (p < 0.05; Tukey's test).

The expression levels of CA, Na+/K+-ATPase, PPO and BGBP were observed to be up-regulated and there was no significant difference in the expression levels of these genes between three weeks. Whereas the expression levels of peroxinectin and hemocyanin were found to be down-regulated. Even though, peroxinectin gene showed no significant difference between the weeks, the expression of hemocyanin in the third week was significant. Crustin gene was observed to be down-regulated for the initial two weeks and then up-regulated, which was significant between all the weeks. SOD gene was significantly different in all the weeks, which was down-regulated in the first week and then up-regulated subsequently.

SOCIAL SCIENCES & DEVELOPMENT

SOCIAL SCIENCES & DEVELOPMENT

Risk analysis and their management in shrimp farming

A study was undertaken among the shrimp farmers (n=15) in Tamil Nadu for production risk analysis and their management. The loss due to major diseases like Hepatopancreatic Microsporidiosis (HPM) caused by *Enterocytozoon hepatopenaei* (EHP) and White Spot Disease caused by White Spot Syndrome Virus (WSSV) ranged between 40-70% in value terms. The farmers incurred an economic loss of ₹2.95 lakh/ha under 40% yield loss and 9.22 lakh/ha under 70% yield loss as compared to a profit of Rs.5.42 lakh/ha in the control i.e unaffected farms (Fig. 1).

Triangulation of the data with the fellow farmers revealed that poor seed quality was a major risk led to yield loss in a range of 30-60%. HPM disease was a major production risk with production losses up to 45% and advanced harvest is the better option to reduce the loss. Sensitizing fellow shrimp farmers in the cluster prevented horizontal spread of the disease. In low saline areas, farmers adopted mixed farming either with paddy or dairy/poultry as a risk management strategy and earned a net return of about ₹27,000/ha or ₹1,00,000/farm. It was observed that smart equipments were installed in farms to auto-start the generator for aeration in the event of power failure.

Shrimp crop insurance product development

Economic analyses were done using the production data of 2020-21 (MPEDA, 2022) and estimated that the business potential present for shrimp crop insurance was ₹750 crores per year with 4% premium. Similarly, the micro credit requirement was estimated at ₹13,000 crores per annum, which is being serviced at present by the informal creditors at higher interest rates (Table

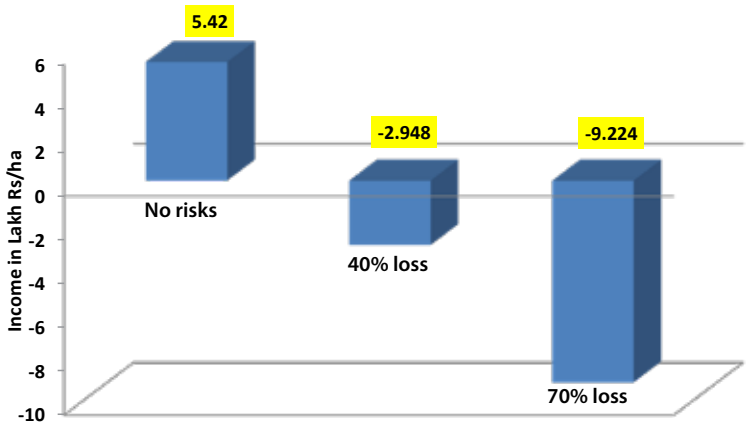


Fig. 1. Income loss in shrimp farming due to diseases (Lakh ₹/ha)

1). A paradoxical situation existed with loss of profitable business to banks and insurance companies on one side, hardships of farmers with minimal access to institutional credit and insurance on the other. Facilitating access to insurance and institutional credit would double the farmers' income in much faster time frame. In this line, ICAR-CIBA and Alliance Insurance brokers jointly developed a Shrimp Crop Insurance Product and the same was filed with Insurance Regulatory Development Authority of India (IRDAI) with UIN IRDAN556RP0118V03200506 by the Oriental Insurance Company Limited, New Delhi in October 2022.

The government's support on premium rate is important as the actual rates quoted by the insurance company starts with 3.7% and goes up to 8.5% based on

S.No.	State	Area ha (A)	Production MT (P)	Productivity kg/ha (Y)	Cost of production per ha @230 /kg vannamei	Value of Premium market segment @2% ₹Crores	Value of Premium value market segment @4% ₹Crores	State requirement of micro credit @ 70% scale of finance on input cost ₹ Crores
White shrimp (*Penaeus vannamei*) - Cost of production ₹230/kg								
1	Andhra Pradesh	71,921	6,34,672	8.82	20,29,651	291.95	583.90	10,218.22
2	Tamil Nadu	8,600	44,735	5.20	11,96,401	20.58	41.16	720.23
3	Gujarat	8,986	50,410	5.61	12,90,263	23.19	46.38	811.60
4	Others	8,600	44,735	5.20	11,96,401	20.58	41.16	720.23
5	Total	1,08,526	8,15,745	7.52	17,28,815	375.24	750.49	13,133.49
Tiger shrimp (*Penaeus monodon*)-Cost of production ₹250/kg								
1	West Bengal	50,000	19,190	0.38	95,950	9.60	19.19	335.83
2	Kerala	2,813.85	1,128.98	0.40	1,00,306	0.56	1.13	19.76
3	Andhra Pradesh	2,591	5,222	2.02	5,03,860	2.61	5.22	91.39
4	Karnataka	2,175	1,000	0.46	1,14,943	0.50	1.00	17.50
5	Others	616.15	1,075.02	1.74	4,36,184	0.54	1.08	18.81
	Total	58,196	27,616	0.47	1,18,634	13.81	27.62	483.28

(Base data: MPEDA, 2022; www.mpeda.gov.in)

Table 1. Estimates of insurance premium and micro credit market for shrimp farming in India

location of the farm and duration of insurance cover required. The client farmer may get a compensation for his inputs to the tune of 80% after deducting salvage value if any, in the event of total crop loss. i.e., more than 70% crop loss. Other difficulties faced farmers such as price risks, slow growth and running mortality issues were not covered in the present product.

Economics of Asian seabass fish farming

Seabass farming comprised of nursery, pre-grow out and grow-out phases. Nursery rearing was done for 50 to 60 days with a stocking density of 10,000 fish fries per acre. Three cycles of nursery rearing were practiced in a year by feeding the naturally available zooplanktons particularly *Ascetes indicus* and fry size fishes from the adjacent brackishwater creek. There was no practice of external feeding with formulated feed in the region. Gross income per acre per cycle was estimated as ₹1.65 lakhs. Transportation charges for fish seed depended on fish size, distance, type of vehicle used and transportation charges claimed for 1,000 kilometers was ₹10 to 14 per seed.

Pre grow-out farming of seabass mainly practiced in and around Bantumilli, Mutyalapalli and Mattagunta villages of Krishna district. Nearly 3,000 to 4,000 acres were under pre grow-out farming. Farmers practiced 3 crops per year with a stocking density of 4,000 to 10,000 fingerlings of 1-3 inch per acre per crop. Farmers used small shrimps/Ascetes, small fishes, juvenile tilapia etc. as feed with an estimated FCR of 6.0. Generally, 30 kg of live fish was fed per day per acre which cost ₹30-35 per kg. Survival rate reported was more than 85 to 90%. The fingerlings were grown to a size of 100 g in 3 months. The sale price of juvenile fish was ₹90 to 100 per piece.

Seabass grow-out culture was practiced in area of 2,500 to 3,000 acres in Krishna district with average culture duration of 18 months. Average stocking density was 2,000 numbers per acre. Tilapia a weed fish in freshwater fish farms were used as live feed extensively with the FCR of 6.0 to 6.5. Initially tilapia was given @ 50 kg/day per acre and gradually increased to 300 kg per day at the end of culture period. The cost of live tilapia was ₹30 to 45/kg. More than 90% of farmers in Krishna district harvested a size of 3-4 kg after 18 months of culture period with an average survival rate of 80%. The farm gate sale price was ₹560-580/kg. Generally, the prices were high during February-May.

Economics of Asian seabass farming in cages

The economic analysis of Asian seabass fish farming in cages was worked out based on the primary data collected from 213 farmers practicing cage culture of seabass in the Kundapura and Byndoor region of Udupi district, Karnataka. The annual fixed cost per kg was to the tune of ₹26.91which included cage structure, accessories, depreciation and interest on capital at 12%. Average operational cost was ₹158.19/kg comprised of feed and seed, labour and other operational expenditure with an interest on working capital calculated at 8%. Average production per cage was estimated to be 1,283 kg. The net income was estimated to be ₹214.90 per kg of production. The cost of production was ₹185/kg with an estimated benefit cost ratio 2.1. The economic assessment showed that cage farming of seabass in the Udupi district of Karnataka was profitable.

Technical efficiency of seabass fish cage aquaculture

The stochastic frontier model employed to estimate the technical efficiency of seabass cage farming indicated that the maximum likelihood estimations of the parameters and the inefficiency functions have the expected signs and of that several were statistically significant. The results revealed that the estimated coefficients of harvested fish size (0.146), stocking density (0.132) and feed (0.06) have a positive impact on the production of seabass in cage and were statistically significant. This indicated that 1% increase in harvested fish size would results in 0.146% increase in output. The coefficient of farming experience of the farmers was statistically significant which implied that the experienced farmers used inputs efficiently compared with the new and inexperienced farmers. The coefficients of the cage ownership have positive impact and were statistically significant at 1%, which showed that owners of the cage culture were more technically efficient. The extension services offered to the farmers were also statistically significant and have positive impact on the production of seabass cage culture. Farmers who gained knowledge through the training and workshops conducted by the extension officers were more effective. The gamma parameter associated with the variance was high (0.73) and were statistically significant at 1% level, which is evident that majority of the variation in the error term is mainly due to the technical inefficiency effects. The average technical efficiency of

the Seabass cage farming was 0.91 which indicated that the farmers were able to produce 91% of the maximum possible production with the given inputs.

Export performance and rejection scenario of Indian shrimp exports during 2021-22

India exported 7.28 lakh tonnes of shrimp worth ₹42,706 crore (USD 5.83 billion) during 2021-22. Exports of shrimps increased by 23.4 per cent in quantity and 31.7 per cent in USD value compared to 2020-21. The USA was the major shrimp importer from India accounted for 47% followed by China (17%), European Union (12%), South East Asia (6%), and Japan (5%). Though exports were increased in 2021-22, small size shrimp harvests due to disease occurrence reduced the global shrimp prices by 20 to 25 percent. Rising global inflation, increased global shrimp supply due to more production in Ecuador and impact of Russia-Ukraine war reduced the demand in importing countries.

Farming systems diagram using SEAGA analysis

A farming system diagram using SEAGA analysis to understand how coastal household livelihoods are assembled was prepared by the beneficiaries using PRA exercise to highlight the livelihood avenues practiced in a village including aquaculture. The diagram showed the flow of resources through women gender within and outside the households. Farming system diagram (Fig.2) drawn for the coastal villages in Minjur block of Tiruvallur district, Tamil Nadu portrayed the off-shore activities like fishing and on-shore activities like wild shrimp collection, salt processing, dry fish making, shrimp production and processing, crab fattening (in pens & boxes), livestock management (poultry and dairy), kitchen gardening and fish marketing. In an another village the on-shore activities included fish farming, wild shrimp collection, clam collection, crab fattening (in tide-fed ponds), sea bass nursery rearing in hapas and polyculture farming of seabass and crab in ponds.

Among the different types of livelihoods of the coastal women, maximum number of women participated in fish sales, dry fish sales and wild shrimp collection. This was followed by other livelihoods like fish vending, clam collection, goat rearing and as labour force in shrimp farm and agriculture. In recent years, majority of coastal women participated in NREGA (National Rural Employment Guarantee Act) securing 100 days' of rural employment followed by crab fattening (in pens and boxes), seabass nursery rearing in hapas,

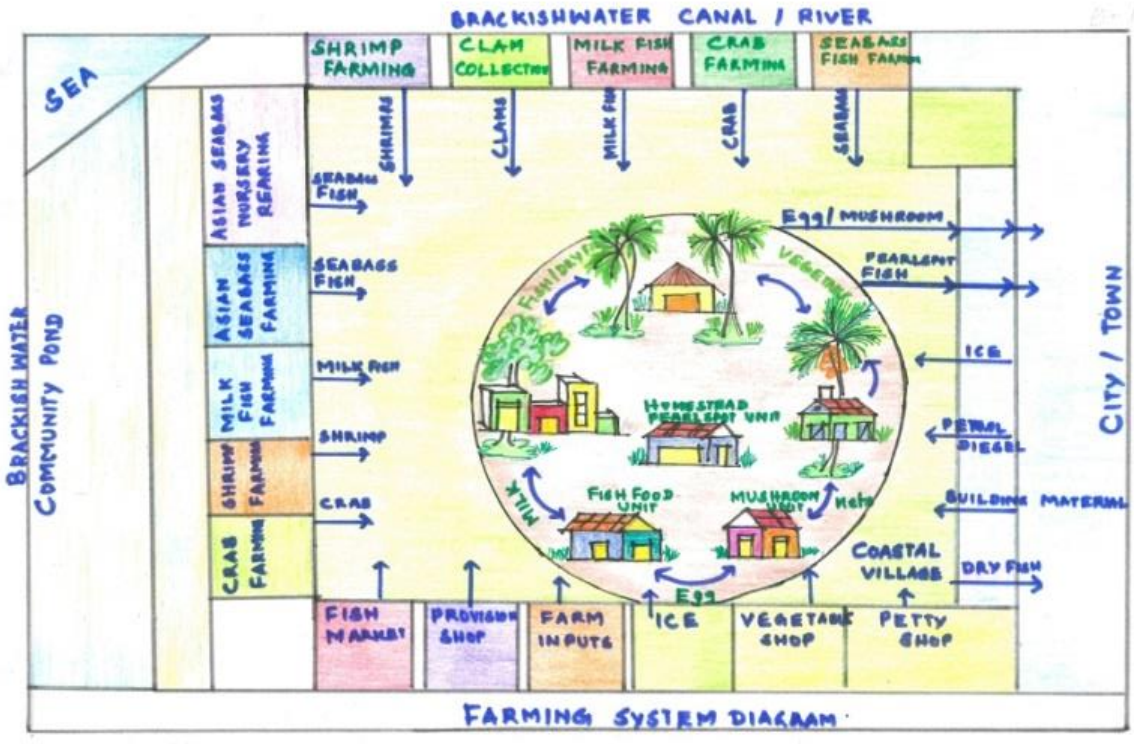


Fig. 2. Farming systems diagram using SEAGA analysis

milk fish farming in ponds and fish feed development. Men dominated the off-shore activities like fishing whereas women dominated the on-shore activities. Both women and men were involved in marketing. It was also noted that women were supported by men in activities like construction of crab pens, harvesting of crabs, pond management and polyculture of seabass and crab, fish transportation, purchase of water crabs and sale of fattened crabs.

Techno-economic assessment of shrimp nursery systems

Seed quality, diseases and market price are the three critical constraints for successful and profitable shrimp farming. Introduction of on-farm nursery wherein the shrimp post-larvae are reared for 25-35 days would supply quality seed for the grow out farming, check the manifestations of diseases confine to nursery and aid in phase wise stocking of shrimp seed in the grow out. It would facilitate year round farming and harvesting in tune with market demand that could ensure fair price for the farmed shrimp. An exploratory field study conducted in Andhra Pradesh and Tamil Nadu (n=33) brought out four different nursery models viz. earthen pond based extensive (n1=9), earthen pond based intensive (n2=11), HDPE lined pond based intensive (n3=6) and HDPE tank based intensive systems (n4=7) being practiced by the shrimp farmers. The size of nursery in earthen ponds was 800-1000m^2 and the volume of HDPE tank nursery was 600 (200*3) tonnes. Nursery preparatory practices were mostly similar but the stocking density and the type of feed used were different in case of intensive systems. Hatchery produced healthy post larvae of size ranged from PL8-12 (approximately 0.02g) were stocked in different densities @500/m^2, 800/m^2, 1000/m^2 and 2000/m^2 respectively in n1, n2, n3 and n4 systems.

The mean survival in the earthen pond nursery was 84% and 76% in HDPE lined nurseries. The shrimp post-larvae were fed with 8-10% of their body weight. Shrimp feeds with 36% crude protein was used in the earthen pond systems but the HDPE lined and tank systems used specialty feeds with 42% crude protein. The number of feedings varied according to the system, 4 to 6 feedings in earthen ponds and 6-8 feedings in HDPE systems per day. The Feed Conversion Ratio (FCR) reported was 0.8 to 1.0 in earthen ponds, whereas, it was 1.2 to 1.6 in case of HDPE systems. The nursery reared juveniles were weighed (no. of seeds per 100 g) counted and shifted to grow out ponds on weight basis using plastic tubs. The cost of production per seed was ₹0.78, 0.72, 0.88 and 0.99, respectively in n1, n2, n3 and n4 systems. The analysis indicated that all the four systems were efficient and produced one gram size shrimp seed in 25-30 days at a cost of less than one rupee. The farmer respondents felt that earthen pond based nurseries were easier to manage than the HDPE systems. The success rate reported in the former was 85% compared to 70% in the later model.

Nursery rearing ensured the supply of healthy shrimp seed for grow-out with 95% survival and minimized the size variation to a large extent. Stunting of shrimp post larvae in the nursery yielded compensatory growth rate in the range of 2.5 to 3.0 g per week and shortened the cropping cycle by 30 days. Therefore, in 60 days of post-nursery farming the shrimps grow to a size of more than 20 g the marketable size. Therefore, adoption of nursery rearing ensured continuous farming throughout the year and paved for three crops of shrimp per annum. Moreover, one-third of energy cost was saved by keeping the seed in the nursery for 25-30 days. Nursery facilitated the avoidance of one month blind feeding as followed in direct stoking and prevented shrimp pond pollution. Further, it saved labour requirement for thirty days which was a considerable saving for the farmers. Altogether, it saved the production cost by 25-30%. Nursery rearing minimized the production risks related to pond water quality, feed management and animal stress due to poor pond management. Disease manifestations were rarely reported in the nursery reared seed and even in rare cases it occurred after 30-40 days in grow out culture by that time the shrimps reached the break-even size of 8-10 g. It facilitated for higher productivity to the tune of 7.0 t/ha with reduced cost of production and thereby enhanced the profitability of shrimp farming. Therefore, it is concluded that on-farm nursery made a significant contribution for the sustainable and profitable shrimp farming.

Effectiveness of exposure visits to CIBA on the awareness level of graduate students

Under and post graduate students visited ICAR-CIBA to practically observe and learn about brackishwater aquaculture. The students got exposed to various research activities of the institute and through interaction with the scientists they had an opportunity

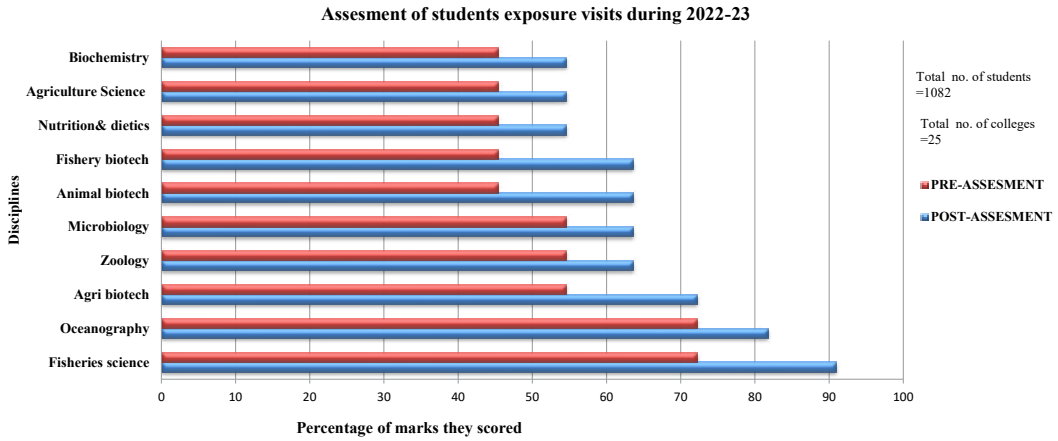


Fig. 3. Awareness levels of students before and after the exposure visits to CIBA (n=1082)

to improve their awareness and inspired to take up research as their career. Although scientific community sometimes considered these visits as an intrusion into their routine working hours, they do agree that such visits help in creating awareness among the students and in kindling their interest in different subject domains. The effectiveness of exposure visits were evaluated in terms of gain in the awareness levels of students. A teacher made test consisted of questions across the subjects exposed to the students was conducted before and after the exposure. A sample of 1,082 students studying varied courses visited CIBA during 2022 from Tamil Nadu, Karnataka, Maharashtra, West Bengal and Punjab states were involved in the analysis. The results revealed that 18-20% increase in the awareness levels of students through their exposure visits to the hatcheries, feed mill, laboratories and experimental farms of CIBA (Fig. 3). Further, the gain in awareness was proportionate to their academic courses studied.

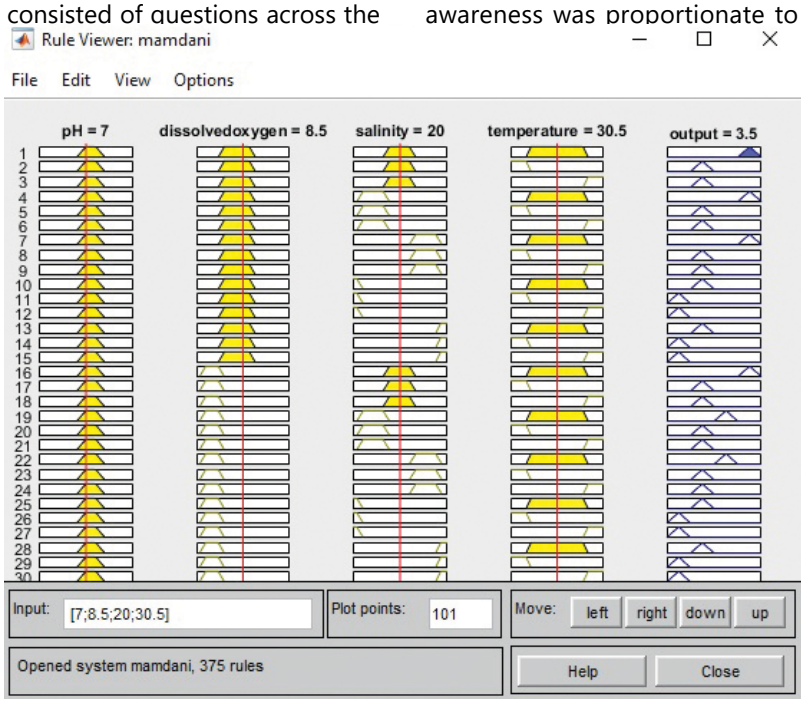


Fig. 4 a. Mamdani sample output

Machine learning based data aggregation model for the development of cage aquaculture monitoring system

Data aggregation models using Mamdani and Sugeno fuzzy based machine learning techniques for monitoring cage aquaculture system were developed and validated for their efficiency. In the model, trapezoidal and triangular membership functions were used for defining the input variables such as pH, salinity, dissolved oxygen and temperature and output variable aggregation area. Totally, 375 fuzzy rules with logical AND operator, truncation implication, and centriod method for defuzzification were employed to develop an efficient Mamdani and Sugeno fuzzy models for aggregating the input values. The model was implemented in MATLAB (Fig. 4a & 4b). The developed models were validated with cage aquaculture data in terms of efficiency and execution time to identify the suitable model for monitoring cage aquaculture systems. The results showed that the Sugeno model responded to the

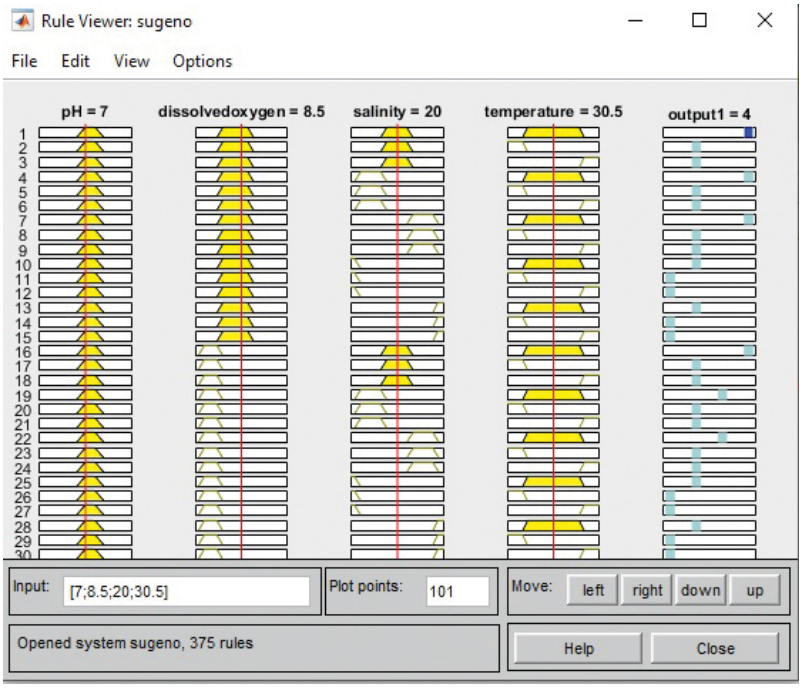


Fig. 4 b . Sugeno sample output

whole range of aggregation value [1-4] compared to Mamdani model [0.5-3.5] (Table 2). It also showed that the average execution time of Mamdani model is 2.05 minutes and Sugeno model is 1.71 minutes. Based on the performance of full range of aggregation values and execution time, and data processing efficiency, Sugeno model worked well for the development of wireless senor network based Artificial Intelligence monitoring system for cage aquaculture.

Development of Aquaculture Information System (AIS)

Aquaculture Information System (AIS), a web based application software was developed to store and retrieve the information about aqua farmers' and their farming practices. The system consisted of pond culture, pen culture and cage culture details. The system was developed using PHP and MySQL. The database structure was created with different parameters on various aspects of pond, pen and cage based practices such as farming system; pond preparation; design of the pen/cage; pen/cage culture preparations; pen/cage management; target species and its characteristics; stocking; feeding; use of chemicals and medications; disease, diagnosis and health management aspects; harvesting; production; better management practices and biosecurity measures in pond system; social participation; mass media exposure; credit orientation; training programme;

Sites or aqua ponds	Input (dataset)				Aggregated area value	
	pH	Dissolved oxygen	Salinity	Temperature	Mamdani	Sugeno
S1	7	8.5	20	30	3.5	4
S2	6.2	4.65	35.7	28	1.98	2.11
S3	8.2	1.67	36.5	33	0.747	1.17
S4	5.32	7.83	14.9	35	1.21	1.82
S5	5.52	13.37	10.62	31	2.5	3
S6	6.22	1	34.6	30	0.993	1.49
S7	8.73	10.5	25.4	29	2.81	3.06
S8	8.37	2.45	27.3	27	1.00	2.11
S9	4.93	4.64	25	27	1.73	2.04
S10	10.5	15.5	35.5	33	0.5	1

• Sugeno model responds to the whole range of aggregation value [1-4] compared to Mamdani model as [0.5-3.5].
• Average execution time: Mamdani model (2.05 minutes) and Sugeno model (1.71 minutes)

Table 2. Results of Mamdani and Sugeno models

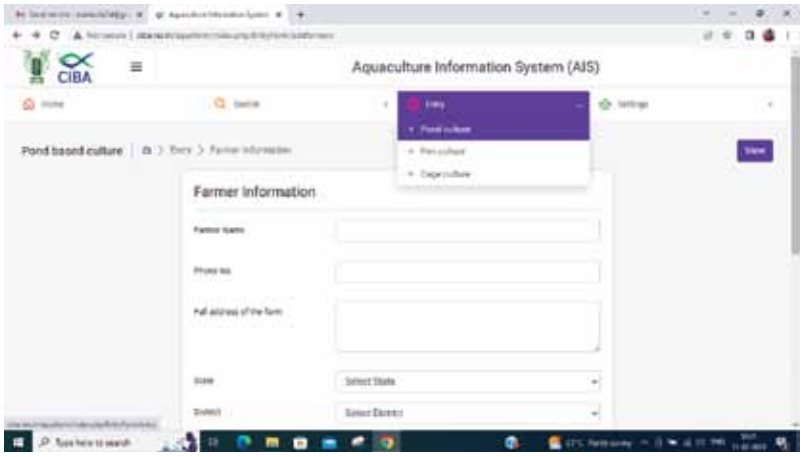


Fig. 5. Entry module of Aquaculture Information System

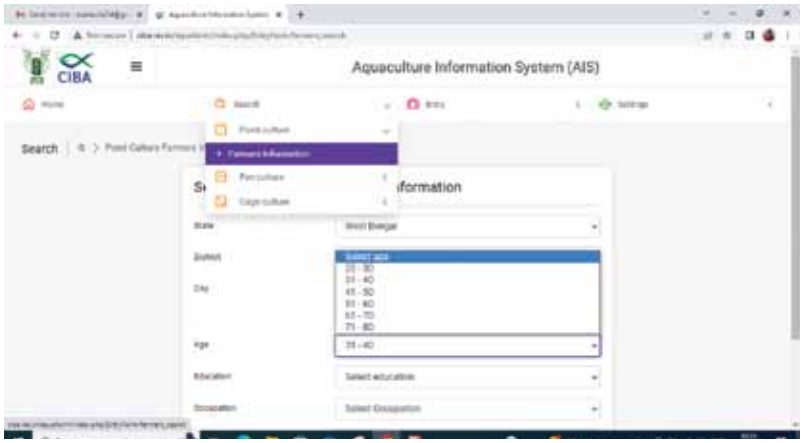


Fig. 6. Search module of Aquaculture Information System

information seeking behaviour; production constraints and economics. The database system contained different tables and each table was defined with identified parameters and its corresponding data type. The entry module allowed the admin to add or delete farm practices information into their corresponding tables for storing (Fig. 5). The search module can be used to search and retrieve information based on keyword search (Fig. 6). Keywords can be combined with Boolean logical operators 'AND' or 'OR'. The AIS need to be tested with farming practices information.

Assessing the livelihood impact of fish waste to wealth technology, CIBA-Plankton*Plus*, using Sustainable Livelihood Framework

CIBA Plankton*Plus* a plankton booster developed from the fish waste has been tested, commercialised for mass production and application in aquaculture. Adoption of this technology has the potential to provide livelihood security to the coastal families involved in the production and marketing of the product. A case study was conducted with a group of people involved in production of the product at Nambikkai Nagar and Kasimedu, in Chennai, Tamil Nadu to find out the improvements in the livelihood scenario of the adopters. Sustainable Livelihood Framework (SLF) of Department of International Development (DFID) was adopted (Fig.7) for conducting the livelihood impact assessment. The framework has five asset capital components such as human, economic, natural, physical and social. These capital components were assessed using 29 indicators and respective indices were calculated to show the outcome of the model using 'before and after' approach (Table 3). Subsequently using the capital indices a Sustainable Livelihood Index (SLI) was calculated with equal weightages (Table 3). The spider web diagram (Fig. 8) of the indices showed that social (45%), natural (42%) and human (25%) capitals had progressive changes after implementation of the technology and these changes were substantial compared with physical (10%) and financial (5%) assets. Though the financial index was low, its significant change was due to 1.5 times increase in annual income and 1.07 times increase in annual expenditure and financial savings. The results showed that adoption of this technology has moderately increased (26%) the livelihood scenario of the people.

Promotion of Integrated Multi-Trophic Aquaculture (IMTA) technology for income generation and optimum use of bio-resources

Socio-economic profile of coastal families

Karankadu (A) and Regunathapuram (B), the two coastal villages in Ramanathapuram district of Tamil Nadu were identified to implement the Integrated Multi-trophic

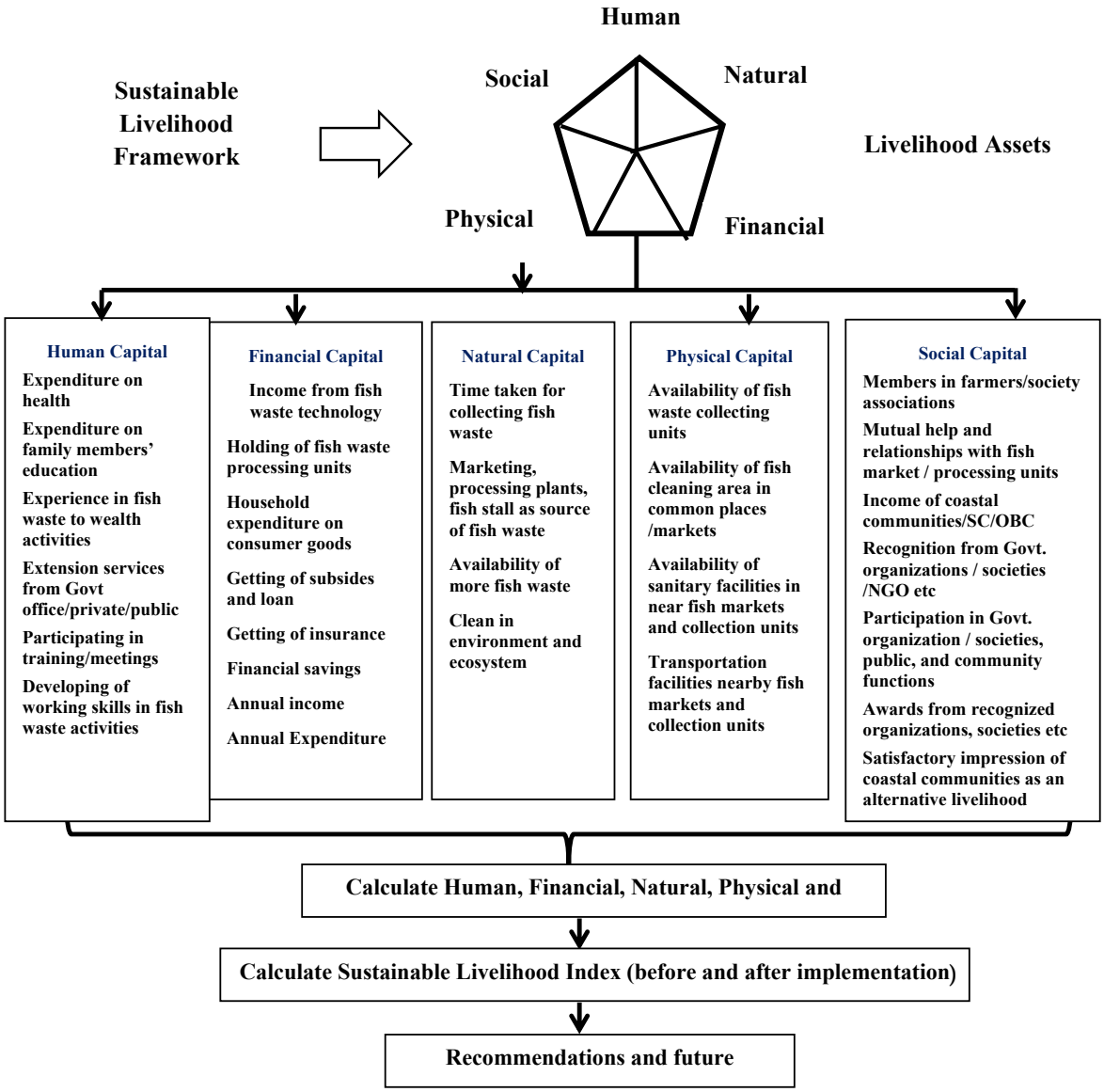


Fig. 7. Proposed Sustainable Livelihood Framework model (modified DFID, 1999).

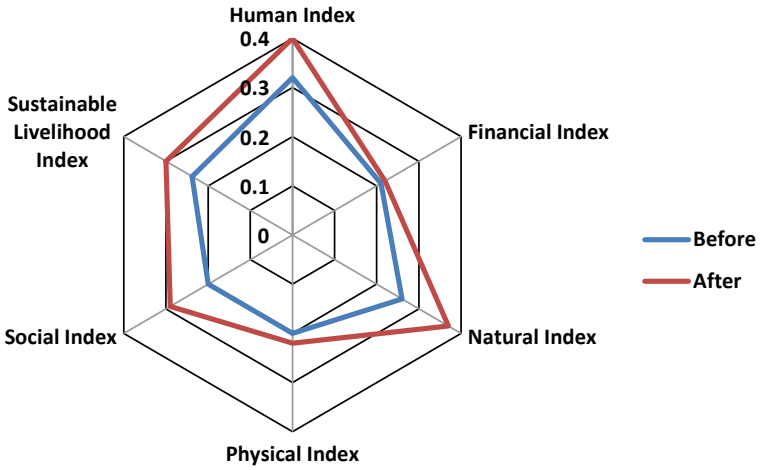


Fig. 8. Sustainable Livelihood Index for the fish waste to wealth technology

Index	Before	After	Difference	Change in index	Explanation
Human Capital Index	0.32	0.4	0.08 (↑25%)	Moderate increase (++)	2.5 times increase in development of working skills in fish waste activities; 1.34 times increase in extension services from Govt. office /private/ public
Financial Capital Index	0.21	0.22	0.01 (↑5%)	Marginal increase (+)	1.5 times increase in annual income and 1.07 times increase in Annual expenditure and financial savings
Natural Capital Index	0.26	0.37	0.11 (↑42%)	Moderate increase (+++)	2.71 time increase in clean in environment and ecosystem
Physical Capital Index	0.2	0.22	0.02 (↑10%)	Marginal increase (+)	2.36 times increase in availability of fish waste collection units
Social Capital Index	0.2	0.29	0.09 (↑45%)	Moderate increase (+++)	2.46 times increase in aatisfactory impression of coastal communities as an alternative livelihood and recognition from Govt. organizations / societies / NGO etc.
Sustainable Livelihood Index	0.238	0.3	0.062 (↑26%)	Moderate increase (++)	Mainly attributable to the cleaning of environment and ecosystem; availability of fish waste collection units and satisfactory impression of coastal communities as an alternative livelihood.

Table 3. Capital and Sustainable Livelihood Index

Aquaculture (IMTA) programme. The socio-economic profile of the villagers was studied based on the primary data collected from 120 randomly chosen sample family households in each village. The data revealed that majority of them lived as nuclear family (A-69%) and (B-77%) with an average family size of 4-5 members. Majority of respondents, 80% and 70% respectively from A and B villages were under the productive age group (36-45 years). Educational attainment was noted as high school level 50% and 60% in A and B villages respectively.

Fishing and Agriculture were the primary occupations of A and B villagers respectively. In village-A, about 89% of the families were small-scale fishers and 11% were involved in allied activities. Fishing and fish sale contributed 90% of their income while 10% income was generated through activities like net mending, fishing labour and fish processing. However, reduction in fish catch led to unemployment resulted in migration by 10% of families. Similarly in village-B, 75% of the people were engaged in agriculture and allied activities and only 25% were dependent on allied occupations. The awareness on fish farming among respondents was negligible in both the villages. Migration to urban areas in search of livelihood was prevalent in both the villages due to depletion of fishery resources and seasonal variability in agricultural employment. Therefore, development of alternative livelihoods using the available natural water resources is an option for providing employment and income to the villagers.

Subsequently, a skill development programmes was organized on "IMTA" during 14-16 September, 2022 in which 62 beneficiaries from village-B and 87 beneficiaries

from village-A participated. Hands on training on identification of brackishwater aquaculture species, soil and water sample collection, fish acclimatization and stocking, feed management, water, soil and health monitoring, sampling and data recording was imparted. A Phone-in-Programme on IMTA models was conducted for three days (30.10.2022 to 01.11.2022). Around 131 queries raised by 109 beneficiaries on the subjects of cage farming (51), seabass nursery rearing (33), milkfish farming (09) and seaweed farming (38) were answered.

Fig. 9. Skill development on IMTA for the beneficiary families

SOCIETAL DEVELOPMENT PROGRAMMES & TECHNOLOGY DEMONSTRATIONS

SOCIETAL DEVELOPMENT PROGRAMMES & TECHNOLOGY DEMONSTRATIONS

Scheduled Caste Sub Plan (SCSP) programmes

Under the SCSP, the institute organised awareness meet, farmers meeting, hands on training and demonstrations for the welfare of scheduled caste beneficiaries in different locations of the coastal states. Based on the potential of the area, interest of community and demand for the technological support, ICAR-CIBA provided all the resources for the demonstration and handhold them for the successful culture. Institute had identified beneficiaries for the scheme in Andhra Pradesh, Gujarat, Tamil Nadu and West Bengal.

Brackishwater cage farming and nursery rearing of Asian seabass fingerlings by Fisherwomen SHGs at Kottaikadu village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu

Asian seabass *Lates calcarifer* is an economically important food fish in India and being reared in brackishwater ponds/cages and open sea. An improved scientific rearing method developed by the Fish Culture Division (FCD) of ICAR–CIBA for seabass fingerlings in a backwater based nursery rearing with formulated feed was adopted. This technology has been promoted under SCSP scheme to create additional livelihood avenues for the rural coastal fisherwomen. Three fisherwomen groups, each consisting 12 members from Kottaikadu village, Cheyyur Taluk, Chengalpattu district (Tamil Nadu) involved in oyster collection activity were trained in the FCD's hatchery at Muttukkadu Experimental Station. In the backwaters of Kottaikadu village, a crab fencing of 30 meter width and 60 meter length (mesh size 25 mm) was installed by involving fisherwomen Self Help Groups (SHGs). Hapas of 2 m length x 1.5 m height x 1 m width were

Fig. 1. Hapas installed in the creek

Fig. 2. Inner view of the fencing with hapas

Fig. 3. Grading of seabass fingerlings

Fig. 4. Uniform size seabass fingerlings for sale

Fig. 5. GI cages for Asian seabass culture in open brackishwater resource at Kottaikkadu, TN.

Fig. 6. Harvested seabass from cages

Fig. 7. Hands on training to SCSP beneficiaries

Fig. 8. Sale of hatchery produced seed of M. gulio

installed inside the crab fencing and seabass fingerlings of 2.0–3.0 cm length and 1.00–1.20 grams weight were stocked @300/hapa. The fishes were fed *ad libitum* twice/thrice a day with formulated nursery rearing feeds. Grading of the seabass fingerlings was done on weekly basis and after rearing for 48 days, the fishes attained a marketable size of 10.52 cm length and 13.50 g weight. The first batch of seabass fingerlings (10,500 Nos.) were sold and revenue of ₹4,20,000 was generated. Dr. L. Murugan, Hon'ble Union Minister of State for Fisheries, Animal Husbandry and Dairying and Information and Broadcasting, Government of India distributed the revenue generated by the SHGs during the Garib Kalyan Sammelan held at ICAR–CIBA, Chennai on 31st May 2022. The second batch of seabass fingerlings (3,800 Nos.) were sold and a revenue of ₹1,58,000 has been generated by these SHGs. In addition, through brackishwater cage farming (2 cages) these SHGs have generated ₹2,21,350 by selling 596 kg farm-produced seabass in the range of 700–1,200 g. A total of ₹3,79,350 has been distributed to these SHGs.

Successful adoption of seed production technology of brackishwater catfish, *Mystus gulio*

Under the SCSP of the institute, Kakdwip Research Centre (KRC) has successfully demonstrated the seed production of *Mystus gulio* as alternate livelihood among Scheduled Caste (SC) beneficiaries of village Buddhapur, South 24 Parganas, West Bengal. In this connection an interaction meet was organized on 21st May, 2022 and hands on training on 'Seed production of Nona Tengra, *Mystus*

gulio' was given from 6-8 July, 2022. The women beneficiaries produced around 20,000 M. gulio fry between July-August, 2022 and sold the fry to local fish growers at the rate of ₹1 during September, 2022.

Successful demonstration of two-tier farming model of *Mystus gulio* and monosex tilapia in scheduled caste community of Sunderbans, West Bengal

Kakdwip Research Centre (KRC) of ICAR-CIBA successfully demonstrated the two-tier farming model as an alternate livelihood aquaculture programme for the scheduled caste community of the village Buddhapur, South 24 Parganas district, West Bengal. The group were assisted with all the farm inputs such as net cage, fish seed, feed etc. In this innovative fish farming method, tilapia and brackishwater catfish, *Mystus gulio* were farmed in the backyard pond of ten families. During the farming, all the pre-stocking pond managements such as bleaching, liming and fertilization of ponds were carried out. Simultaneously, net cage of 3 x 2 x 1 m were prepared and installed in one corner of the pond. Estuarine mono-sex tilapia was stocked (@ 1 number m^{-2}) in the pond and brackishwater catfish, *Mystus gulio* was stocked in cage (@ 10 m^{-2}). At the end of six months of farming a total of around thirty kg of tilapia and four kg of *M. gulio* were harvested from each backyard pond (area: 2 50 m^2). The harvest has given the nutritional security and generated the revenue of ₹6,100 for each family.

Alternate livelihood of SC women in seed production of ornamental fishes during off season of *M. gulio* breeding

Under the Scheduled Caste Sub Plan (SCSP) of the institute, Kakdwip Research Centre (KRC) of the institute has initiated the seed production of ornamental fishes (orange chromide, *Etroplus maculatus* and gold fish, *Carassius auratus*) during off-season of *M. gulio* breeding. Orange chromide breed from April to October and gold fish breed round the year. Therefore, seed production of both the species was practiced during lean season of *M. gulio* seed production. More than 2,000 of orange chromide fry (30-40 mm) was produced and sold at the rate of ₹7; and 1,000 numbers of gold fish seed was produced and sold at the rate of ₹5 to local ornamental fish traders.

Income generation and livelihood support using an innovative shrimp farming technology at Pattipulam, Chengalpattu district, TN

A field demonstration to disseminate copefloc (live feed) technology was carried out at

Fig. 9. Sale of ornamental fish orange chromide by SCSP beneficiaries to fish traders

Fig. 10. Ornamental fish sales by SCSP beneficiaries to fish traders of Buddhapur district in the presence of the Director, ICAR-CIBA

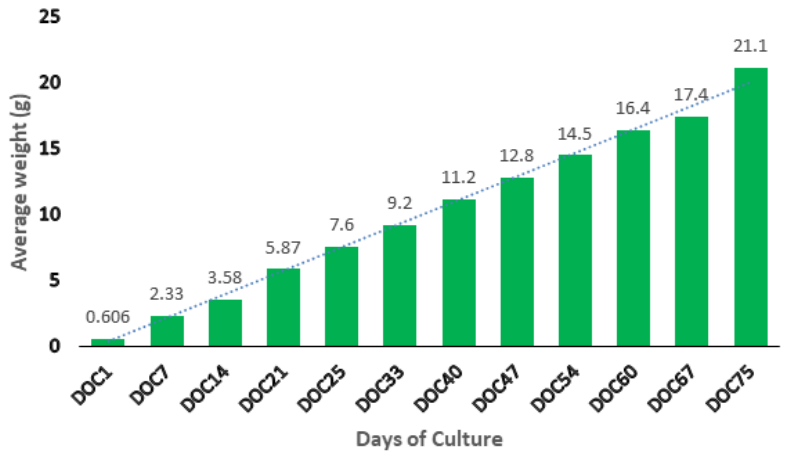


Fig. 11. Average growth of shrimp on different days of culture

Pattipulam village pond to provide livelihood support and income generation to 5 families consist of 15 people under SCSP. Post larvae (PL12) of *P. vannamei* were stocked at the rate of 10,000 nos/ton once the density of copepods in FRP tanks reaches above 1,000 nos/L in nursery phase for a period of 21 days at MES, ICAR-CIBA. When the size of the juveniles attained 0.312 to 0.552 g with an average growth and survival range of 94 to 100% was supplied to SCSP beneficiaries. Nursery reared *P. vannamei* were stocked in earthen pond, once the density of copepods reached above 500 nos/L in a pond of 6,000 m^2

Fig. 12. Harvesting P. vannamei after copefloc based nursery phase of 21 days followed by 75 day of copefloc based grow out culture in earthen pond.

and shrimp reared at a density of 40 nos/m^3 for a grow out period of 75 days. A total biomass of 4.2 tons of *P. vannamei* was harvested with FCR of 1.42 and average weight of shrimp reached up to 21.1 g sold it for ₹ 300/kg. Average survival of shrimp was 85% with a production of 7 tons/ha. A total income of ₹12.5 lakh was generated using this innovative technology benefited 5 families to provide livelihood support and income generation.

Homestead farming model at Marakkanam under SCSP

Homestead farming models remain highly valid where farmers wanted to culture shrimp or fishes in inland farming areas or areas where the coastal water bodies are polluted or proximity to water resources are remote. During the homestead farming trial conducted at Marakkanam, Chellam Theru for the benefit of SCSP communities, the nursery reared *Penaeus vannamei* shrimp were stocked at 5,000 number per tank in 2 numbers of 20 ton HDPE tank each having 15 ton water capacity. Salinity during the culture trial was 15-20 ppt. The average water quality parameters during the trial was 4,700 ppm hardness, 170 ppm alkalinity, 0.25 ppm total ammonia nitrogen (TAN), 0.3 ppm NO_2-N and 0.7 ppm PO_4-P. After 56 days of rearing an average weight of 10 g shrimps were obtained with 92% survival and 37-41 kg production per tank. The farmers realized an income of ₹16,700 in two month culture trial. This farming model can help the traditional or small scale farming communities with minimum access to the intensive farming.

Community fish farming integrated with agro-based farming among SC coastal community in Tamil Nadu

Fig. 13. Harvested P. vannamei with beneficiaries

Brackishwater canals and creeks leading from Pulicat Lake is a rich source of brackishwater resources for brackishwater interventions. Aquaculture Technologies viz., crab farming in pens was demonstrated by integrating with agro-based farming like poultry farming among 30 Scheduled Caste families of Thonirevu village, Kottaikuppam Panchayat, Pulicat and Kattur colony (New) Minjur, Tiruvallur dt. TN. was adopted under the SCSP component of the institute.

Brackishwater aquaculture technologies like crab farming in pens and fish food unit was integrated with community and societal developments like children and youth library cum study centre and terrace garden. Crab pens were designed and farm accessories were distributed to the beneficiaries for farming. Avocations adopted by beneficiaries were observed to be viable means of enterprise for their livelihoods. Socio-economic status, nutritional status, skill development, decision making roles and dignity were improved among the coastal SC beneficiaries. Financial and marketing linkages were created. Mass media programmes were initiated and the interventions were publicized in dailies and television. Bank accounts were opened and profit was saved and shared among the groups and also reinvested in farming. These interventions have given them an alternative livelihood, to learn a new avocation, to earn an additional income to improve the standard of living and socio-economic improvement of these beneficiaries under the SCSP initiatives.

Crab farming and harvest

At Thonirevu village Kottaikuppam Panchayat, Pulicat and Kattur village, Minjur Taluk, Tiruvallur dt. (TN). Two trials were conducted in 2 crab pens (10 x 15 ft) and 10 crab boxes. Water crabs 50 and 30 kg in the size range of 640-660

g were stocked at a density of 1/ m^2. They were fed with trash fish at the rate of 10% of the body weight daily in two rations. After 30 days of stocking from 2 trials. A total of 45 kg of hardened crabs at Thonirevu and 30 kg at Kattur village were harvested from the pens and an amount of ₹45,000 & 25,000 respectively were generated from the sales of the mud crabs. This profit amount was deposited in the beneficiary's bank account and shared among the beneficiaries and reinvested in crab farming activity.

Demonstration of shrimp farming to SC communities at Matwad village, Navsari

Navsari Gujarat Research centre of ICAR-CIBA demonstrated farming of whiteleg shrimp *P. vannamei* as a livelihood option for SC communities in Navsari and Vejalpore at Matwad village during May to September, 2022 under the Scheduled Caste Sub Plan. Navsari Valmiki Samaj Matsya Udhyog an SHG comprising of 12 members Scheduled caste members residing in Kaharwad area of Vejalpore has taken up shrimp farming as a livelihood activity and formed an SHG viz.,. The SHG was initially provided basic training on different aspects of shrimp farming. Under the livelihood program, 1.6 lakh *P. vannamei* PL was stocked in to two 1-acre ponds (SD 20 nos/m^2) during the month of June after completion of pond preparation, water treatment and fertilisation. The shrimp were on grown for a period of 87 days and harvested during the months of August and September. The final harvest resulted in a total production 1,992.5 kg of shrimp with and average body weight of 16.6 g and survival rate of 75%. The scheduled caste SHG could generate an income of ₹5.97 lakhs through the shrimp farming activity

Fig. 14. Crab farming units established at Pulicat and SHG's with harvested crabs.

Fig. 15. Harvesting of shrimp from demonstration pond under SCSP scheme at Navsari, Gujarat

Fig. 16. Beneficiaries receiving the income generated from the sales of shrimp farming under SCSP scheme

with an average farm gate price of ₹300/kg. On 6th October 2022, a small event was organised at the NGRC office in Navsari to hand over the revenue generated from the sale of shrimp and cheque for an amount of ₹5,97,753 was handed over to the members of the SHG group.

Farming and demonstration of *Agarophyton tenuistipitatum* in brackishwater areas of Kolathur village, Chengalpattu district, TN

Agarophyton tenuistipitatum is prominent indigenous brackishwater seaweed species in the east coast region of Tamil Nadu. During field survey of all the coastal riverine system of Chengalpattu district viz., Muttukadu lagoon, Mahabalipuram backwater, Kalpakkam backwater, Palar backwater, Odiyur backwater, and Alamparai fort backwater, it is observed that this species is growing naturally. A scheduled caste self-help group consisting of 5 members were selected for seaweed farming in open water system (Buckingham canal, Kolathur village) selected based on water quality, depth, water current, nutrient availability and transparency. It is located at latitude 12°14′7.71″N and longitude 79°58′16.94″E as shown.

An area of 50 m × 50 m was enclosed by 25 mm polypropylene (3 ply) net and fixed by eucalyptus poles. The mesh size of the net was large enough to ensure water exchange without clogging. *Agarophyton tenuistipitatum* seedlings were collected from shallow brackishwater region during low tide. The fresh seaweed seedlings were cleaned thoroughly to remove epiphytes and encrusting organisms. Initial seeding material was placed in 20 hapas of two different sizes, 2 x 2 x 2 m and 4 x 4 x 2 m in a minimum water depth of 1 m at low tide. Seedlings of *Agarophyton tenuistipitatum* weighing 100 g/m^2 uniformly

Water quality	Initial day of culture	Final day of culture
Water temperature (°C)	30.01±0.48	29.98±0.55
Salinity	17.80±1.21	21.00±0.45
DO (mg L^{-1})	8.97±0.25	8.63±0.77
pH	8.15±0.24	8.02±0.03
Turbidity (NTU)	27.07±0.57	8.20±2.03
NO_2-N (mg L^{-1})	0.028±0.012	0.020±0.002
NO_3-N (mg L^{-1})	0.107±0.082	0.053±0.006
NH_4-N (mg L^{-1})	0.132±0.047	0.045±0.021
PO_4-P (mg L^{-1})	0.197±0.009	0.091±0.010

Table 1. Water quality parameters in the study area.

Fig. 17. Hapa cultivation of seaweed at Kolathur, Chengalpattu district

distributed in the bottom of the net bags. It was observed that salinity is about 17.80±1.21 ppt at the start of the culture and has risen to 21±0.45 at the end of culture. Nutrient loadings were observed to be reduced at the final day of culture compared to the initial day of culture. Seaweed was weighted and analyzed for specific growth rate and result showed that SGR 2.892±0.16% d^{-1} in hapas after the period of 30 days the seaweed was found to be four times on average from the initial stocked quantity, the up-scaling and marketing of seaweed is supported for the benefit of beneficiaries.

Red snapper culture in FRP-HDPE hybrid cage at Thonirevu village, Pulicat, TN

Snapper culture was adopted by the SC beneficiaries of Thonirevu village as an alternate employment and additional livelihood income generation activity. In total 12 SC beneficiaries were selected. Two numbers of 6 meter diameter FRP-HDPE hybrid cages were fabricated and deployed in the brackishwater creek at Thonirevu village with a distance of 200 m from the coast. About 450 numbers of snapper advanced fingerlings with a size range of 60-100 g were stocked in each cage. The fishes are being fed twice with commercial pellet feed having 40% protein content. The beneficiaries were initially trained with necessary scientific inputs about the cage culture of red snapper by the fish culture experts of the institute. Initially the cages, snapper fingerlings and feed were given by CIBA in order to promote the activity and to benefit the beneficiaries in the first demonstrational crop. The monthly growth monitoring is being carried

Fig. 18. Hapa cultivation and collection of Agarophyton tenuistipitatum

out by the beneficiaries under the supervision of the project team.

Biofloc based grow-out farming of shrimp for eco-based aquaculture

Farmers-friendly technologies developed by the institute for the welfare of the shrimp farming community. About 5 beneficiary SC families were selected for ecobased shrimp aquaculture at Muttukadu. Biofloc nursery reared *Penaeus vannamei* (0.7-1 g) from the nursery units at Kovalam Experimental Station of the institute were stocked at 40 numbers per sq. m in grow-out ponds at Muttukadu. At the end of

Fig. 19. Fabricated FRP-HDPE hybrid cages deployed in the brackishwater creek at Thonirevu village for fish culture.

3 month grow-out culture *P. vannamei* attained an average body weight of 25 g with a productivity of up to 8 ton per ha. The 40 count harvested shrimps were sold @ ₹350 per kg and the income generated was distributed among the beneficiaries.

Fig. 20. Shrimp harvested in the presence of the DDG, ICAR and the Director CIBA at Muttukadu under SCSP scheme.

Awareness meetings and trainings

Fig. 21. A harvest-cum-field day on demonstration of copefloc based shrimp farming at Muttukadu Experimental Station of ICAR-CIBA on 29th April 2022

Fig. 22. National Campaign on 'Non-Conventional Aquaculture Systems' at Thonirevu village, Pulicat, Thiruvallur district of Tamil Nadu on 23.07.2022 under the SCSP scheme.

Fig. 23. Awareness programme on 'homestead mixotrophic rearing system in brackishwaters' on 26.09.2022

Fig. 24. Training-cum-workshop on 'Biofloc based high density nursery and grow-out farming at Kovalam Experimental Station on 14th June 2022

Fig. 25. 'Diversification of livelihoods among coastal groups through brackishwater aquaculture technologies' integrated with agro-based technologies for Scheduled Caste Families in Pulicat region of Tiruvallur district in Tamil Nadu on 30th September 2022.

Fig. 26. 'Har Ghar Tiranga' campaign at Pattipulam village, Chengalpattu district of Tamil Nadu on 12.08.2022 under the SCSP scheme as a part of Azad Ka Amrit Mahotsav

Scheduled Tribe Component (STC)

Under Scheduled Tribe Component (STC), demonstrations (170 beneficiaries), trainings (130 beneficiaries); and awareness camps (835 beneficiaries) conducted in Tamil Nadu, Gujarat, Maharashtra, Odisha and West Bengal gave livelihood upliftment and income generation for tribal communities ranged from ₹0.3 lakhs to ₹11.39 lakhs. The tribal beneficiaries are continuing the demonstrations/ technologies for their livelihood support. An impact analysis was undertaken to ascertain the progressive changes in the socio-economic status of tribal communities through participation in the STC interventions of CIBA in South Gujarat.

Community fish farming integrated with agro-based model, Kattur and Kulathumedu tribal villages, Pulicat, Tamil Nadu

Pulicat Lake in Tiruvallur district of Tamil Nadu is the richest brackishwater resource in the State. In order to utilize this resource for the livelihood development of coastal tribal communities, ICAR-CIBA has adopted 32 tribal families from Lakshimipuram tribal nagar (12 families), Kattur village, Minjur block and Kulathumedu village (20 families), Pulicat in Tiruvallur district, Tamil Nadu. Hands-on training followed by the demonstration units were established for milkfish farming in pond and pens; nursery rearing of seabass in hapas; seabass culture in cages; crab farming in pen, tide-fed pond and boxes integrated with poultry farming, terrace based vegetable gardening for enhancing the income level of these tribal beneficiaries. Tide-fed pond (40 x 60 ft.) and three number of pens (10 x 15 ft.) were stocked with water crabs in the size range of 640-660

Fig. 27. Crab farming in pens, Kattur, Pulicat, Tamil Nadu

Fig. 28. Beneficiaries of poultry and duck farming, Kattur, Pulicat, Tamil Nadu

Fig. 29. Seabass nursery rearing in hapas and pre-grow out in floating cages, Kattur, Pulicat, Tamil Nadu

Fig. 30. Hervest mela of mud crab, Kulathumedu, Pulicat, Tamil Nadu

Fig. 31. Handing over the benefit sharing money to the beneficiaries, Kattur, Pulicat, Tamil Nadu

g. Crabs were fed with molluscan meat or trash fish twice a day @ 5% to 10% of body weight. The water salinity during the demonstration ranged between 10 to 34 ppt and temperature between 23-30°C. After 30 days of stocking, a total of 73.3 kg and 70 kg of hardened crabs were harvested from the pen and boxes installed in the pond. From crab farming, sale of sea bass fingerlings fingerlings, poultry and eggs they realized an income of ₹1,40,000 and deposited the same in their bank account and shared among the group members. Assessments reveal that these technologies are technically feasible and economically viable for their livelihood improvement. This has created awareness among fisher folk about the value of brackishwater resources and the need for their conservation and sustainable utilization. During lean season they had an alternate livelihood opportunity. Marketing linkages have been created with nearby crab markets.

Front-line demonstrations of mudcrab culture at Kovalam, Kancheepuram district, Tamil Nadu

Front-line demonstration was conducted for twelve tribal farmers to show them the potential of mud crab culture in boxes and pond at Kovalam Experimental Station (KES), Kanchipuram district, Tamil Nadu. Two hundred mudcrabs (size 123-213 g) were stocked in floating boxes and in pond. After 104 days of culture, crabs attained a weight of 350-1,047 g with a survival of 57%. From crab farming, they realized an income of ₹38,000 and shared among the group members. This has created awareness among tribal people about the value of brackishwater resources.

Low volume cage culture of seabass and pearlspot in creek as an alternative livelihood development for the tribal communities of Visrampur, Palghar, Maharashtra

Low volume cage culture of seabass and pearlspot in creeks as a livelihood support was demonstrated with the participation of tribal SHGs (10 members) in Visrampur, Palghar, Maharashtra. NGRC-CIBA, Navsari supported tribal SHG members through the supply of inputs like net cages, cage frames, fish seed, feed, barrels, water quality kits, etc., apart from providing technical know-how on cage-based fish farming in the creek. A total of 5 cages of 4 x 4 x 2 m size (32 m^2) were fabricated and installed in the creek. Seabass fingerlings (4,000 numbers of 50-60

Fig. 32. Harvested of mud crab by tribal farmers, Kovalam, Tamil Nadu

Fig. 33. Low volume cages installed for culture of seabass and pearlspot, Visrampur, Palghar, Maharashtra

Fig. 34. Partial harvest of seabass and pearlspot by tribal SHGs, Visrampur, Palghar, Maharashtra

Fig. 35. Project team with tribal SHGs during harvest of seabass at Visrampur, Palghar, Maharashtra

g size) were stocked in four cages at a density of 1,000 juveniles/cage, whereas pearlspot fingerlings (2–3 inches) were stocked in one cage at a density of 3,000 per cage. Stocked seabass and pearlspot were fed formulated feed twice a day based on body weight. After an 8-months culture period, the stock was harvested in June 2022, and the tribal SHG generated a total income of ₹7.23 lakhs through the sale of seabass (77% survival and an average size of 470 g) and pearlspot (82% survival and an average size of 80 g). After the success of this cage culture model, from September 2022 onwards the Mangrove Foundation, Mumbai have collaborated with this SHG and provided the inputs in subsidy mode with scientific/ technical support from ICAR-CIBA.

Sustained Integrated Aqua-Agri-Poultry and Goat-rearing model as an alternative livelihood development option for tribal communities, Singod village, Navsari, Gujarat

Navsari Gujarat Research Centre of CIBA, Navsari, demonstrated

an 'Integrated Aqua-Agri-Poultry and Goat-rearing Model' for the livelihood and nutritional security of the 40 tribal communities, Self-Help Group- Singod Halpati Samaj Yuva Matsya Udhyog Juth, in Singod village, Navsari district, Gujarat. A pond of 2500 sq. m. (1.5 m depth) was developed for an integrated farming of fish and shellfish with goat (16 x 12 ft.) and poultry (40 x 20 ft.) in a shed on one side of the pond dyke, whereas 100 sq. m. of the other dyke was developed for vegetable farming. NGRC of CIBA supported the tribal SHG through the supply of 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 2022, tribal SHGs were supported with supply of Pangasius fingerlings (4-5 inches), solar street lamps, and feed.

The SHG have become self-sustained and from the income generated from this model they purchased 40,000 Catla & Rohu fish seed and 5 ton feed in the current year 2022 with their previous year's income of ₹7.91 lakhs. The SHG developed a small live fish sale counter at the farm itself and selling their farm produce of worth ₹20,000-25,000 weekly with the market linkages created by NGRC of CIBA. The SHG earned an income of ₹11.39 lakhs from the sale of partially harvested 7,125 kg of fish (pangasius: 500-1,000 g; tilapia: 300-500 g; rohu-catla: 1,000-2,000 g) and goats (5 goats, 20-30 kg each) over an eight-month period (February-December, 2022). Thus, integration of livestock with fish not only resulted in good growth and survival of fish and livestock but also sustained the livelihood of tribal SHG in Singod, Navsari.

Fig. 36. Distribution of inputs to Tribal SHGs, Singod, Navsari

Fig. 37. Distribution of inputs to Tribal SHGs, Singod, Navsari

Fig. 38. Distribution of inputs to Tribal SHGs, Singod, Navsari

Fig. 39. Interaction meeting with SHG and scientists of CIBA at tribal IFF unit, Singod, Navsari

Fig. 40. Stocking of seabass for nursery rearing by tribal SHGs, Mendhar, Navsari, Gujarat

Integrated Aqua-Agri-Poultry and Goat-rearing model in brackishwater pond for the livelihood and nutritional security of tribal communities, Mendhar, Navsari, Gujarat

Success of 'Integrated Aqua-Agri-Poultry and Goat-rearing model' at Signod, Navsari, Gujarat, the Gujarat Fish Farmers Producer Co-op. Society Ltd. (GFFPO) Navsari, signed MoU with ICAR-CIBA, for the demonstrations of different brackishwater aquaculture technologies for the livelihood upliftment of tribal members of GFFPO. Hence under STC, NGRC of CIBA adopted 20 scheduled tribe members of GFFPO and renovated 4,000 sq. m. pond at Mendhar, Navsari for the demonstration of brackishwater integrated aqua-agri-poultry-goat farming model.

Fig. 41. Grading by tribal SHGs, Mendhar, Navsari, Gujarat

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 whereas, 300 sq. m. area of other dyke is developed for horticulture crops. Infrastructure facilities such as GI sheet grading shed (20*10 ft), storage shed (20*10 ft), goat shed (20*10 ft), poultry shed (20*10 ft), etc were established for the demonstration of this model. Inputs such as seabass seed (1 inch) – 10,000 nos; pearlspot seed (1 inch) – 10,000 nos; crab boxes -1,000 nos; hapa-80 nos; feed-150 kg; feeding boats - 2 nos solar lamps - 8 nos; etc were distributed to the beneficiaries. The SHG earned ₹1.3 lakhs from the sale of 2,500 no. 3-4 inches seabass fingerlings to farmers for grow-out culture of seabass.

Fig. 42. Harvested seabass fry by the tribal SHGs at Mendhar (Gujarat)

Demonstration of brackishwater aquaculture technologies for livelihood support of tribal communities at Sahada village, Balasore district, Odisha

Farming demonstration trials were initiated in Sahada village of Balasore district (Odisha) where a large proportion belongs to tribal communities. CIBA has adopted 20 tribal farmers and nursery rearing of seabass (2,500 nos) was initiated in pond system. These seabass seeds yield a good survival of 66% till fingerlings in the hapa based nursery system. With experience, a higher overall survival was observed compared to last year.

Mystus gulio was stocked @ 50,000 nos/acre and after one year of culture partly harvested at 40±8 g with 55% survival. The growth was very slow because of inconsistency in feeding. Similarly, Milkfish (*Chanos chanos)* (3,000 nos) seeds were stocked in hapas as nursery and later shifted to a plankton rich pond system. And a higher survival of 73% was obtained in nursery rearing with 50 DOC. was grow-out farming of milkfish was continued in the pond culture system with supplemental feeding.

Fig. 43. Stocking of P. vannamei by tribal farmers, Sahada village, Balasore district, Odisha

Demonstration of brackishwater ornamental fish seed production technology to the coastal communities of Sunderbans

The Mousuni Island was severely devastated by frequent extreme cyclonic events of *Aila, Amphan* and *Yaas*. Around 100 tribal families of which around 50 reside at the coastal belt of Baliyara. Earlier, tribal residents were primarily engaged in agriculture but now agriculture productivity has gone down drastically due to soil salinization. Tribal population were also engaged with traditional fish culture in their homestead ponds, however, practices of scientific fish culture were unknown to them. Hence, seed production of brackishwater ornamental fishes, polyculture of fishes, scientific pond management and feeding practices were demonstrated to them. Seed production of brackishwater ornamental fishes viz., orange chromide (*Etroplus maculatus*), pearlspot (*Etroplus suratensis*) and nursery rearing of spotted scat (*Scatophagus argus*) fry were demonstrated. An average survival rate of 80% was obtained during the nursery rearing of early fry to fingerling stage. Around 500 orange chromide fry (3-4 cm), 2,000 pearlspot fingerlings (4-5 cm) and 500 spotted scat fingerling (4-5 cm) were harvested and sold at the rate of ₹5, ₹7 and ₹10, respectively to ornamental traders. An income of ₹21,500 was generated by beneficiaries through adoption of these aquaculture based interventions demonstrated under the Scheduled Tribe Component (STC) at Kakdwip Research Centre of the institute within six months.

Impact analysis: Empowerment of tribal communities through participation in aquaculture and allied activities in South Gujarat

Demonstration of aquaculture and allied activities such as nursery rearing of seabass, milk fish, pearl spot; cage and pond based culture practices of seabass, milk fish an pearl spot; integrated fish farming; kitchen / vegetable gardening; crab culture in ponds and boxes; ornamental fish culture; freshwater fish culture; polyculture of shrimp and fish; poultry and goat farming were conducted under Scheduled Tribe Component (STC) plan. An impact analysis was undertaken to ascertain the socio-economic improvement of beneficiary tribal families. A sample of 150 tribal farmers from coastal villages of south Gujarat viz., Kabilpore, Pathri, Danti, Navipardi, Onjal, Matwad, Signod and Vishrampur were randomly selected for the study.

Five dimensions of empowerment such as Family and Social, Political, Psychological, Knowledge and skill and Economic were selected for this study. A number of items were arranged under each of these five dimensions and the tribal farmers taking part in the survey were asked to indicate their perceived extent of empowerment in a four point continuum taking into account their situations before and after participation in the STC intervention. A paired sample t-test was used to test the differences between the empowerment scores of tribal 'before' and 'after' taking part in the STC activities. Pearson's product moment correlation coefficient (r) was computed to examine significance of the relationships

Fig. 44. Release of pearlspot brooder in cage by Director, CIBA

Fig. 45. Bamboo cage for pearlspot breeding with mud pot for egg deposition

Fig. 46. Harvested pearlspot juveniles by tribal farmer

Fig. 47. Marketing of second batch of pearlspot juveniles by tribal farmers to an ornamental trader

between tribal's empowerment through participation in aquaculture and allied activities and selected independent variables. Multiple regression analysis was used to identify the influencing variables which explained the variation in their perceptions.

The results revealed that the farmers in the study area achieved a significant level of empowerment in all dimensions measured after involvement in the STC intervention (Table 2). Stepwise multiple regression analysis shows that out of five selected dimensions of empowerment psychological empowerment alone was responsible for 89% of the variation in overall empowerment; whilst, knowledge and skill predicated 7.7% of the variation.

The total empowerment score of a respondent was obtained by summing the scores obtained from all five measures of empowerment. Possible scores ranged from 0 to 90. However, the obtained scores ranged from 0 to 56 and 5 to 68 respectively in before and after participation in the interventions. The respondents were classified into four categories on the basis of their empowerment scores, as shown in Table 3. Data presented in Table 2 indicates that there was a clear improvement in to their empowerment status through their participation in aquaculture and allied activities through STC interventions. The mean empowerment scores before participation (20.78) and after participation (26.05) clearly indicated the improvement, which was confirmed by the test significance ('t' value).

Relationships between the selected 13 influencing variables and overall empowerment score were determined by Pearson's product moment correlation coefficient (r). The results show that farming experience (0.849**), extension service contact (0.860**), training exposure (0.864**), knowledge in aquaculture (0.882**) and participation in aquaculture (0.859**) had significant and positive relationship with extent

Empowerment dimension	Possible score range	Mean and Standard deviation		Unit score		t- value for difference of means
		Before	After	Before	After	
Family and Social	0-18	4.97 (4.10)	6.36 (4.36)	0.28	0.35	-8.28
Political	0-12	3.27 (2.48)	3.76 (2.20)	0.27	0.35	-4.88
Psychological	0-18	4.85 (3.91)	6.07 (4.64)	0.27	0.31	-6.96
Knowledge and skill	0-27	4.48 (4.22)	6.28 (5.72)	0.17	0.23	-5.35
Economic	0-15	3.15 (2.55)	3.59 (2.61)	0.21	0.24	-3.52

Table 2. Scores obtained by the respondent in five dimensions of empowerment before and after their participation in STC intervention (n=150)

of empowerment. The stepwise regression analysis further revealed that 92% of the variation in the empowerment can be accounted by the combined effect of five independent variables such as knowledge in aquaculture (77.8%), participation in aquaculture (8.5%), training exposure (3.6%), farming experience (1.5%) and extension agency contact (1.0%). Therefore, considerable socio-economic improvement was obtained due to aquaculture and allied activities through STC intervention among the tribal communities.

Categories	Percentage		Mean and Standard deviation		t- value for difference of means
	Before	After	Before	After	
Low empowerment	39	37	20.78 (16.19)	26.05 (17.56)	-10.28
Medium empowerment	49	40			
High empowerment	12	19			
Very high empowerment	0	4			

Table 3. Categories of tribal farmers according to their status of overall empowerment before and after participation in aquaculture and allied activities through STC intervention


ARSONS

HUMAN RESOURCE DEVELOPMENT (HRD)

Training programmes attended

SCIENTISTS

S. No.	Name and Designation	Programme Name	Venue	Duration	Organized by
1	Dr. M. Poornima, Principal Scientist	Online training programme on 'Integrated Scientific Project Management for Women Scientists / Technologists'	Online	3-7th January, 2022	Centre for Organization Development, Hyderabad
2	Dr. M. Makesh, Principal Scientist	Online training programme on 'Metagenomic Data Analysis'	Online	19-24th January, 2022.	ICAR-Indian Agricultural Statistics Research Institute, New Delhi
3	Dr. Sujeet Kumar, Scientist	Online training programme on 'Metagenomics Data Analysis'	Online	19-24th January, 2022.	ICAR-Indian Agricultural Statistics Research Institute, New Delhi
4	Dr. M. Makesh, Principal Scientist	Online training on 'Competency Enhancement of Training Functions by HRD Nodal Officers of ICAR'	Online	21-23rd February, 2022.	ICAR-NAARM, Hyderabad
5	Dr. Ezhil Praveena, Senior Scientist	Fish Vaccination: Theory Innovation and application	Online	15th February, 2022	Asian Fisheries, NACA
6	Dr. D. Deboral Vimala, Principal Scientist	Online Training programme on 'National Facilitators Development Programs (NFDP) for Agriculture Extension Management'	Online	7-12th March, 2022	MANAGE, Hyderabad
7	Dr. T. Bhuvaneswari, Senior Scientist	Two day training on the use of validated protocol for estimation of antimicrobial usages at farm level	Online	25-26th April 2022	NIPHM and DOR, Hyderabad
8	Shri. R. Aravind, Scientist	Training Programme on 'Seaweed Cultivation (Phase –II)'	-	18-20th October, 2022	CSIR- CSMCRI, Mandapam Camp

TECHNICAL STAFF

S. No.	Name and Designation	Programme Name	Venue	Duration	Organized by
1	Shir. S. Rajamanickam, Assistant Chief Technical Officer	Off Campus Training Programme on Motivation, Positive thinking and communication Skills for the Technical Officer	Online	18-24th May, 2022	ICAR- IISWC
2	Shri. G. Thiagarajan, Technical Officer	Online Training Programme on 'Motivation Positive Thinking and Communication Skills'	Online	13-16th September, 2022	ICAR-NAARM Hyderabad

ADMINISTRATIVE STAFF

S. No.	Name and Designation	Programme Name	Venue	Duration	Organized by
1	Shri. P. Srikanth,	Online Training on 'Pension & Retirement Benefits'	Online	18-20th April, 2022	ICAR-NRRI, Cuttack
2	Assistant Finance and Accounts Officer	Online Training on 'Pension & Retirement Benefits'	Online	18-20th April, 2022	ICAR-NRRI, Cuttack
3	Smt. B. Prasanna Devi,	Online Training on 'Pension & Retirement Benefits'	Online	18-20th April, 2022	ICAR-NRRI, Cuttack

Training programmes conducted

Sl. No.	Name of the Training	Duration	No. of Participants
1	Training programme for state fisheries officials, Govt. of Kerala on 'Recent advances in hatchery seed production and farming of milkfish and grey mullet'	3-7 January, 2022	8
3	Training Programme on 'Disease Management of Brackishwater Aquaculture Farming'	21-26 March, 2022	26
5	'Hands on Training on Biofloc Production Technology for Aquaculture'	17- 21 May, 2022	13
6	Skill cum entrepreneurship development training program on 'Aqua feed Preparation Techniques and Quality Control'	25-27 May, 2022	26
7	Hands-on Training Program on RNAseq Data Analyses	8-10 June, 2022	25
8	Customised training programme on 'Shrimp pond water and soil analytical techniques and interpretation of results'	15-17 June, 2022	21
9	Hands on training on 'Shrimp and mud crab aquaculture: A practical exposure'	21-25 June, 2022	15
10	A 6-day field orientation Training for the Shrimp Farmers of Rajasthan under PMMSY	28 June - 3 July, 2022	11
11	Skill Development Training Programme for the Fisherwomen on Brackishwater Aquaculture Technologies	7 July, 2022	20
12	'Histopathological Techniques for Brackishwater Aquatic Animal Disease Diagnosis'	18-23 July, 2022	3
13	Hands-on training programme on 'Seed Production of Nona Tengra, *Mystus gulio*'	6-8 July, 2022	12
14	A hands-on Training Programme on 'Seed production and farming of brackishwater finfishes'	5-9 September, 2022	15
15	'Hands-on Skill Development Training on Aqua Feed Preparation Techniques and Quality Control'	27-29 September, 2022	21
16	Hands-on Training on 'Recent Advances in Diagnosis and Management of *Enterocytozoon hepatopenaei* (EHP) in Brackishwater Shrimp Aquaculture'	26 September – 1 October, 2022	11
17	Training programme on 'Pond and soil analytical techniques and interpretation of results'	11- 13 October, 2022	12

18	Five day training on 'Shrimp culture and disease management in inland saline areas'	12-16 December, 2022	8
19	Hands-on training program on 'Omics Data Analysis and its Applications'	15-21 December, 2022	16
Kakdwip Research Centre, West Bengal			
20	Internship training to Fisheries College Students from Birsa Agriculture University (BAU), Jharkhand	16-25, April, 2022	25
21	Breeding and seed production of *Mystus gulio*	13-18 May, 2022	6
22	Hands-on training on 'Seed production and farming of brackishwater finfishes'	1-7 September, 2022	15
23	Internship Training Programme on Brackishwater Aquaculture for the outgoing B.F.Sc students of College of Fisheries, Birsa Agriculture University (BAU), Jharkhand	9-13 September, 2022	28
Navsari Gujarat Research Centre, Gujarat			
24	A Training Program on Brackishwater Cage Farming	22-24 March, 2022	50
25	Field Training for the Shrimp Farmers of Rajasthan	28 June-3 July 2022	13
26	'On-field training' for the post graduate and Ph.D. students of Aquatic Animal Health Division of ICAR-CIFE, Mumbai	9-10 September, 2022	14
27	Training programme on 'Brackishwater cage farming of Asian seabass' for the staff of Mangrove Foundation, Govt. of Maharashtra at NGRC-CIBA, Navsari	28 September -1 October, 2022	30

Ph. D. Awarded

S. No.	Name of the Student	Thesis Title	Supervisor	Date of award
1	Shri. P. Saravanan	Spring effect of defense genes in *Penaeus monodon* with respect to white spot virus (WSSV) infection	Dr. Subhendu Kumar Otta	10.05.2022
2	Shri. P. Arvind Kumar Ray	Microencapsulation of *Vibrio* bacterial cell based immunostimulant for improved delivery and enhance efficacy in penaeid shrimp	Dr. C. Gopal	08.06.2022
3	Shri. Dr. S. Thirumurthy	Geospatial multicriteria for assessing coastal resources vulnerability in northern districts of Tamil Nadu, India	Dr. M. Jayanthi	08.06.2022
4	Mrs. A. Swathi	Pathogenesis and insights into the functional pathways of shrimp *L. vannamei* infected with WSSV virus	Dr. M.S. Shekhar	17.11.2022

Society of Coastal Aquaculture and Fisheries (SCAFi) activities

Online Talk Series

A new online talk series 'Aquaculture without borders' was initiated under the banner of SCAFi during the year for the benefit of researchers and students to get to know the updated status of aquaculture activities across different nations. Eight such lectures were finalized and organized during the period June 2022 to January 2023 as per the pre-fixed schedules.

- Aquaculture in the Philippines - Dr. Edgar C Amar, SEAFDEC, Iloilo, Philippines, delivered talk on 22nd June 2022.
- Aquaculture in Vietnam - Dr. Phạm Quốc Hùng, Nha Trang University, Vietnam, delivered talk on 20th July 2022.
- Status of fisheries/aquaculture in Japan with a focus on shrimp - Dr. Marcy N. Wilder, JIRCAS delivered talk on 1st September 2022.
- Aquaculture in Bangladesh - Prof. Dr. M.A. Salam, Bangladesh delivered talk on 14th September 2022.
- Aquaculture in Kuwait - Dr. Azad Ismail Saheb, Kuwait Institute for Scientific Research delivered talk on 14th October 2022.
- Aquaculture in Sri Lanka - Prof. Upali S. Amarasinghe, University of Kelaniya, Sri Lanka delivered talk on 23rd November 2022.
- Aquaculture Development in South East Asia - The science and the economics, Prof. Kuperan Viswanathan, Malaysia delivered talk on 16th December 2022.
- Sustainable Solutions for Aquaculture in the USA - Dr. P.S. Sudheesh, Project Leader (Aqua-USA), Merck Animal Health (USA) delivered talk on 25th January 2023.

Workshops, Seminars and Meetings

Celebration of Nation's 73rd Republic Day

CIBA celebrated the 73rd Republic Day on 26 January 2022 in its headquarters and in its research centers. At Chennai, Dr. K.P. Jithendran, Director, unfurled the national flag addressed the particpants. He congratulated Dr. S. Ayyappan, former Secretary, DARE & Director General, ICAR and Dr. M.L. Madan, former Deputy Director General (Animal Sciences), ICAR for being conferred upon the prestigious Civilian Awards, Padma Shri by Govt. of India. He distributed certificates to the winners of the *Selfie with Daughter* contest conducted on National Girl Child Day event on 24 January 2022. Kakdwip Research Centre, KRC unit of CIBA recreation club organized its 2nd Annual sports involving all the staff and their family members on this occasion.

Agri Business Meet 2022 and Product Launch

Agri Business meet was conducted on 14th February 2022 at Chennai. During the meet different products NOVACIDE-ALF, Anti-Lice Formulation and NOVATAN-AMS Autotrophic Microbial Solution to mitigate nitrite) developed by M/s Alpha Biologicals, Nellore with the technology support of ICAR-CIBA were launched formaly for sale in the aquaculture sector. The products were released by Dr. K.P. Jithendran, Director, ICAR-CIBA in the presence of farmer representatives, industry professionals and scientists.

International Women's Day 2022 was celebrated

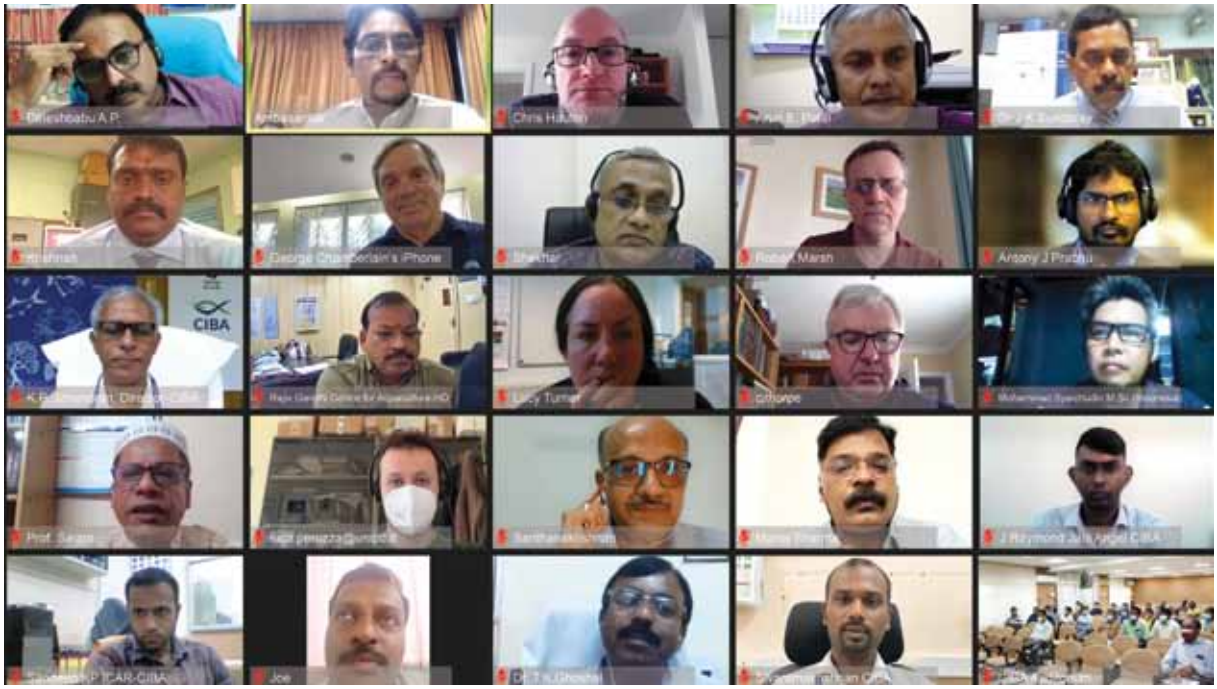
International Women's Day (IWD) was celebrated on 8th March, 2022. ICAR-CIBA organized varied programmes like free medical camp, donation for cancer patients through Cancer Institute (WIA), Chennai, and special invited talk by medical professionals and many competitive events for institute staff. On 7th March 2022, for helping the cancer patients, a donation of ₹85,500 was collected from ICAR-CIBA staff and handed over to Dr. G. Selvaluxmy, Director and Dr. Shirley, Head of the Department, Pathology, Cancer Institute (WIA), Adyar, Chennai. On 8th March 2022, Dr. A. Sethuramashankaran, a renowned Consultant Diabetologist & Bariatric Physician from Lakshmi Diabetic Centre, Chennai gave an informative talk on the topic, 'Chronic diseases- are they a prize for modernization?'.

Focus Group Discussion with Insurance companies for re-introduction of shrimp crop insurance in India on 22 March 2022

ICAR-CIBA has been working with National Fisheries Development Board, national and international insurance broking companies and public and private insurance companies for the reintroduction of crop insurance for shrimp aquaculture. On 22.3.2022, CIBA arranged a focus group discussion with senior officials from Oriental insurance and Alliance insurance brokers towards facilitating re-introduction of shrimp crop insurance in India. Dr. K.P. Jithendran, Director inaugurated the programme and stressed upon the need for shrimp crop insurance. Dr. T. Ravisankar, Principal Scientist, Social Sciences Division presented the technical aspects shrimp farming on economic perspective. Ms. Shelly Dheer, Deputy General Manager and Mr. Safia Patel, Chief Regional Manager from Oriental Insurance and others discussed in detail with CIBA Scientists on various technical and insurance aspects.

Virtual Workshop on 'Diversifying crustacean culture – developing future climate resilience'

A two-day virtual workshop was conducted by ICAR-CIBA on 'Diversifying crustacean culture: developing future climate resilience' in collaboration with University of Southampton, UK and The Pirbright Institute, UK on 22nd and 23rd March 2022 as part of the international collaborative project, 'Diversification of potential crop species in brackishwater aquaculture, adaptation for climate resilience' funded by Natural Environment Research Council, UK. The two days scientific deliberations consist of presentations, panel discussion from various stakeholders.



27th Research Advisory Committee Meeting

The 27th Research Advisory Committee (RAC) Meeting of ICAR-Central Institute of Brackishwater Aquaculture (CIBA) was conducted during 29-30 March 2022 at the headquarters in Chennai. Chairman of the RAC committee, Prof. Madhusoodana Kurup, Former Vice Chancellor of Kerala University of Fisheries and Ocean Studies (KUFOS) and Members Dr. M. Vijayakumaran, Retired Principal Scientist of ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Dr. Lalit C. Garg, Retired Scientist of National Institute of Immunology (NII), Shri. S. Santhana Krishnan, CEO of Maritech Pvt. Ltd., Chennai and Dr. Pravin Puthra, Assistant Director General (Marine Fisheries), ICAR participated in the two days deliberation.

Interaction meeting with tribal farmers of Singod-Halpati Samaj Matsya Udhyog Juth

Navsari Gujarat Research Centre (NGRC) of ICAR-CIBA conducted an interaction meeting with tribal families on 'Aquaculture and allied activities for livelihood development of tribal communities' at Singod village in Navsari, Gujarat, on 19th April, 2022. The tribal village has been adopted by NGRC of CIBA for demonstration of pond-based cage culture and allied activities under the scheduled tribe component. Dr. K.P. Jithendran, Director, inaugurated the meeting and interacted with the members of the Singod-Halpati Samaj Matsya Udhyog Juth (Tribal SHG). The director handed over a cheque for ₹7.83 lakhs, the revenue generated by the SHG through sale of fish and other farm produce to Shri. Kaushik Halpati, President, Singod-Halpati Samaj Matsya Udhyog Juth.

Farmers Meet in alignment with Garib Kalyan Sammelan and Prime Minister's interaction with beneficiaries of Govt. of India

CIBA in collaboration with Chennai Petroleum Corporation Limited (CPCL), Indian Oil Corporation Limited (IOCL), Chennai, Bharat Petroleum Company Ltd. (BPCL), Chennai organized the Hon'ble Prime Minister's Garib Kalyan Sammelan at ICAR CIBA campus Chennai on 31st May 2022. A mammoth gathering of more than 1,500 people consisted of fishers, women beneficiaries from coastal villages, aqua farmers, women beneficiaries of Prime Minister's Ujjwala LPG Scheme have participated in the event. The programme was inaugurated by Dr. L. Murugan, Honourable Union Minister of State for Fisheries, Animal Husbandry and Dairying and Information and Broadcasting, Government of India who was the chief guest.

World Environment Day

CIBA, Chennai celebrated the World Environment Day 2022 on 4th June. Dr. P. Krishnan, Director, Bay of Bengal Programme – Inter Governmental Organisation (BOBP-IGO), the Chief Guest highlighted that India set to become world's second largest economy by 2050, and he highlighted the challenges with relation to environment in connection with the such a rapid growth and stressed necessity of scientific backing to keep the environment safe. Dr. K.P. Jithendran, Director, stressed the need to look into our contribution on keeping the environment better and understand its importance for safety of future generation.

National Fish Farmers Day and National Campaign on Emerging Aquaculture Systems and Practice

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) observed the National Fish Farmers Day and the National Campaign on 'Emerging Aquaculture Systems and Practices' as part of the Azadi Ka Amrit Mahotsav on 11th July, 2022. Navsari Gujarat Research Centre (NGRC) of ICAR-CIBA conducted the Hindi webinar under the "National campaign on emerging aquaculture systems and practices" for the benefit of farmers from Gujarat, Maharashtra, Haryana, Punjab and Rajasthan. In the virtual mode, Dr. Manoj M Sharma, a progressive shrimp farmer from Gujarat state presented a talk on "Recent advances in shrimp farming and scope for brackishwater finfish farming". Also a field level interaction was organized at Karangadu village in Ramanathapuram district, Tamil Nadu on Integrated Multi-trophic Aquaculture.

39th Institute Research Council (IRC) meeting

The 39th Institute Research Council (IRC) meeting of ICAR-CIBA was conducted during 25th-26th July 2022. The meeting was chaired by Dr. K.P. Jithendran, Director, CIBA & Chairman, IRC. The meeting began with welcome address by Dr. K.P. Kumaraguru vasagam, Member Secretary, IRC & OIC PME. The chairman expressed that this is being his first IRC meeting after assuming the charge of Director in May 31st, 2021. In his address, he stressed that the research programmes should be in tune with with the needs of the sector. This was followed by presentations from individual scientists of the five research divisions of CIBA.

76th Independence Day

ICAR-CIBA celebrated the 75th anniversary of Indian Independence with pride and honour on 15th August, 2022 at its headquarters and regional centres. Dr. K.P. Jithendran, Director, hoisted the National Flag. The Director in his address narrated the campaigns and events organized by the institute during the last one year as part of the *Azadi Ka Amrit Mahotsav*.

54th Institute Management Committee (IMC) meeting

ICAR-CIBA had its 54th Institute Management Committee (IMC) meeting on 20th Aug, 2022 at its headquarters, Chennai. The meeting was chaired by Dr. K.P. Jithendran, Director, CIBA & Chairman, IMC. Members of the IMC, Dr. B.P. Mohanty, ADG (Inland Fisheries), ICAR, Dr. K.V. Rajendran, Head, Aquatic Environment and Health Management Division (CIFE), Dr. G.S. Saha, Principal Scientist (CIFA), Dr. Shubhadeep Ghosh, SIC, Visakhapatnam Regional Centre of CMFRI, Shri. S. Sathish Kumar, farmers' representative from Tamil Nadu and several co-opted members from CIBA representing Administration, Finance, PME and Engineering cell participated in the meeting.

Brainstorming workshop on regulating the use of chemicals and veterinary medicinal products (VMPs) in Indian aquaculture at NAAS Complex, ICAR, New Delhi

Under the All India Network Project on Fish Health (AINP_FH), ICAR-CIBA, Chennai organised a brainstorming workshop on regulating the use of chemicals and veterinary medicinal products (VMPs) in Indian aquaculture at NAAS Complex, ICAR, New Delhi during 25-26 August 2022. The AINP_FH project funded by ICAR is developing standards for the use of chemicals, biologicals and VMPs in the country. This nationally important meeting was presided by Dr. J.K. Jena, Deputy Director General (Fy.), ICAR, New Delhi. The chief guest was Shri. Sagar Mehra, Joint Secretory, DoF, Ministry of Fisheries, Animal Husbandry and Dairying, GoI. In his address, Joint Secretary emphasized the need to provide quality aquaculture inputs to farmers to ensure safe fish production. In the presidential address, Dr. J.K. Jena, DDG (Fy.) highlighted the need for regulatory policies backed by strong scientific data.

Free COVID vaccination camp

Under campaign on Covid Vaccination Amrit Mahotsav, ICAR – CIBA organized Free Covid Vaccination Booster Camp on 17th September, 2022 for the benefit of its staff and their family members. The event was organized in association with Urban Public Health Centre, Mandaveli, Chennai. Totally, 131 doses of Covid booster doses (Covaxin – 33; Covishield – 98) were administered during the Camp.

Inaguration of Diagnostic Laboratory' in collobration with Agri-Business Incubation (ABI) promoted startup Company

A 'Diagnostic Laboratory' was inaugurated on 19th October 2022 at the Agri-Business Incubation (ABI) facility of ICAR-CIBA, Chennai to accommodate Illume Gene India LLP, Bangalore and Diagnomics (OPC) Pvt Ltd., Chennai as incubatees.

Vigilance Awareness Week

CIBA observed the Vigilance Awareness Week (VAW) from 31st October to 6th November, 2022. To start with the scientists and staff of CIBA took the "Integrity Pledge for Organisations" under the leadership of Dr. Kuldeep Kumar Lal, Director, ICAR-CIBA on 31st October, 2022. The Institute also encouraged the family members of the staff and the persons with whom the Institute deals with for purchase and services to take the e-pledge (Integrity Pledge) available on the website of the Central Vigilance Commission. Subsequently various competitions such as essay writing, cartoon making and an open quiz programme on the theme "Corruption-free India for a Developed Nation" were conducted during the week.

Special Lecture on 'Cancer disease awareness' in view of National Cancer Day

Society of Coastal Aquaculture and Fisheries (SCAFi) and Women Cell of ICAR-CIBA jointly conducted a special lecture on 'Cancer disease awareness' coinciding with the National Cancer Day on 23rd November, 2022. Dr. V. Sridevi, a renowned Oncologist, currently working as Professor in Surgical Oncology at Cancer Institute (WIA), Chennai presented the lecture in hybrid mode at ICAR-CIBA headquarters. Dr. Kuldeep K. Lal, Director, ICAR-CIBA in his opening remarks emphasized the relevance of the programme and stated that awareness and early detection as the first important step in the fight against cancer.

World Antimicrobial Awareness Week under the theme 'Preventing Antimicrobial Resistance Together'

The World Antimicrobial Awareness Week (WAAW-2022) was observed at the ICAR-CIBA during 18 to 24th November, 2022. The Indian Network for Fisheries and Animal's Antimicrobial Resistance (INFAAR) team of ICAR-CIBA has coordinated the programme by incorporating a number of initiatives to increase awareness among the staff and students.

National Agricultural Education Day – 2022

ICAR-CIBA celebrated National Agricultural Education Day on 3rd December 2022 to commemorate the birth anniversary of Dr. Rajendra Prasad, the first President of Republic of India, as Agricultural Education Day. Dr. Chindi Vasudevappa, Vice Chancellor, the National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Haryana graced the occasion as the Chief Guest for the function. Dr. Kuldeep K. Lal, Director, ICAR-CIBA, in his opening remarks underlined the importance of national agricultural education day, importance of food processing and value addition in fisheries.

Awards & Recognitions

ICAR-CIBA Bags Swachhta Pakhwada Award for Year 2021

ICAR-Central Institute of Brackishwater Aquaculture was awarded with Swachhta Pakhwada Award-2021 (Second Prize) for the work done on cleanliness and hygiene during the occasion of the Annual Conference of Vice Chancellors of Agricultural Universities and Directors of ICAR institutes on 13th April 2022. The Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying, Govt. of India Shri. Parshottam Rupala presented the award to Dr. K.P. Jithendran, Director, ICAR-CIBA in the presence of Shri. Narendra Singh Tomar, Hon'ble Minister of Agriculture & Farmers Welfare, Govt. of India, Smt. Sushri Shobha Karandlaje, Hon'ble Minister of State for Agriculture & Farmers Welfare, Government of India, Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR and other dignitaries.

ICAR-CIBA Stall won 'Best Exhibitor – Winner' Award in the Exhibition Event of 12th Indian Fisheries Aquaculture Forum

ICAR-Central Institute of Brackishwater Aquaculture participated in the exhibition event of 12th Indian Fisheries Aquaculture Forum organized by the Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TNJFU) at Chennai during 5-7th May 2022. Dr. Joy Krushna Jena, Deputy Director General (Fisheries), ICAR, New Delhi inaugurated the event on 5th May 2022 along with Dr. G. Sugumar, Vice Chancellor of TNJFU, Nagappatinam in the presence of Dr. K.P. Jithendran, Director, ICAR-CIBA. The stall consisted of live specimen of major species of shrimp, mud crab and finfishes like Asian seabass, pearl spot, milkfish, monoangel, grey mullet etc. In addition, exhibits on major technological achievements of the institute, feed samples, disease diagnostic kits, extension publications and reports were also displayed. About 850 delegates visited the stall and has won the 'Best Exhibitor – Winner' Award. During the valedictory event, Dr. K.P. Jithendran, Director, ICAR-CIBA received the award comprising a Shield and the Certificate from Dr. Joy Krushna Jena, DDG (Fisheries Science), ICAR, New Delhi.

ICAR-CIBA received Ganesh Shankar Vidhyarthi Hindi Patrika Puruskar - 2021 for *Jal Tarang*

ICAR-CIBA Hindi Magazine '*Jal Tarang*', was awarded the Ganesh Shankar Vidhyarthi Hindi Patrika Puruskar-2021 (2nd prize) by ICAR. Director of the institute, Dr. K.P. Jithendran received this award from the Hon'ble Union Minister for Agriculture and Farmers Welfare Shri. Narendra Singh Tomar during the 94th ICAR Foundation Day held on 16th July 2022. The award included a shield and citation. Hindi cell of ICAR-CIBA is publishing Annual Hindi Magazine, *Jal Tarang* since 2015 to take forward the knowledge of brackishwater sector among the Hindi speaking farmers. This is the second time that CIBA is receiving this prestigious ICAR award. The previous award was received for *Jal Tarang* in the year 2017.

ICAR-CIBA received 'Appreciation Award' for the exemplary work in 'People's Movement for Clean Cities -2022' from the Greater Chennai Corporation, Chennai, Tamil Nadu

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA), Chennai received 'Appreciation Award' for the exemplary work in "People's Movement for Clean Cities -2022" under the Swachh Bharat Mission from the Greater Chennai Corporation, Chennai, Tamil Nadu based on the range and scale of organizing the various swachh activities including innovative waste management to waste-to-wealth initiatives besides documentation and dissemination of the technologies for waste management since 2015. Dr. C.V. Sairam, Director-in-Charge, Dr. P. Mahalakshmi, Principal Scientist & Nodal Officer, Swachh Bharat Mission, ICAR-CIBA received the award from the Respectful Mayor of Chennai Ms. Priya Rajan on 26.12.2022 in presence of Swachh Bharat Mission office bearers of the institute.

ICAR-CIBA received the 'Best of India Biz Award' for special display and presentation during 19th International edition of 'Mega Goa World EXPO and Summit 2022'

ICAR-CIBA received the joint award '**Best of India Biz Award**' along with ICAR-IARI, ICAR-IGFRI & ICAR-CCARI for special display and presentation in 19th International edition of 'Mega Goa World EXPO AND Summit 2022' jointly organized by the Chamber for impex, traditional and integrated health and Trinity group at Dr. Shyama Prasad Mukherjee AC Stadium, Panaji, Goa from 4th to 6th August 2022. Certificate and prize was presented by Shri. Nilesh Cabral, Minister of Public Works, Govt. of Goa to Shri. Tanveer Hussain, Scientist who represented the institute in the exhibition.

Individuals

• Springer Nature-IVS Award 2022 for the best paper of the year 2021 in the section of Aquatic Virology: Flow cytometry analysis of apoptotic progression and expression analysis of four apoptosis-related genes in *Penaeus vannamei* in response to white spot syndrome virus infection. [**Swati, A., Shekhar, M.S., Katneni, V.K., Vijayan, K.K.** 2021. Virus Disease, 32 (2), 244-250]

• Received 'Dr. Hiralal Choudhury Gold Medal' at 1st Indian Fisheries Outlook 2022 organized by ICAR-CIFRI on 22-24 March 2022- **Dr. A. Panigrahi**

• Awarded best oral presentation award under aquaculture theme in 1st Indian fisheries outlook 2022 held at ICAR CIFRI, Barrackpore, Kolkata, West Bengal during 22-24 March, 2022- **Dr. Prem Kumar**

• Awarded the 'Best Aquaculture Scientist Award 2022' at India International Aquaculture Expo 2022, by Aqua International Group, NRS Publications, on 6-8 April 2022- **Dr. A. Panigrahi**

• Received the TNJFU Excellence Award 2022 for Best Scientist-Fisheries Extension during 12th Indian Fisheries Aquaculture Forum (IFAF) organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TNJFU) held at Chennai during 5th - 7th May 2022- **Dr. B. Shanthi**

• Best Oral Presentation Award for the paper entitled 'Unravelling of the complex genome of Indian white shrimp *Penaeus indicus*' in 12th Indian Fisheries & Aquaculture Forum organized by Tamil Nadu Dr. J.Jayalalithaa Fisheries University (TNJFU) and Asian Fisheries Society–Indian Branch (AFS-IB), May 5-7, 2022, Chennai- **Dr. M.S. Shekhar**

• Best Oral Presentation award for SRF working under NICRA project during 12th Indian Fisheries & Aquaculture Forum organized by Asian Fisheries Society of Indian Branch and Tamil Nadu Dr. J. Jayalalitha Fisheries University during 5-7 May, 2022- **Mr. Vishwajeet Potadar**

• Awarded the oral presentation with First position for the paper entitled 'Understanding virulence and siderophore system of luminescent bacterial pathogen *Vibrio campbellii*' in the National Symposium on 'Self-Reliant Coastal Agriculture' organized by ICAR-CCARI, Goa during 11-13 May, 2022- **Dr. Sujeet Kumar**

• Best Poster Presentation Award for the paper entitled "Shrimp genomics and its application for genetic improvement programmes in aquaculture, in "Advances in Agriculture and Food System towards Sustainable

Development Goals (AAFS2022), 22-24th August 2022, University of Agricultural Sciences, Bangalore- **Dr. M.S. Shekhar**

• Awarded the oral presentation with First position for the paper entitled 'Sequential pathology of hepatic microsporidiasis in *Penaeus vannamei shrimp*' in the 7th National Conference on Agricultural Scientific Tamil organized by Madras Veterinary College, Chennai during 2-3 September, 2022- **Dr. P. Ezhil Praveena**

• Awarded with First position for the paper entitled 'Sea lice, *Caligus minimus* outbreak in pearlspot, *Etroplus suratensis* and evaluation of the efficacy of different disinfectants' in the 7th National Conference on Agricultural Scientific Tamil organized by Madras Veterinary College, Chennai during 2-3 September, 2022- **Dr. Ananda Raja**

• Received Best Paper award (First place) for the paper entitled 'Mitochondrial DNA based genetic diversity studies on *Pseudetroplus maculatus* fish', during 7th National Conference on Agricultural Scientific Tamil, organized by Madras Veterinary College Chennai during 02-03 Septemebr 2022- **Dr. B. Sivamani**

• Awarded the oral presentation with First position for the paper entitled 'Significance of *V. harveyi* and *V. campbellii* in Indian shrimp hatcheries in National Conference (Hindi) Sustainable Aquaculture for Atmanirbhar Bharat organized by ICAR-CIFA & Association of Aquaculturists during 23-24 September, 2022- **Dr. Sujeet Kumar**

• Awarded with First position for the paper entitled 'Biosafety, withdrawal and efficacy of anti-parasitic drug lufenuron in Asian seabass (*Lates calcarifer*) under tropical Indian climate' in compendium of '31st National congress of parasitology' organized by Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) Chennai during 10-12th November, 2022- **Dr. Ananda Raja**

• Received 'Dr. S.S. Misra Life-time Achievement Award' at XVIII AZRA International Conference on 'Advances in Applied Zoological Researches towards Food, Feed & Nutritional Security and Safer Environment' on 10-12 November 2022, Bhubaneswar, Odisha- **Dr. A. Panigrahi**

• Received Best Poster presentation award for the paper entitled 'Role of immune genes in hepatic microsporidiasis infection in *Penaeus vannamei* shrimp' during the IAVP congress held at Dept. of Veterinary Pathology, CoVSc., Hyderabad, 17-20th November, 2022- **Dr. P. Ezhil Praveena**

• Secured best oral presentation award (2nd position) under the theme on Innovation for Nutritional Security conference on Responsible Aquaculture and Sustainable Fisheries Interact (RASHI-2022) during 13-16 December, 2022 at College of Fisheries, Central Agricultural University, Lembucherra, Tripura, India- **Dr. Prem Kumar**

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
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 Product 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
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

STATE FISHERIES DEPARTMENTS

The institute has well established linkage with state fisheries departments mainly for transfer of technologies.

Consultancies, Technology Development & Transfer

Mud crab seed production with M/s Aqgromalin Farmtech Services Pvt. Ltd., Chennai

ICAR-CIBA is promoting M/s Aqgromalin Farmtech Service Pvt. Ltd., a farm diversification corporate business enterprise for a startup program in mud crab seed production and scaling up of mud crab farming with a supply chain. This collaboration is expected to increase the availability of mud crab seed to farmers for stocking.

Collaborative programme on calibration and validation of water testing protocol

Institute signs MoU with M/s AA Biotech Pvt. Ltd., Chennai on 27th April 2022 for calibration and validation of water testing protocol for use in Aquaculture which helps in rapid detection of environmental parameters with more accuracy and reliability in addressing the farm level issues, support geo location and provision for rectifying errors in tests at the farm site.

Indigenous shrimp larval feed technology transferred to Coastal Corporation Ltd.

Shrimp Larvi*Plus*, indigenous shrimp larval feed technology was transferred to Coastal Corporation Ltd, Vishakapatnam, Andhra Pradesh on 6th May, 2022. This technology is predicted to promote the production of indigenous cost-effective shrimp larval feed to farmers. Dr. J.K. Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi during his address appreciated the scientists and highlighted the necessity for promoting indigenous shrimp larval feed.

Consultancy services for eco-friendly biofloc based nursery/grow-out system

ICAR-CIBA signed an agreement with M/s Halten Aqua Consultancy, Ernakulam on 6th May, 2022 for providing consultancy on Biofloc technology for eco-friendly and sustainable farming. The technology facilitates improved water quality, reduces water pollution and mitigates the risk of introduction and spread of pathogens and also reduces the external application of feed thereby reducing the cost of production.

Promoting livelihood development and welfare of fish workers welfare federation of India (FISHFED)

To enhance skill development, self-reliance, create employment for fish workers ICAR-CIBA signed MoU with Fish workers Welfare Federation of India (FISHFED) on 7th May, 2022. The agreement covers demonstration of technologies like, fish waste to wealth, finfish cage culture, integrated fish farming, finfish and shrimp nursery, grow-out farming, crab farming, feed formulation and processing, etc. for the livelihood improvement of fish workers across the country.

Contract research for evaluating the therapeutic efficacy of herbal products against important pathogens of shrimp

An agreement was signed with M/s Naturalle Herbal Remedies Pvt. Ltd. on 23rd May, 2022 for contract research to evaluate the therapeutic efficacy of RESURGE (herbal product) for *Enterocytozoon hepatopenaei* (EHP) and for evaluation of bactericidal efficacy of WIPE & LEAP (two herbal formulation products) against vibrio species and *Pseudomonas aeruginosa*. This association is expected to paves a new way in enhancing the immune function of aquatic animals due to their antioxidant and antimicrobial properties.

Transfer for indigenous shrimp feed technology to HELINI Biomolecules, Chennai

Institute signed an agreement with M/s HELINI Biomolecules, Chennai on 23rd May, 2022 for setting up of customized feed mill to cater the needs of small and marginal farmers. The proposed feed unit will meet the demands of aquaculture farmers in Tamil Nadu.

Technology or bioremediation of nitrogenous waste in shrimp ponds

ICAR-CIBA signed a MoU with M/s HELINI Biomolecules, Chennai on 11th August, 2022 for up-scaling and commercial production of Water Probiotic-CIBAMOX. This product has innovative combination of ammonia oxidizing bacteria, nitrite oxidizing bacteria and denitrifying bacteria for effective control of nitrogenous wastes in shrimp aquaculture.

Developing and validating of innovative IOT / AI based monitoring system for smart aquaculture operations

A MoU was signed for knowledge partnership for developing and validating of innovative Internet of Things / Artificial Intelligence based monitoring system for smart aquaculture system with Sairam Group of Institutions on 11th August, 2022. CIBA will provide scientific and technical guidance to Sairam Institution for development and refinement of monitoring system for smart aquaculture system.

Transfer of Plankton^{Plus} technology

ICAR-CIBA signed a MoU with FISHFED, INDIA on 27th September, 2022 for Plankton^{Plus} - a value added product developed from fish waste/ trimmings. This technology is useful for the cleanliness campaign of the government; provides an alternate livelihood for the coastal communities and act as an initiative program for Swachh Bharat Mission / Clean India Mission.

Cage based pearlspot seed production

ICAR-CIBA signed MoU with Sri. Ganesh, Kundapura aqua-farmer on 3rd October, 2022 for technology transfer on cage based pearlspot seed production. This technology is expected to overcome limitation of quality seed availability and caters the needs of pearlspot farming in Karnataka and other the west coast states.

Production of probiotic bacterial biomass solid state fermentation

To utilize the Solid State Fermentation Facility for production of Probiotic Bacterial Biomass, M/s Poseidon Biotech, Chennai has linked with ICAR-CIBA on 17th November 2022. It is planned to upgrade the nutritional characteristics of raw materials and production of new innovative products for the aquafeed manufacturing industry. These types of alternative ideas and solutions for the growing demand in aquaculture are greeted.

Evaluating the efficiency of frozen zooplankton in larval and nursery rearing systems of penaeid shrimps

Sumantrak Specialties, Mumbai signed MoU with ICAR-CIBA on 20th December 2022 to evaluate the efficiency of frozen zooplankton product in larval and nursery rearing systems of penaeid shrimps. The evaluation of natural copepod-based product in the novel technology will facilitate its use as a complete feed in nursery stages for marine shrimp/fish larvae as well as broodstock shrimp feed. This kind of innovative project in CIBA's robust technology package for shrimp nursery and inclusion of frozen zooplankton will enhance the quality shrimp seed in the sector.

AGRI-BUSINESS ACTIVITIES

Promoting diagnostics service start-ups to provide affordable services to Indian shrimp farming

Introduction of incubate services to the fisheries officials and farmers of Punjab

Commercial launch of NOVACIDE-ALF (Anti-lice formulation) and NOVATAN-AMS (Microbial consortia)

Focus group discussion with Insurance Companies for re-introduction of shrimp crop insurance in India

Patents Applied

1. Anti-microbial peptide from *Penaeus vannamei* for the treatment of vibriosis.
Application No. 202241063291, 09.11.2022

Revenue Generated

SERVICES OFFERED AND NAME OF THE FIRM	₹ (in lakhs)
Collaborative research programme on calibration and validation of water testing protocol for use in aquaculture for M/s AA biotech Pvt. Ltd., New No.16/1, 48th Street, 9th Avenue, Ashok Nagar, Chennai.	1.16
Technology transfer for shrimp larval feed production for Coastal Corporation Ltd., Regd. Off.: 15-1-37/3, Nowroji Road, Maharanipeta, Vishakapatnam, Andhra Pradesh.	4.13
Consultancy service for eco-friendly biofloc based multi-phased nursery/ grow-out shrimp farming technology for Halten Aqua Consultancy, 68/1818, Market road, North end, Kombara, Ernakulam, Kerala.	1.18
Technology transfer for shrimp feed processing and production for Helini Biomolecules, Ohmlina, 26, 2nd Avenue Main Road, 7th Cross St., Khuthubi Complex, Vettuvankeni, Chennai.	2.36
Contract research for evaluation of therapeutic efficacy of Resurge (Herbal Product) for *Enterocytozoon hepatopenaei* in shrimp for M/s Naturalle Herbal Remedies Pvt. Ltd. located at 16-15-973, 3rd Street, Srisai Nagar, Children park road, Nellore, Andhra Pradesh.	5.01
Contract research for evaluation of bactericidal efficacy of Wipe & Leap (two herbal formulation products) against *Vibrio* species (*Vibrio harveyi, V. Parahaemolyticus, V. Vulnificus, V. Alginolyticus*) and *Pseudomonas aeruginosa* for M/s Naturalle Herbal Remedies Pvt. Ltd., located at 16-15-973, 3rd Street, Srisai Nagar, Children park road, Nellore, Andhra Pradesh.	2.01
Technology transfer of "Cibamox"- water probiotic technology to M/s Helini Biomolecules, Ohmlina, 26, 2nd Avenue Main Road, 7th Cross St., Khuthubi Complex, Vettuvankeni, Chennai.	2.36
Technology transfer on breeding and seed production of pearlspot, *Etroplus suratensis* in cage based rearing system for Sri Ganesh 6/6, Gonnana mane Karkikali, Uppundakundapura, Tarapathi, Kundapuraudupi, Karnataka.	1.18
Transfer of technology on Plankton*Plus* for Fishworkers welfare federation (FISHFED) of India, 302, Plot 66A, Sector 4A, Koparkhairne, Navi Mumbai.	4.42
MoU for utilizing the solid state fermentation facility for production of probiotic bacteria by M/s Poseidon Biotech, No. 2 & 3, PKM Cross Street, Padasalai Road, Mel Ayanampakkam, Chennai.	0.88
Evaluate the efficiency of frozen zooplankton in larval and nursery rearing systems of penaeid shrimps for M/s. Sumantrak Specialties, Near Raikar Chambers, 8th Floor, Daffodils, 802 C Wing, Neelkanth Garden, Govandi Station Road, Govandi East Mumbai Mumbai Suburban, Maharashtra.	11.8
TOTAL	**36.49**

DIAGNOSTIC SERVICES	₹ (in lakhs)
AQCS Samples (Polycheates, Artemia, Feed):	20.39
Private Company Samples:	1.53
Farmer Samples:	1.90
TOTAL	**23.82**

Official Language Implementation

Parliamentary Committee on Official Language inspected the works of Hindi in CIBA

On 18.05.2022, the second sub-committee of the Parliamentary Committee on Official Language inspected the work of official language being carried out at the ICAR-Central Institute of Brackishwater Aquaculture. The committee was chaired by Hon'ble Members of Parliament Prof. Rita Bahuguna Joshi and Mrs. Ranjan Ben Bhatt along with other office bearers of the committee. The Hon'ble MP expressed satisfaction over the activities related to the official language in the institute and gave instructions to do maximum official work in the official language in the coming days. On organizing regular workshop, the honourable member said that all officers and employees of the institute should ensure regular presence in the workshop so that official language can be used in a better way. During the inspection, Director of the institute, Dr. K.P. Jithendran, Dr. Praveen Putra (Assistant Director General, Marine Fisheries), Smt. Seema Chopra, (Director, Official Language), Mr. Navin Kumar Jha (Chief Administrative Officer), Dr. Sujeet Kumar (Senior Scientist and Hindi Officer) and other senior officers of the Institute were also present.

CIBA received Ganesh Shankar Vidhyarthi Hindi Patrika Puruskar - 2021 for *Jal Tarang*

ICAR-CIBA Hindi Magazine '*Jal Tarang*', was awarded the Ganesh Shankar Vidhyarthi Hindi Patrika Puruskar-2021 (2nd prize) by ICAR. Director of the institute, Dr. K.P. Jithendran received this award from the Hon'ble Union Minister for Agriculture and Farmers Welfare Shri. Narendra Singh Tomar during the 94th ICAR Foundation Day held on 16th July 2022. The award included a shield and citation. Hindi cell of ICAR-CIBA is publishing Annual Hindi Magazine, *Jal Tarang* since 2015 to take forward the knowledge of brackishwater sector among the Hindi speaking farmers. This is the second time that CIBA is receiving this prestigious ICAR award. The previous award was received for *Jal Tarang* in the year 2017.

Hindi week observed at ICAR-CIBA during 14 – 20th September, 2022

ICAR-CIBA celebrated Hindi Week during 14 - 20th September 2022 to promote the usage of Hindi as an official language. During the week, different competitions such as Hindi noting, Hindi drafting, singing of poem and song, extempore, vocabulary, quiz competitions were organized wherein the scientists, staff and research scholars of CIBA enthusiastically participated. Besides the above, another competition under the "Hindi Incentive Scheme" was also held to promote the usage of Hindi in official work. A sum total of 123 participants took part in these competitions. The valedictory function was organized on 20th September, 2022 wherein Dr. Sujeet Kumar, Senior Scientist & Officer-In-Charge, Hindi Cell presented the achievement of Hindi Cell during the year 2021-22. He gladly informed that ICAR-CIBA won the prestigious Ganesh Shankar Vidhyarthi Award from the ICAR for CIBA Hindi magazine '*Jal Tarang*', and Parliamentary Committee on Rajbhasha also appreciated the efforts of the Hindi Cell. Shri Navin Kumar Jha, Chief Administrative Officer and member of Hindi Cell presented a talk on "Rajbhasha Hindi: Status and Direction" and stressed the importance of Hindi, Regional language and English in the present dynamic world. Dr. K.P. Jithendran, Director, ICAR-CIBA released the Hindi version of CIBA Annual Report-2021 and distributed the prizes to the winners of various competitions. In his presidential address, Director remarked the linguistic diversity of India and importance of Hindi in communicating across the Nation. Dr. M. Shashi Shekhar, Dr. Akshya Panigrahi and Dr. J. Raymond Jani Angel, members of Hindi Cell coordinated the programmes. The program ended with the vote of thanks by Shri. R.K. Babu, Senior Finance and Accounts Officer & Member, Hindi Cell.

Research & Administrative Meetings

RESEARCH ADVISORY COMMITTEE (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F. No. 18-3/2016-ASR-I dated 06.02.2020) for a period of three years with effect from 01.01.2020 to 31.12.2022.

Chairman	**Dr. Madhusoodana Kurup**
Members	Dr. M. Vijayakumar Dr. Lalit C. Garg Dr. Asim K. Pal Dr. Santhana Krishnan Dr. Pravin Puthra, ADG (M. Fy.) Dr. K.P. Jithendran, Director
Member Secretary	**Dr. Subhendu Kumar Otta**

The 27th meeting of the Research Advisory Committee (RAC) of CIBA was held during 29-30th March 2022 at CIBA Headquarters, Chennai.

INSTITUTE RESEARCH COUNCIL (IRC)

The Institute Research Council (IRC) of CIBA has been constituted as follows:

Chairman	**Dr. K.P. Jithendran, Director**
Members	Dr. M. Jayanthi, Principal Scientist & SIC-CCD Dr. M. Kailasam, Principal Scientist & SIC-FCD Dr. M. S. Shekhar, Principal Scientist & SIC-NGBD Dr. C. V. Sairam, Principal Scientist & SIC-SSD Dr. M. Muralidhar, Principal Scientist, SIC-Env. Dr. K. Ambasankar, Principal Scientist & SIC-Nutri. Principal Investigators of all the projects
Member Secretary	**Dr. K.P. Kumaraguru vasagam, Principal Scientist & OIC, PME Cell**

The 39th IRC Meeting was held on 25-26th July 2022 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. K.P. Jithendran, Director**
Members	Dr. B.P. Mohanty, ADG (M.Fy.), ICAR, New Delhi Dr. K.V. Rajendran, Principal Scientist, ICAR-CIFE, Mumbai, Maharashtra Dr. Shubhadeep Ghosh, Principal Scientist, Visakhapatnam Regional Centre of CMFRI, A.P 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)
Member Secretary	**Smt. V. Usharani, Administrative Officer**
Co-opted Members	Dr. K.P. Kumaraguru Vasagam, Principal Scientist & OIC, PME Cell Dr. P. Mahalakshmi, Principal Scientist & OIC Engineering Cell & AKMU Shri Navin Kumar Jha, CAO & Head of Office Shri R.K. Babu, Senior Finance & Accounts Officer Smt. E. Amudhavalli, AAO (C&B) Shri A. Sekar, AAO (Estt.) Shri P. Srikanth, AFAO Shri K. Raghavendra, AAO (Stores)
Non-Official Members	Shri S. Satish Kumar, Farmers' Representative Shri P. Rama Chandra Raju, Farmers' Representative

The 54th meeting of the Institute Management Committee (IMC) of CIBA was held in the CIBA Headquarters, Chennai on 20th August, 2022

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. K.P. Jithendran, Director**
Members Secretary	Dr. T. Ravisankar, Principal Scientist
Member	Dr. M. Jayanthi, Principal Scientist & SIC-CCD Dr. S. Kannappan, Principal Scientist Shri Navin Kumar Jha, CAO & Head of Office Shri R.K. Babu, Senior Finance & Accounts Officer Smt. V. Usharani, AO
Staff Side	
Secretary	Shri N. Jagan Mohan Raj, Technical Officer
Members	Shri K. Raghavendra, AAO Shri V. Kishorkumar, LDC Smt. S. Prabhu, Technical Assistant Shri R. Mathivanan, Skilled Support Staff Shri Indra Kumar, Skilled Support Staff

The meeting of the Institute Joint Staff Council (IJSC) of CIBA with the new members was held in the CIBA Headquarters, Chennai on 9th September, 2022.

GRIEVANCE COMMITTEE

The composition of the Institute Grievance Committee (reconstituted by CIBA vide Office Order F. No. 48-16/2010-Admn. dated 02.07.2019) is as follows:

Chairman	**Dr. K. P. Jithendran, Director**
Elected Members	Dr. T. Ravisankar, Principal Scientist
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**
Elected 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**
Elected 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

LIAISONING COMMITTEE

The composition of the Liaisoning Committee has been constituted by CIBA vide Office Order F.No.48-16/2010-Admn. dated 06.06.2016 is as follows:

Chairman	**Dr. S. Kannappan, Principal Scientist**
Members	Dr. K. Ambasankar, Principal Scientist Dr. R. Saraswathy, Principal Scientist Dr. Akshaya Panigrahi, Principal Scientist Dr. M. Kumaran, Principal Scientist Dr. P.K. Patil, Principal Scientist

Services & Assignments

SERVICES IN COMMITTEES

Dr. K.P. Jithendran, Director (Acting) (1st January – 27th October 2022)

- Member, Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai
- Member, ICAR Regional Committee No. VIII
- Member, Executive Committee Member - National Centre for Sustainable Aquaculture (NaCSA)
- Member, Coastal Aquaculture Authority
- Member, Board of Tamil Nadu Fisheries Development Corporation Limited, Chennai
- Member, Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur
- Member, Scientific Advisory Committee for Dr. Perumal Krishi Vigyan Kendra
- Member, National Committee on Introduction of Exotic Aquatic Organisms into Indian waters, constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi
- Member, Advisory Committee on Hilsa Conservation and Research
- Member, High Power Society "Society for Promotion of Shrimp Farming in Punjab", headed by Additional Chief Secretary, Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, constituted by Department of Fisheries, Punjab Member, Central Standing
- Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) for formulation of unit cost norms, unit costs and guidelines in respect of all the components and sub-components of the PMMSY Member, Expert Committee to draft the Coastal Aquaculture Authority (CAA) Amendment Bill, 2021, constituted by the Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India.
- Member, Technical Advisory Committee for the GNF-BMZ Project "Building a transnational, civil society partnership to increase the resilience of coastal population in South Asia", constituted by the Governing Board of Centre for Research on New International Economic Order (CReNIEO), Chennai
- Member, 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

Dr. Kuldeep Kumar Lal, Director (From 28th October 2022 – 31st December)

- Member, Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai
- Member, ICAR Regional Committee No. VIII
- Member, Executive Committee Member - National Centre for Sustainable Aquaculture (NaCSA)
- Member, Coastal Aquaculture Authority
- Member, Board of Tamil Nadu Fisheries Development Corporation Limited, Chennai
- Member, Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur
- Member, Scientific Advisory Committee for Dr. Perumal Krishi Vigyan Kendra
- Member, National Committee on Introduction of Exotic Aquatic Organisms into Indian waters,

constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi.

- Member, Advisory Committee on Hilsa Conservation and Research
- Member, High Power Society "Society for Promotion of Shrimp Farming in Punjab", headed by Additional Chief Secretary, Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, constituted by Department of Fisheries, Punjab
- Member, Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) for formulation of unit cost norms, unit costs and guidelines in respect of all the components and sub-components of the PMMSY
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- Member, Technical Advisory Committee for the GNF-BMZ Project "Building a transnational, civil society partnership to increase the resilience of coastal population in South Asia", constituted by the Governing Board of Centre for Research on New International Economic Order (CReNIEO), Chennai
- Member, 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
- Member, National Organizing Committee for the 8th Global Symposium on Gender in Aquaculture & Fisheries, organized during 21-23 November 2022 at Kochi, Kerala.
- Member, National Advisory Committee for Conference on "Fisheries and Aquaculture : An Ecological Perspectives – 2023 (IESFAC-2023)", organized by College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, during 22-24 February 2023

SCIENTISTS

- CCSEA nominee by the Ministry of Fisheries, Animal Husbandry and Dairying, Department of Animal Husbandry and Dairying, Govt. of India- **Dr. M. Poornima, Dr. R. Ananda Raja**
- CCSEA nominee to IAEC of M/s. Bioklone Biotech Pvt. Ltd., Christian Medical College (CMC), Anna University, Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), and BCG vaccine laboratory, Tamil Nadu- **Dr. R. Ananda Raja.**
- Member of Expert Panel for Live Polychaete Worms In-House Quarantine Facility of AQCS, Chennai-Inspection of Aquatic Quarantine Facility for import of live SPF polychaetes by M/s NSR traders, Kona Forest Village, Thondangi mandal, East Godavari District, Andhra Pradesh- **Dr. T. Bhuvaneswari**.
- DBT nominee for IBSC, NBFGR, Lucknow- **Dr. S.K. Otta**
- Academic Council Member of KUFOS, Kerala- **Dr. S.K. Otta**
- Acting as a Principal Member of the Aquaculture Subcommittee under FAD 12.1 of BIS - **Dr. K. Ambasankar**
- Co-opted Member in Board of Studies for Faculty of Fisheries Science, Kamdhenu University, Gujarat by Honorable Vice Chancellor of NAU, Navsari - **Shri. Pankaj Amrut Patil**
- Nominated as representative for the preparation of India's Adaptation Communication for the agriculture sector in India - **Dr. M. Muralidhar**
- Involved in physical inspection of Broodstock Multiplication Centre facility of M/s. Vaishnavi Aquatech, Surat, Gujarat, for Penaeus monodon as a member of the Technical and Inspection Committee constituted by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying (Govt. of India – **Dr. M. Muralidhar, Dr. C.P. Balasubramanian, Dr. K. Vinaya Kumar**
- Acted as an Expert member of Technical and Inspection Committee for establishment of Brood Stock Multiplication Centres (BMCs) by Ministry of Agriculture & Farmer's Welfare, on 28 April, 2022 - **Dr. M. Muralidhar**
- Acted as an Expert in the 30th Research Council meeting of Tamil Nadu Veterinary and Animal Sciences University held on 7 December 2022 at Madras Veterinary College - **Dr. K. Ambasankar**

Swachh Bharat Abhiyan

Swachhta Pakhwada Activities

ICAR-CIBA has conducted Swachhta Pakhwada 2022 programmes at headquarters, Chennai, Muttukadu Experimental Station (MES) at Muttukadu and the two regional centres viz., Kakdwip Research Centre (KRC), West Bengal and Navsari-Gujarat Research Centre (NGRC), Gujarat. As a part of the Swachhta Pakhwada, CIBA scientists, staff and students has organized various activities at Institute campuses and adopted villages. Weeding of old files, disposal of office scrap materials and outdoor special swachhta programmes in the adopted villages on 'waste to wealth', cleanliness drives, rallies, waste management, tree plantation, kitchen gardening etc. were organised during 16-31 December 2022. In addition to organise awareness programmes, CIBA has distributed cleaning materials, value-added products from fish wastes, Plankton^{plus} and Hori^{Plus}, vegetable farming materials, tanks, drip irrigation items, vegetable seeds etc. to self-help group members, farmers and coastal communities. Around 730 participants including scientists, staff, farmers and students attended the various Swachhta Pakhwada activities.

Swachhta Pledge

Swachhta Pledge was taken by the Scientists, Officers, Staff and Students at CIBA Headquarters and its campuses. After the pledge, tree planting was done at MES, NGRC and KRC campuses.

Swachhta Pledge by Scientists, staff, research scholars and students, ICAR-CIBA, Chennai

Tree planation at KRC of CIBA, Kakdwip, West Bengal

Cleaning of office premises and weeding out of the files and records

The weeding out of the files and records from Stores, Administration, Audit and Accounts Section and Library and cleanliness drive in various laboratories and common places in the institute premises including research centres at Gujarat and Kakdwip were undertaken. Due to disposal of materials nearly 600 sq. ft. space was freed and utilised as a storage facilities, and ₹8,35,838 revenue was generated. The processing of files by the Administration, Audit & Accounts and Stores sections were carried out through e-office, being 100% implementation of e-office, this enabling paperless office.

Cleaning of unserviceable items from office premises at headquarters of CIBA, Chennai

Awareness-cum-rallies and tree plantation programme

Awareness-cum-rallies and tree plantation programme were organised with students and scholars from Fisheries College, Thoothudui and CIBA at MES of CIBA, Muttukadu, Santhome High Road, Santhome and M.R.C main road, Raja Annamalai Puram, Tamil Nadu. Various placards explaining about different means to avoid plastic waste, go greens, say to no plastics etc was administered to the participants.

Awareness program and rallies by Fisheries College students and staff of CIBA at MES of CIBA, Muttukadu, Tamil Nadu

Rallies on 'shun single use plastics' at Santhome High Road, ICAR-CIBA, Chennai

Awareness programmes on safe disposal of degradable / non-degradable items and shun single use plastics

ICAR-CIBA has organised awareness programmes on safe disposal of degradable / non-degradable items and 'shun single use plastics' in the adopted villages such as Buddhapur (South 24 Parganas, West Bengal), Thonirevu (Pulicat, Tamil Nadu) and Kottaikadu (Kanchipuram, Tamil Nadu). CIBA staff sensitized the villagers about climate change and importance of cleanliness. Villagers were also briefed about judicious use and safe disposal of single use plastics. They were also apprised about the deleterious effect of various harmful anthropogenic activities like dumping of single use plastic in natural ecosystem, importance of safe disposal of degradable / non-degradable items etc. Later, cleaning of village road, surroundings of a shared facility used by the villagers for community gathering and backwater area and removal of non-degradable items were carried out by the participants.

Distribution of cleaning aids and bins for waste disposal to the villagers in Buddhapur village, South 24 Parganas, West Bengal

Cleaning of backwater at Kottaikadu village, Kanchipuram, Tamil Nadu

Water harvesting for agriculture and importance of kitchen and vegetable garden

Scientists at NGRC demonstrated water harvesting through excavation of pond and utilization of the harvested rain water for round the year horticultural crop and fish cultivation. Scientists explained importance of recycling of waste water and water harvesting for horticulture applications in their village. As a part of the Swachhta Pakhwada programme, villagers participated in the horticulture activity and cultivation of crops on the pond dykes and with irrigation from harvested pond water.

NGRC of CIBA also organized awareness programme on importance of kitchen garden and utilization of pond dyke of Integrated Fish Farming (IFF) model for vegetable garden at Singod, Navsari and Mendhar village, Navsari, Gujarat. CIBA scientists appraised the farmers about the importance of utilization of homestead and fish pond fallow land by converting to kitchen garden for cultivation of horticultural crops and also utilization of pond dyke of IFF model in the form of vegetable garden that provides extra incomes, meet up domestic needs for vegetables and nutrition, and create clean and aesthetic surroundings of house and IFF model. This would also help in keeping house premise weed-free and maintaining healthy organic environment.

Distribution of vegetable garden materials to tribal farmers, Mendhar village, Navsari, Gujarat

National Farmers Day or Kisan Diwas

KRC of CIBA observed National Farmers Day or Kisan Diwas in the recently inaugurated fish waste processing facility at KRC Campus on 23rd December 2022. As part of the event, awareness on converting fish waste-to-wealth and sharing of experience by the firm who adopted CIBA waste-to-wealth technology: Plankton^{Plus} were organised. Mr. Biswajit Samanta from M/s TK Enterprises to whom the Plankton^{plus} technology was transferred, shared his experience on the production and performance of Plankton^{plus} in shrimp and fish culture and also their marketing potential. He pointed out that the farmers who are using Plankton^{Plus} are satisfied with the product and opined that the product reduces the cost of production by reducing the feed input. CIBA scientists demonstrated to the participants about the protocol for recycling of fish wastes to value-added products and their usage in commercial aquaculture and agriculture. The valued-added products, Plankton^{plus} and Hori^{Plus} were distributed to self-help group members.

Experience sharing on production and performance of fish waste to value-added product, Plankton^{plus} , by M/s TK enterprises, Kakdwip

Demonstration of preparation of fish waste to values-added product, KRC of CIBA, Kakdwip

Distribution of fish waste to values added product to self-help group members, Kakdwip

Community mobilization for plastic waste shramdaan

KRC of CIBA, Kakdwip organized a community mobilization for plastic waste shramdaan at Mousani village, South 24 Parganas district in West Bengal to create awareness on shun single use plastics, waste management, usage of organic farming, cleanliness, hygiene and sanitation among the Self Help Group (SHG) members, tribal farmers and villagers. CIBA staffs explained about Swachh Bharat Mission aim and objectives; importance of self-help principles; safe disposal of wastages from village premises including domestic wastages; and hygiene and sanitation. They also highlighted the importance of kitchen garden and organic farming related with their health aspects. As part of the program, plastics, waste materials and other debris were removed from the village road and the surroundings of a primary school.

Awareness meeting at Mousani village, South 24 Parganas district in West Bengal

Cleanliness drive for removal of plastic and waste materials in the village premises, Mousani village, South 24 Parganas district, West Bengal

Speech competition among coastal communities

ICAR-CIBA, Chennai conducted an awareness-cum-speech competition among coastal communities at Thonirevu village, Pulicat, Tamil Nadu to sensitize the coastal women, men, youth and children on impact of Swatch Bharat Mission and minimizing the use of single usage plastics, effects of plastic on marine life and oceans, recycling of fish waste to value-added products etc. This program was followed by a speech competition wherein 7 coastal women participated and presented their views on a clean and plastic free India with emphasis on negative impacts of plastic on environment, importance of reducing open defecation, water management, how to use domestic wastages. Prizes were distributed to the participants.

Awareness on 'Importance of swachhta campaigns' at Thonirevu village, Pulicat, Tamil Nadu

Speech on 'Importance of swachhta campaigns' by participants at Thonirevu village, Pulicat, Tamil Nadu

'Appreciation Award' to ICAR-CIBA from the Greater Chennai Corporation, Chennai, for the exemplary work in 'People's Movement for Clean Cities-2022'

ICAR-CIBA, Chennai received the 'Appreciation Award' for the exemplary work in 'People's Movement for Clean Cities-2022' under the Swachh Bharat Mission from the Greater Chennai Corporation, Chennai, Tamil Nadu based on the range and scale of organizing the various swachh activities including innovative waste management to waste-to-wealth initiatives besides documentation and dissemination of the technologies for waste management since 2015. Dr. C.V. Sairam, Director-in-Charge, Dr. P. Mahalakshmi, Principal Scientist & Nodal Officer, Swachh Bharat Mission, ICAR-CIBA and Mr. Jagan Mohan Raj, Member, Swachh Bharat Mission committee of CIBA received the award consisting a certificate and shield from the Respectful Mayor of Chennai Ms. Priya Rajan on 26.12.2022. It was highlighted in the print media.

ICAR-CIBA, Chennai received the 'Appreciation Award' for the exemplary work in 'People's Movement for Clean Cities-2022

Mera Gaon Mera Gaurav Programme

ICAR-CIBA implemented an innovative initiative "*Mera Gaon Mera Gaurav*" the flagship programme of the Hon'ble Prime Minister of India. *Mera Gaon and Mera Gaurav* (MGMG) Scheme was implemented in three districts of Tamil Nadu viz., Chennai, Chengalpattu and Thiruvallur. During the period 2022, Scientists in 14 teams implemented the programme in 14 villages, in a phased manner of making a visit in a month for need based activities. The scientists provided information to the farmers on technical and related aspects of aquaculture in a time frame through mobile phones and personal visits (based on the need/emergency). ICAR-CIBA provided the required information, knowledge and advisories on regular basis. The farmer group put forth their desire on receiving the technologies. ICAR-CIBA scientists periodically updated farmers about aquaculture activities through phone and mobile messages. The farmers were made sensitive of national importance programme such as National Fish Farmers Day, Swachh Pakwada, World Fisheries Day, etc.

The team of scientists had undertaken 48 visits, 28 meetings and 3 training programmes, under the patronage of the MGMG. In addition, 8 demonstrations were conducted, 152 mobile advisories have been extended, 3 literatures were distributed, and 3 campaigns were organized during the reported period. These activities were taken up for technology dissemination from lab to land and to create awareness among the shrimp/ fish farmers. The demonstrations were conducted under the five major heads by ICAR-CIBA for the benefit of the farming community proved that it has given them an alternative livelihood to earn an additional income to improve the standard of living and socio-economic improvement of coastal community..

- Comparative assessment of nursery rearing of Asian seabass under different salinity regimes as a livelihood development model for the coastal fisher families.
- Utilization of open brackishwater water bodies for nursery rearing of finfishes as a livelihood support activity.
- Waste to Wealth: Recycling of fish waste to value-added products, CIBA-Plankton^{Plus} and Horti^{Plus}.
- 'Re-circulatory Aquaculture System' model for pearlspot nursery rearing in tribal villages.
- Homestead backyard pearlspot hatchery activity demonstrated among the clam collecting coastal families.

Technical support of ICAR-CIBA for the production of CIBA-Plankton^{Plus} and CIBA-Horti^{Plus}

Distinguished Visitors

Sl. No.	Details of visitors	Date of visit
Headquarters		
1	Shri. Jatindra Nath Swain IAS, Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi.	10th January, 2022
2	Dr. V. Kripa, Member Secretary, Coastal Aquaculture Authority.	10th January, 2022
3	Dr. A. Sethuramashankaran, Consultant Diabetologist & Bariatric Physician, Lakshmi Diabetic Centre, Chennai.	8th March, 2022
4	Ms. Shelly Dheer, Deputy General Manager, Mr. Safia Patel, Chief Regional Manager, Oriental Insurance, Mr. A. Srinivasan, Vice President, Mr. K. V. Pathasarathy, Chief Manager and Mr. Kuldeep Bhadekar, Assistant Vice President (Agricultural Insurance).	23th March, 2022
5	Dr. J.K. Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi.	7th May, 2022
6	Dr. L. Murugan, Hon' ble Union Minister of State for Fisheries, Animal Husbandry and Dairying & Information and Broadcasting, Government of India.	31st May, 2022
7	Shri. Arvind Kumar, Managing Director CPCL, Chennai and Shri V.C. Asokan Executive Director, IOCL.	31st May, 2022
8	Dr. P. Krishnan, Director, Bay of Bengal Programme – Inter Governmental Organisation (BOBP-IGO).	4th June, 2022
9	Shri. Jatindra Nath Swain IAS, Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying.	18th June, 2022
10	Dr. R. Ramasubramanian, Head, Coastal Systems Research, MSSRF, Chennai.	4th August, 2022
11	Dr. Bimal Mohanty, Assistant Director General (Inland Fisheries), ICAR, New Delhi.	21st August, 2022
12	Shri. G.P. Sharma, Joint Secretary (Finance), ICAR, New Delhi.	1-2 September, 2022
13	Dr. C.K. Thankamani, Director, ICAR–Indian Institute of Spices Research, Kozhikode, Kerala.	12th September, 2022
14	Dr. J.K. Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi.	27th September, 2022
15	Dr. V. Sridevi, Oncologist & Professor in Surgical Oncology at Cancer Institute (WIA), Chennai.	23rd November, 2022
16	Dr. Chindi Vasudevappa, Vice Chancellor, National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Haryana.	3rd December, 2022
17	Dr. K.G. Tirumurugaan, Project Director I/C, Translational Research Platform for Veterinary Biologicals, TANUVAS, Chennai.	13th December, 2022
Kakdwip Research Centre, West Bengal		
18	Shri. Biplab Roy Chowdhury, Hon'ble Minister of Fisheries, Govt. of West Bengal.	6th September, 2022
19	Shri. Bankim Chandra Hazra, Hon'ble Minister of Sundarban Affairs, Govt. of West Bengal.	5th December, 2022
Navsari Gujarat Research Centre, Gujarat		
20	Shri. Nitin Sangwan, IAS, Commissioner of Fisheries, Government of Gujarat.	30th May, 2022

Shri. Jatindra Nath Swain IAS, Secretary, Department of Fisheries visited CIBA, Chennai

Shri. Jatindra Nath Swain IAS, Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying visited CIBA, Chennai on 10th January, 2022. The Secretary visited state-of-the-art shrimp and finfish hatcheries and the pilot-scale feed mill at Muttukadu Experimental Station of ICAR-CIBA and interacted with scientists, Shri. Swain stressed on developing innovative and efficient technology options for the farming community. He stressed on transformative changes required for realizing the goals and the critical roles of researchers could play in it. Further, Secretary had also appreciated the progress in eco-based farming such as biofloc farming technology for shrimp nursery and grow-out technology.

Deputy Director General (Fisheries) ICAR, Dr. J.K. Jena, visited Kovalam experimental station (KES) of ICAR-CIBA

Deputy Director General (Fisheries) ICAR, Dr. J.K. Jena, visited Kovalam experimental station (KES) of ICAR-CIBA on 7th May 2022, and inaugurated the newly constructed modular biofloc nursery rearing unit

Shri. Biplab Roy Chowdhury, Hon'ble Minister of Fisheries, Govt. of West Bengal visited Kakdwip Research Center of CIBA

On 6th September 2022, Shri. Biplab Roy Chowdhury, Hon'ble Minister of Fisheries, Govt. of West Bengal visited Kakdwip Research Center of ICAR-CIBA. The Hon'ble minister witnessed the ongoing activities such as pond reared hilsa broodstock developed at the centre besides various resources and facilities available at the centre

Dr. Joykrushna Jena, Deputy Director General (Fisheries) visited CIBA, Chennai for second time during September, 2022

Dr. Joykrushna Jena, Deputy Director General (Fisheries), ICAR, New Delhi visited CIBA, Chennai during 27-28 September 2022. During the visit, Dr. J.K. Jena inaugurated the new facilities such as Kiosk in MES and Centre for Bioinformatics in the presence of Dr. K.P. Jithendran, Director.

Shri. Bankim Chandra Hazra, Hon'ble Minister of Sundarban Affairs, Govt. of West Bengal visited Kakdwip Research Center of CIBA

On the occasion of the celebration of World Soil Day, on 5th December, 2022, Shri Bankim Chandra Hazra, Hon'ble Minister of Sundarban Affairs, Govt. of West Bengal honoured the function as the chief guest and inaugurated the farmer's meet, Kiosk and fish waste processing unit at Kakdwip Research Center.

Shri. Nitin Sangwan IAS, Commissioner of Fisheries, Gujarat visited farm at Matwad, Gujarat

Shri. Sangwan IAS, Commissioner of fisheries, Govt of Gujarat visited NGRC farm on 30th May 2022. He visited the facilities and appreciated the research and development activities of the NGRC of CIBA in the west coast in Brackishwater aquaculture development.

Personnel

Sl. No.	NAME	DESIGNATION	REMARKS
SCIENTISTS			
1	Dr. Kuldeep Kumar Lal	Director	Joined at CIBA on 28.10.2022 (AN)
2	Dr. K.P. Jithendran	Principal Scientist & Director (Acting)	Director (Acting) (up to 28.10.2022- FN)
3	Dr. C.V. Sairam	Principal Scientist	
4	Dr. T. Ravisankar	Principal Scientist	
5	Dr. M. Muralidhar	Principal Scientist	
6	Dr. (Smt) M. Jayanthi	Principal Scientist	
7	Dr. (Smt) B. Shanthi	Principal Scientist	
8	Dr. C.P. Balasubramanian	Principal Scientist	
9	Dr. M. Kailasam	Principal Scientist	
10	Dr. (Smt) D. Deboral Vimala	Principal Scientist	
11	Dr. M. Shashi Shekhar	Principal Scientist	
12	Dr. (Smt) P. Nila Rekha	Principal Scientist	
13	Dr. K. Ambasankar	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. Kumaraguruvasagam	Principal Scientist	
26	Dr. R. Jayakumar	Principal Scientist	
27	Dr. T. Senthil Murugan	Principal Scientist	
28	Dr. Vinaya Kumar Katneni	Senior Scientist	Promoted to next higher grade w.e.f. 12.06.2019
29	Dr. (Smt) P. Ezhil Praveena	Senior Scientist	Promoted to next higher grade w.e.f. 07.01.2020
30	Dr. Krishna Sukumaran	Senior Scientist	Transferred to CMFRI Regional Station, Vizhinjam on 30.10.2022
31	Dr. R. Ananda Raja	Senior Scientist	Promoted to next higher grade w.e.f. 08.01.2020
32	Dr. (Smt). Shyne Anand	Senior Scientist	Promoted to next higher grade w.e.f. 07.01.2021

33	Dr. Sujeet Kumar	Senior Scientist	Promoted to next higher grade w.e.f. 07.01.2021
34	Dr. B. Sivamani	Senior Scientist	Promoted to next higher grade w.e.f. 07.01.2020
35	Dr. (Smt) R. Geetha	Senior Scientist	Promoted to next higher grade w.e.f. 23.06.2021
36	Dr. P. Kumararaja	Senior Scientist	Promoted to next higher grade w.e.f. 08.01.2022
37	Dr. (Smt) T. Bhuvaneswari	Senior Scientist	Promoted to next higher grade w.e.f. 10.02.2020
38	Shri. Ashok Kumar Jangam	Scientist (SS)	
39	Dr. (Smt) N. Lalitha	Scientist	Promoted to next higher grade w.e.f. 07.01.2021
40	Dr. (Smt) Vidya Rajendran	Scientist	
41	Dr. Satheesha Avunje	Scientist	
42	Shri. T. Sathish Kumar	Scientist	
43	Shri. K.P. Sandeep	Scientist	
44	Dr. J. Raymond Jani Angel	Scientist	
45	Dr. Aritra Bera	Scientist	
46	Smt. Mary Lini	Scientist	
47	Dr. Vinay Tharabenahalli Nagaraju	Scientist	
48	Shri. T. Sivaramakrishnan	Scientist	Promoted to next higher grade w.e.f. 01.01.2020
49	Shri. Dani Thomas	Scientist	Promoted to next higher grade w.e.f. 01.01.2021
50	Shri.R. Aravind	Scientist	Promoted to next higher grade w.e.f. 01.01.2021
TECHNICAL			
1	Dr. S. Sivagnanam	Chief Tech. Officer	
2	Shri. D. Raja Babu	Chief Tech. Officer	
3	Shri. R. Puthiavan	Chief Tech. Officer	Promoted on 01.01.2020
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	Tech. Officer	
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. Karaian	Senior Tech. Asst.	
15	Shri. S. Prabhu	Technical Asst.	
16	Shri. K.V. Delli Rao	Technical Asst.	
ADMINISTRATION			
1	Shri. Navin Kumar Jha	Chief Administrative Officer	Joined at CIBA on 28.03.2022

2	Shri. Babu R.K.	Senior Finance & Accounts Officer	Transferred to IISR, Kozhikode on 18.10.2022
3	Smt. Komal Sheokand	Senior Finance & Accounts Officer	Joined at CIBA on18.11.2022
4	Smt. V. Usharani	Administrative Officer	
5	Shri. M. Krishna Moorthy	Principal Private Secretary	Joined at CIBA on 29.08.2022
6	Shri. P. Srikanth	Assistant Finance Accounts Officer	
7	Smt. E. Amudhavalli	Asst. Admn. Officer	
8	Shri. A. Sekar	Asst. Admn. Officer	
9	Shri. Raghavendra. K	Asst. Admn. Officer	Promoted on 28.07.2022
10	Smt. E. Mary Desouza	Asst. Admn. Officer	Promoted on 13.10.2022
11	Smt. S. Nalini	Private Secretary	
12	Shri. K.G. Gopala Krishna Murthy	Private Secretary	
13	Smt. K. Hemalatha	Personal Assistant	
14	Smt. K. Subhashini	Personal Assistant	
15	Smt. R. Vetrichelvi	Assistant	Promoted on 29.06.2022
16	Smt. M. Mathuramuthu Bala	Assistant	Promoted on 30.08.2022 (AN)
17	Smt. B. Prasanna Devi	Upper Division Clerk	
18	Shri. R. Kumaresan	Upper Division Clerk	
19	Shri. A. Paul Peter	Upper Division Clerk	
20	Shri. V. Kishorkumar	Lower Division Clerk	
21	Shri. S. Solin Igneshus	Lower Division Clerk	Promoted on 05.07.2022
22	Shri. R. Raja Sekar (on deputation from CMFRI)	Lower Division Clerk	Relieved from CIBA on 31.10.2022 (AN)
SKILLED SUPPORT STAFF			
1	Shri. V.M. Dhanapal	Skilled Support Staff	Retired on 31.03.2022
2	Shri. V. Kumar	Skilled Support Staff	
3	Shri. C. Saravanan	Skilled Support Staff	
4	Shri. S. Selvababu	Skilled Support Staff	
5	Shri. C. Ragu	Skilled Support Staff	
6	Shri. P.G. Samuvel	Skilled Support Staff	
7	Shri. M. Sakthivel	Skilled Support Staff	
8	Shri. R. Mathivanan	Skilled Support Staff	
9	Shri. R. Indra Kumar	Skilled Support Staff	
10	Shri. G. Dayalan	Skilled Support Staff	
11	Shri. Kanaka Prasad	Skilled Support Staff	
12	Shri. J. Murugan	Skilled Support Staff	
Kakdwip Research Centre of CIBA			
SCIENTISTS			
1	Dr. Debasis De	Principal Scientist & OIC	
2	Dr. T.K. Ghoshal	Principal Scientist	
3	Dr. Sanjoy Das	Principal Scientist	
4	Dr. Prem Kumar	Senior Scientist	Promoted to next higher grade w.e.f. 10.02.2021

5	Mrs. Babita Mandal	Scientist	
6	Dr. N.S. Sudheer	Scientist	Promoted to next higher grade 01.01.2020
7	Mrs. Leesa Priyadarsani	Scientist	Promoted to next higher grade w.e.f. 01.01.2021
8	Shri. Biju. I.F.	Scientist	Promoted to next higher grade w.e.f. 01.01.2021
9	Mrs. Misha Soman	Scientist (On study leave)	Promoted to next higher grade w.e.f. 01.01.2021
TECHNICAL			
1	Smt. Chhanda Mazumder	Technical Officer	Promoted on 28.11.2020
ADMINISTRATION			
1	Shri. Sanjoy Some	Lower Division Clerk	
SKILLED SUPPORT STAFF			
1	Smt. L.R. Bhuiya	Skilled Support Staff	
2	Shri. P.C. Das	Skilled Support Staff	
Navsari-Gujarat Research Centre of CIBA			
1	Shri. Pankaj Amrut Patil	Scientist	Promoted to next higher grade w.e.f. 01.01.2021
2	Shri. Jose Antony	Scientist	Promoted to next higher grade w.e.f. 01.01.2021
3	Shri. Tanveer Hussain	Scientist	Transferred to CMFRI Regional Station, Vizhinjam on 14.10.2022

Infrastructure Development

Sl. No.	Name
1	Construction of Peripheral bund at Kovalam Experimental Station (KES) of CIBA, Kelambakkam, Chennai
2	Providing compound wall / barbed wire fencing, around the farm area and construction of gate etc., at KES of CIBA, Kelambakkam, Chennai
3	Construction of RCC tank at fish hatchery, Muttukadu Experimental Station (MES) of CIBA, Muttukadu, Chengalpattu
4	Fixing of name board for CIBA Outlet/Kiosk at MES of CIBA, Muttukadu, Chengalpattu
5	Providing PUF Sandwich panel shed near ornamental shed at MES of CIBA, Muttukadu, Chengalpattu
6	Providing Semi-permanent shed for the Transformers, RMG, DG sets and electrical panel etc., at CIBA Hqrs, R.A. Puram, Chennai
7	Providing transparent roofing sheet and granite flooring in the outdoor experimental shed at MES of CIBA, Muttukadu, Chengalpattu
8	Providing concrete platform in front of the ornamental shed at fish hatchery side of the MES of CIBA, Muttukadu, Chengalpattu
9	Renovation of the indoor rotifer mass culture room (next to technical staff room) in fish hatchery campus to be used as environmental manipulation room at MES of CIBA, Muttukadu, Chengalpattu
10	Installation of panel board with electrical cabling for experimental units at KES of CIBA, Kelambakkam, Chennai
11	Providing M.S. Gate at the Main entrance of the KES of CIBA, Kelambakkam, Chennai
12	Renovation of boundary wall to safe guard the property at KRC of CIBA, Kakdwip
13	Renovation of main dyke in the river side of the Sector A at KRC of CIBA, Kakdwip
14	Renovation of grill fencing around garden at KRC of CIBA, Kakdwip
15	Providing concrete platform and semi-permanent shed for installation of 125 KVA DG at NGRC of ICAR-CIBA, Gujarat
16	Repair and renovation of the existing effluent treatment tanks at MES of CIBA, Muttukadu, Chengalpattu
17	Providing transparent roofing sheet and granite flooring in the outdoor experimental shed at MES of CIBA, Muttukadu, Chengalpattu
18	Repair and renovation of RCC Fish fry tanks with roof sheet at MES of CIBA at Muttukadu, Chengalpattu

Providing M.S. Gate at KES of ICAR-CIBA

The Kiosk outlet at MES of ICAR-CIBA

Construction of compound wall at KES of ICAR-CIBA

Fish fry tank at MES of ICAR-CIBA

Shrimp hatchery ETP tank at MES of ICAR-CIBA

Shed in shrimp hatchery at MES of CIBA

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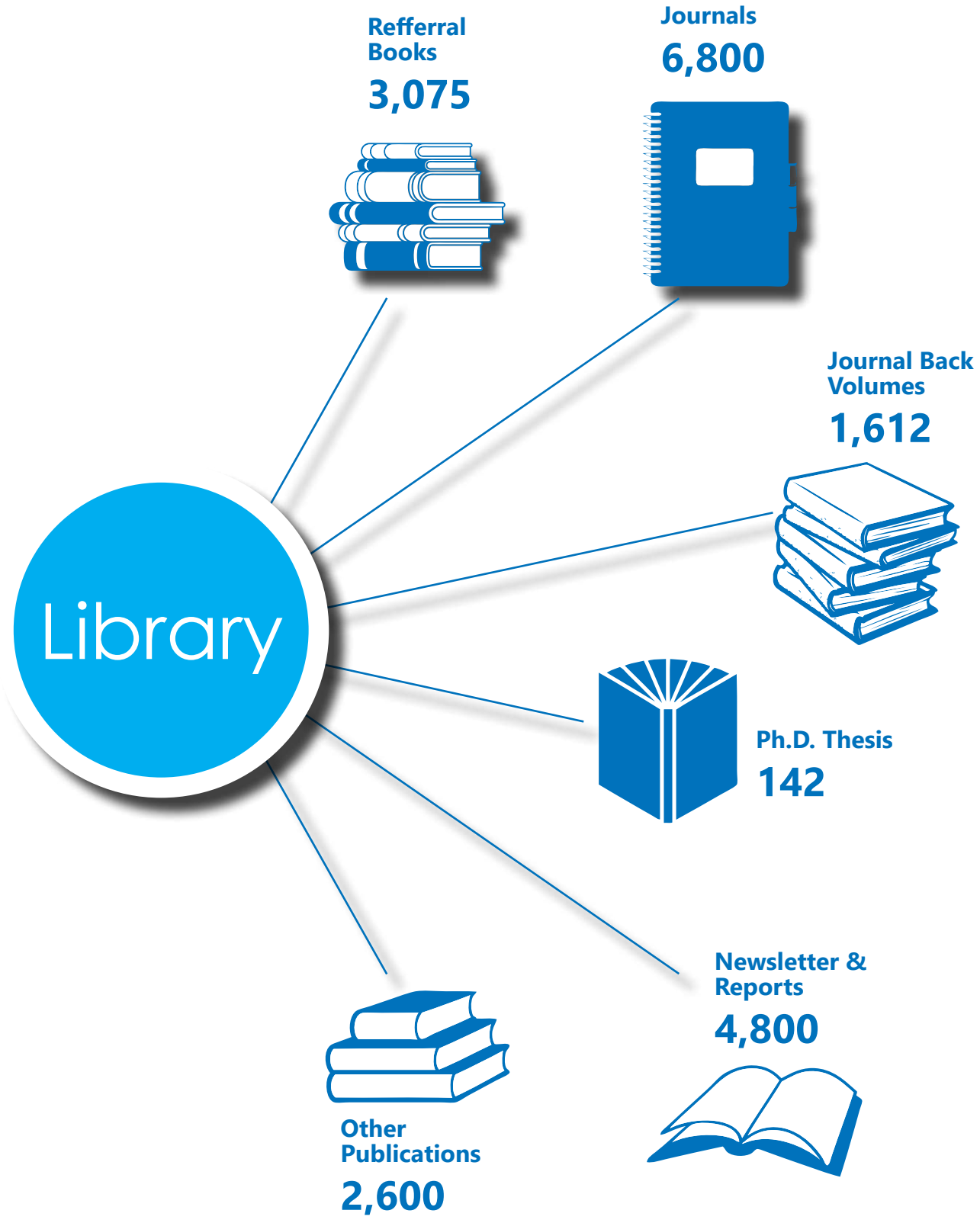
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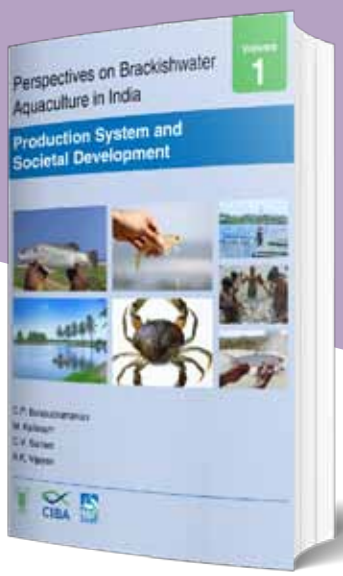

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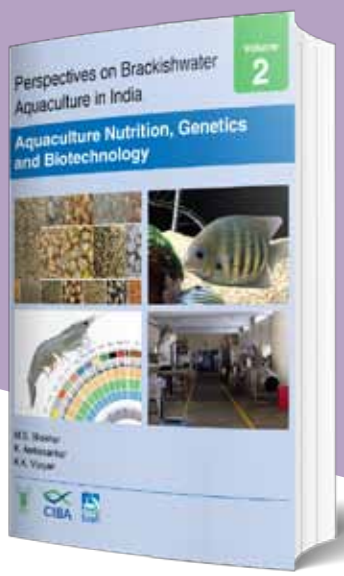

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Parimita, P., Panda, Mallick, B.C., Kumar, P., 2022. Effect of petroleum ether extracted *Moringa oleifera* phytochemicals on the immunological status of *Mystus gulio* fingerlings. 1st Indian Fisheries Outlook 2022 on 'Priming Indian Fisheries in attaining Sustainable Development Goals', 22-24 March, 2022, ICAR-CIFRI, Barrackpore.

Patil, P.A., Hussain, T., Ambasankar, K., Kailasam, M., Mahalakshmi, P., Vijayan, K.K., 2022. Growth performance and feed utilization of grey mullet fingerlings fed with different levels of protein formulated

feed in nursery culture in pond. Souvenir and abstracts of National Symposium on Self-Reliant Coastal Agriculture, 11-13 May, 2022, ICAR-CCARI, Goa.

Patil, P.A., Hussain, T., Kailasam, M., Sairam, C.V., Sivaramakrishnan, T., Ambasankar, K., Vijayan, K.K., Sanaye, S., 2022. Development of low volume low cost cage culture of seabass and pearlspot in creeks as an alternate livelihood activity for mangrove based coastal fisher folks of Maharashtra. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022, Chennai.

Patil, P.A., Patel, K.A., Ambasankar, K., Hussain, T., Kailasam, M., Mahalakshmi, P., Antony, J., Vijayan, K.K., 2022. Effect of feeding different dietary crude protein levels on growth performance of nursery cultured pearlspot fry provided with and without substrates in hapa in pond. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022, Chennai.

Poornima, M., Das, S., Praveena, P.E., Jithendran K.P., 2022. Tilapia tilapinevirus infection: disease of concern in tilapia farming in India, International Conference on 'Responsible Aquaculture and Sustainable Fisheries Interact' (RASHI), organized by: College of Fisheries, CAU (Imphal), Tripura, India College of Fisheries Lembucherra Alumni Association (COFLAA) & North East Society for Fisheries and Aquaculture (NESFA), India during 13-16, December, 2022.

Poornima, M., Otta, S.K., Praveena, P.E., Bhuvaneswari, T., Vidya, R., Biju, I.F., Rajan, J.J.S., Nalayeni, K., Jithendran, K.P., 2022. Report on occurrence of infectious diseases in farmed mud crab in India. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022, Chennai.

Poornima, M., Praveena, P.E., Bhuvaneswari, T., Rajan, J.J.S., Jithendran, K.P., 2022. Viral nervous necrosis: An issue of concern in seabass (*Lates calcarifer*) hatchery production and farming. Hybrid Mode National Symposium on Self-Reliant Coastal Agriculture organized by the ICAR-Central Coastal Agricultural Research Institute, Goa and Association for Coastal Agricultural Research during 11-13 May, 2022.

Praveena, P.E., N.U. Allie, T. Sathish Kumar, T. Bhuvaneswari, S. K. Otta, M. Poornima and K.P. Jithendran, 2022. Pathology of *Enterocytozoon hepatopenaei* and white spot syndrome virus coinfection in *Penaeus vannamei* shrimp. 12th Indian Fisheries and Aquaculture Forum, 5-7th May, 2022, Chennai.

Praveena, P.E., T. Bhuvaneswari, T. Sathish Kumar and K.P. Jithendran, 2022. Sequential pathology of hepatic microspordiasis in *Penaeus vannamei* shrimp. Seventh National Conference on Agricultural Scientific Tamil organized by Madras Veterinary College, Chennai during 2-3rd September, 2022.

Praveena, P.E., T. Sathish Kumar, T. Bhuvaneswari, S. K. Otta, M. Poornima and K.P. Jithendran, 2022. Role of immune genes in hepatic microsporidiosis infection in *Penaeus vannamei* shrimp. IAVP congress held at Dept. of Vet. Pathology, CoVSc., Hyderabad, 17-20 November, 2022

Ragavendran, C., Otta, S.K., Patil, P.K., 2022. Comparative effect of different sanitizers on shrimp white spot syndrome virus (WSSV) inactivation in experimental and simulated field conditions. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022, Chennai.

Raja, R.A., 2022. Parasitic infestations and their eco-friendly control strategies in brackishwater aquaculture. Presented as a resource person to the 'NFDB–PMMSY sponsored National workshop on Capture Fisheries (Biotoxin – Safety Hazards)' during 17-18 March, 2022 held at CAS in Marine Biology, Annamalai University, Parangipettai.

Raja, R.A., Patil, P.K., Avunje, S., Jithendran, K.P., 2022. Emamectin benzoate as an effective anti-parasitic drug in aquaculture under tropical Indian climate – An overview. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022. Chennai.

Raja, R.A., Patil, P.K., Avunje, S., Kumar, T.S., Sivaramakrishnan, T., Jithendran, K.P., 2022. Biosafety, withdrawal, environmental safety of an anti-parasitic drug, emamectin benzoate in Asian Seabass (*Lates calcarifer*) under tropical Indian climate and its efficacy against fish louse, *Argulus quadristriatus*. International Veterinary Pathology Congress–2022 at the Department of Veterinary Pathology, College of Veterinary Science (C.V.Sc.), Rajendranagar, P.V. Narasimha Rao Telengana Veterinary University, Hyderabad during 17-20th November, 2022.

Rajesh, R., Saraswathy, R., Patil, P.K., Kumararaja, P., Avunje, S., Gopinath, D., 2022. Degradation of emamectin benzoate in pond water under tropical

condition. 12th Indian Fisheries and Aquaculture Forum, 5-7 May 2022, Chennai.

Ramya, M., Poornima, M., 2022. Aqua tourism: Aqua parks and note on bait fishing stress relief activity. Online global hospitality and tourism conference on contemporary marketing paradigms (GHTC-2022) during 27-29 July, 2022.

Revi, A., Gopinath, D., Sandeep, K.P., Sukumaran, S., Kumararaja, P., Saraswathy, R., Dayal, J.S., Nagavel, A., Muralidhar, M., 2022. Effect of stocking density on dynamics of carbon fractions in Vannamei culture. 12th Indian Fisheries and Aquaculture Forum, 5-7 May 2022, Chennai.

Sandeep, K.P., De, D., Sivaramakrishnan, T., Mahalakshmi, P., Ambasankar, K., 2022. Effect of fish waste hydrolysate as plankton booster in the growth of Indian white shrimp, *Penaeus indicus*. 1st Indian Fisheries Outlook 2022 on 'Priming Indian Fisheries in Attaining Sustainable Development Goals'. ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata.

Saravanan, P., Bala Amarnath, C., Praveena, P.E., Bhuvaneswari, T., Poornima, M., Jithendran, K.P., Otta, S.K., 2022. Characterization of Inhibitor of Apoptosis (IAP) gene in *Penaeus monodon* by 2-D gel electrophoresis analysis. 12th Indian Fisheries and Aquaculture Forum, 5-7 May 2022, Chennai.

Sivaramakrishnan, T., Ambasankar, K., Felix, N., Sandeep, K.P., Bera, A., Kailasam, M., Vijayan, K.K., 2022. Effect of dietary soy lecithin inclusion levels on growth, feed utilisation, fatty acid profile, deformity and survival of milkfish (*Chanos chanos*). 1st Indian Fisheries Outlook 2022 on 'Priming Indian Fisheries in attaining Sustainable Development Goals', March 22-24, 2022, at ICAR-CIFRI, Barrackpore, Kolkata.

Sivaramakrishnan, T., Ambasankar, K., Sathish kumar, T., Sandeep, K.P., Bera, A., Raja, R.A., Suresh, E., M. Kailasam, M. and Felix, N. 2022. Effect of dietary vitamin E supplementation on growth, fatty acid composition, intestinal histology and haemato-immune indices of milkfish, *Chanos chanos* larvae. Indian Fisheries and Aquaculture Forum, 5-7 May, Chennai.

Sravanthi, O., Dayal, J.S., Muralidhar, M., 2022. Effect of dietary lipid level on growth performance in tiger shrimp, *Penaeus monodon* reared at three different water salinities. 12th Indian Fisheries and Aquaculture Forum, 5-7 May 2022, Chennai.

Subburaj, R., Kailasam, M., Thiagarajan, G., Venu, S., Madhavi, M., Sukumaran, K., Kumar, P., 2022. Amino acid and fatty acid profiles of spontaneous and induced spawn eggs of Asian seabass *Lates calcarifer* as a tool for egg quality. 12th Indian Fisheries and Aquaculture Forum 5-7 May, 2022, Chennai.

Subburaj, R., Kailasam, M., Vasagam, K.P.K., Sukumaran, K., Biswas, G., Kumar, P., Bera, A., Thiagarajan, G., 2022. Value chain analysis of Asian seabass *Lates calcarifer* seed production and marketing. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022, Chennai.

Sudheer, N.S., Balasubramanian, C.P., Kannappan, S., Biju, I.F., Aravind, R., Anand, P.S.S., Panigrahi, A., Jayanthi, M., Jithendran, K.P., 2022. Optimization of rearing protocol and reproductive characteristics of brackishwater polychaete *Namalycastis abiuma*. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022, Chennai.

Vinay, T.N., Patil, P.K., Avunje, S., Panigrahi, A., Jayanthi, M., 2022. Role of gut microbiota in health and production of Indian white shrimp, *Penaeus indicus*. 12th Indian Fisheries and Aquaculture Forum, 5-7 May, 2022, Chennai.

Participation in Conferences, Meetings, Workshops and Symposia

Dr. K.P. Jithendran, Director (Acting) (1st January – 27th October 2022)

NATIONAL

- Meeting to discuss on budget allocations (RE 2021-22 and BE 2022-23) with Fisheries Institutes, convened by Deputy Director General (Fy.), ICAR at SMD (Fisheries), ICAR, New Delhi held on 6th January 2022
- Meeting to discuss on EFC/ SFC with Fisheries Institutes, convened by Deputy Director General (Fy.), ICAR at SMD (Fisheries) ICAR, New Delhi held on 13th January 2022
- Meeting to discuss about the Technical cadre with Fisheries Institutes, convened by Deputy Director General (Fy.), ICAR at SMD (Fisheries) ICAR, New Delhi held on 22nd January 2022
- Meeting to discuss on the virtual audit of India's shrimp disease control system, by the Department of Fisheries, Thailand, convened by Dr. M. Kathikeyan, Director, MPEDA at Kochi held on 31st January 2022
- Meeting related to the presentation on Agricultural Research Management System (ARMS), chaired by Secretary, DARE and Director General, ICAR at New Delhi held on 2nd February 2022
- EFC Meeting for continuation of DARE/ICAR Central Sector Scheme "Fisheries and Aquaculture for Sustainable Development" under the chairmanship of Secretary, DARE and Director General, ICAR at New Delhi held on 2nd February 2022
- FAO Webinar to discuss on the comprehensive document on inland fisheries resources of India, for inputs and improvement of the contents at CIFRI, Barrackpore held on 8th February 2022
- Consultation on the Indian Fisheries Vision@2047 organized under the Chairmanship of Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying at New Delhi held on 8th February 2022
- Meeting related to the presentation on Agricultural Research Management System (ARMS), chaired by Secretary, DARE and Director General, ICAR at SMD (Fisheries) ICAR, New Delhi held on 9th February 2022
- First Meeting of the Technical Advisory Committee constituted for the GNF-BMZ Project "Building a transnational, civil society partnership to increase the resilience of coastal population in South Asia", organized by Centre for Research on New International Economic Order (CReNIEO) at Chennai on 14th February 2022
- Meeting of Group on "National Accounting Framework for Blue Economy", under the Chairmanship of Secretary (Statistics & PI) to discuss issues relating to developing a framework for estimating economic contributions of Blue Economy organized by National Statistical Office (NSO), Ministry of Statistics and Programme Implementation at New Delhi held on 22nd February 2022
- Webinar on "SMART (Sustainable, Modern/Mechanized, Atma Nirbar, Resilient & Tech. driven) Agriculture, to discuss focused implementation of Budget Announcement 2022 organized by ICAR on 24th February 2022
- Meeting with ICAR Fisheries Institutes convened by DDG (Fy.), ICAR at SMD (Fisheries) on 2nd March 2022
- Senior Officers Meeting of ICAR Institutes to discuss on budget utilization and related issues, convened by Secretary, DARE and Director General, ICAR, at New Delhi held on 7th March 2022
- Sixty Ninth meeting of the Coastal Aquaculture Authority at Chennai held on 14th March 2022
- Meeting with ICAR Institutes to discuss on budget utilization and related issues, convened by Director (Finance), ICAR at New Delhi held on 16th March 2022
- Virtual Project Meeting of Indo-UK Collaborative Project "Diversification of potential

crop species in brackishwater aquaculture, adaptation for climate resilience" at CIBA, Chennai during 22-23 March 2022

- Science Leaders Conference organized by Vigyan Bharati and Ministry of Science and Technology (DSIR/CSIR/DST and DBT) organized at CSIR-Indian Institute of Chemical Technology (IICT) Hyderabad held during 26-27 March 2022
- Meeting on budget and expenditure review for 2021-22, chaired by the Director General, ICAR at New Delhi held on 29 March 2022
- 22nd Meeting of the Technical Committee to oversee and monitor the functioning of Aquatic Quarantine Facility under the chairmanship of Member Secretary, CAA, on virtual mode at Chennai held on 5th April 2022
- Annual ICAR Directors Conference organized at C. Subramaniam Auditorium, NASC, ICAR, New Delhi held on 13th April 2022
- 67th Executive Committee Meeting of Rajiv Gandhi Centre for Aquaculture organized at MPEDA, Kochi held on 22nd April 2022 12th Indian Fisheries and Aquaculture Forum organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Ponneri organized at IMAGE, Chennai held during 5-7 May 2022
- National Symposium on "Self-reliant Coastal Agriculture", organized by ICAR-Central Coastal Agricultural Research Institute, Goa held on 11 May 2022
- Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.), ICAR organized by SMD (Fisheries) ICAR, New Delhi held on 17th May 2022 on virtual mode
- Joint Program of ICAR-National Bureau of Fish Genetic Resources, Lucknow and VGP Marine Kingdom, Chennai, to monetize indigenous marine ornamental organisms, captive bred and reared by the native woken of Lakshadweep at VGP Marine Kingdom, Chennai, held on 20th May 2022
- Meeting with Director General, ICAR with regard to the Farmers Meet organized in connection with the Prime Minister's Garib Kalyan Sammelan on 31st May 2022, on virtual mode at ICAR, New Delhi held on 23rd May 2022
- 7th Meeting of the Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY), on virtual mode at Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi held on 26th May 2022
- 70th Meeting of Coastal Aquaculture Authority on virtual mode at CAA, Chennai held on 3rd June 2022
- Consultative workshop on "Way Forward for Enhancement of Seafood Exports from India" jointly organized by MPEDA & CAA and supported by NFDB at Hotel Rain Tree, St. Mary's Road, Chennai held on 17th June 2022
- Meeting pertaining to procurement through GeM, under the Chairmanship of Secretary, ICAR, on virtual mode held on 12th July 2022
- Meeting of the Expert Committee to assess the situation of AHPND in the affected countries and possible risks in importing shrimp broodstock in the present situation and suggest measures to be adopted of lifting the existing ban in India, organized by Coastal Aquaculture Authority (CAA), on virtual mode at CAA, Chennai held on 13th July 2022
- Joint Inspection of the Board of Directors of TNFDC Ltd. of the Commercial cum office space in the Additional Administrative building situated at Santhome, Chennai, as Member of Board of Director at TNFDC Ltd. Santhome Chennai held on 14th July 2022
- Meeting of Review Committee of Group-A officials of ICAR-CIBA to ensure probity among government servants under FR 56(J) at SMD (Fisheries) ICAR, New Delhi held on 15th July 2022
- 94th Foundation Day and Award Ceremony of ICAR at A.P. Shinde Hall, NASC Complex, Pusa, New Delhi held on 16th July 2022
- Meeting of the Expert Committee constituted to draft the Coastal Aquaculture Authority (Amendment Bill) on virtual mode held on 22nd July 2022
- Meeting with regard to EFC Discussions pertaining to Fisheries Division to Financial Advisor, ICAR, convened by DDG (Fy.), ICAR, New Delhi at SMD (Fisheries) ICAR, New Delhi held on 10 August 2022
- Attended the International brainstorming workshop on "Regulating the use of chemicals and veterinary medicine products (VMPs) in Indian aquaculture" organized by ICAR-CIBA at NAAS complex, New Delhi during 25-26 August 2022

- Meeting to discuss regarding the Presentation on Institutional Performance (Fisheries Institutes) to the Hon'ble Agriculture Minister at SMD (Fisheries) ICAR, New Delhi held on 1st September 2022
- 1st Audit Committee Meeting of Tamil Nadu Fisheries Development Corporation Limited, Chennai on Virtual Mode held on 7 September 2022

  9th Annual General Meeting of SCAFi at CIBA, Chennai held on 14th September 2022
- Discussion on framework for development and management of shrimp aquaculture in brackishwater/ saline water in Inland area, under the co-chairmanship of Joint Secretary (Marine Fisheries) and Joint Secretary (Inland Fisheries), MFAHD, Govt. of India at Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, New Delhi held on 19th September 2022
- Monthly Meeting of Fisheries SMD & Directors of Institutes, convened by DDG (Fy.), ICAR, on virtual mode at SMD (Fisheries) ICAR, New Delhi held on 21st September 2022
- 71st Meeting of Coastal Aquaculture Authority at CAA, Chennai held on 22nd September 2022
- Meeting of the Special Campaign 2.0 for disposal of Pending Matters during 2nd October to 31st October, 2022 at ICAR, New Delhi held on 26th September 2022
- International Conference – Seaweed India 2022, jointly organized by Smart Agri-Post and BOBP at Delta Auditorium NCSCM, Chennai held on 28th September 2022

Dr. Kuldeep Kumar Lal, Director, (28 October 2022 – 31 December 2022)

- Presentation by Director General, ICAR on "Revitalizing ICAR: Aspiration and Action Plan" on virtual Mode at ICAR, New Delhi held on 11th November 2022
- Presentation by Deputy Director General (Crop Science) on activities and aspirations of ICAR on virtual Mode at ICAR, New Delhi held on 14th November 2022
- 8th Global Conference on Gender in Aquaculture and Fisheries (GAF8) jointly organized by Central Institute of Fisheries Technology, Kochi and Society of Fisheries Technologists (India) and Gender in Aquaculture Fisheries Section of the Asian Fisheries Society at Bhaskareeyam Convention Centre, Elamakkara, Kochi held on 20th -22nd November 2022
- Presentation by Deputy Director General (Animal Science) on activities and aspirations of ICAR on virtual Mode at ICAR, New Delhi held on 22nd November 2022
- Presentation by Deputy Director General (Education) on activities and aspirations of ICAR on virtual Mode at ICAR, New Delhi held on 25th November 2022
- Meeting to discuss and finalize the SFC document, convened by DDG (Fy.), ICAR at SMD (Fisheries), ICAR held on 25th November 2022
- Meeting to discuss the comments on SFC document convened by CMFRI, on virtual mode at CMFRI, Kochi held on 27th November 2022
- Seventy Second Meeting of the Coastal Aquaculture Authority (CAA) on virtual mode at CAA, Chennai held on 2nd December 2022
- Brackishwater Aquaculture Farmer's Meet and Harvest Mela organized on the occasion of the celebration of World Soil Day at Kakdwip Research Centre of CIBA, Kakdwip held on 5th December 2022
- International Conference on "Responsible Aquaculture and Sustainable Fisheries Interact (RASHI)" jointly organized by College of Fisheries, Central Agricultural University, Tripura, North East Society for Fisheries and Aquaculture (NESFA), India and College of Fisheries Lembucherra, Alumni Association (COFLAA) at CoF, Tripura held on 13th-14th December 2022
- Presentation by Deputy Director General (Education) to Celebrate International Year of Millets 2023, chaired by the Secretary, DARE and Director General, on virtual mode at ICAR, New Delhi held on 15th December 2022

SCIENTISTS

- Regional Capacity Building Programme on Aquatic Animal Diseases organized by ICAR-NBFGR and APAARI during 4-12 January, 2022- **Dr. S.K. Otta**
- Virtual meeting under Chairmanship of Joint Secretary (Marine Fisheries), DoF regarding infection of Mud Crab with Mud Crab Reovirus (MCRV) reported from Tamil Nadu, Andhra Pradesh and Odisha

and other diseases reported under National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) held on 13 January 2022 - **Dr. M. Poornima, Dr. S.K. Otta**

- Webinar on 'Bridging the gap between academic research and industry conducted' by ICAR-National Institute of High Security Animal Diseases (ICAR-NIHSAD), Bhopal on 14 January, 2022 – **Dr. M. Poornima**
- Webinar on Carbon finance for agriculture towards Climate Risk Mitigation organised by National Institute of Agricultural Extension Management (MANAGE), Hyderabad on 20th January 2022 – **Dr. M. Muralidhar**
- Attended workshop on "Climate resilient -farming in the salt affected lowlands of Sundarbans" organized by South Asian Forum for Environment (SAFE) at ICAR-CSSRI, RRS, Canning Town on 21st January, 2022.- **Dr. Debasis De**
- Attended NASF Empowered committee meeting for hilsa project on 01.02.2022- **Dr. Debasis De**
- Virtual audit meeting of Thailand on import ban due to IMNV organised by MPEDA held on 11 February 2022-**Dr. S.K. Otta**
- International webinar on Applications of Bioinformatics in Biotechnology Studies conducted by LLB-School, Chennai and NyBerMan Bioinformatique d'Europe on 11 February 2022 – **Dr. M. Poornima**
- Virtual audit meeting of Thailand Govt. in lifting ban due to IMNV in India – coordinated by MPEDA during 14–17, February 2022- **Dr. S.K. Otta**
- Webinar on "National Surveillance Programme for Aquatic Animal Diseases: A Step towards Establishing Disease Governance System in India" NBFGR, Lucknow, 15 February 2022– **Dr. S.K. Otta**
- 32nd virtual meeting of the National Committee on Introduction of Exotic Aquatic Species into Indian Waters by Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India - 16 February 2022- **Dr. S.K. Otta**
- BIS organized an awareness and implementation webinar on 'Indian Standards on Aqua feed' on 17th February 2022. More than 100 participants from industry and government fishery departments attended the awareness program - **Dr. K. Ambasankar**
- UK-India Aquaculture Innovation club – 18 February 2022- **Dr. S.K. Otta**
- DST Sponsored online training programme for women scientists on Community Resource Management from 21-25 February 2022 organised by Indian Institute of Forest Management, Bhopal - **Dr. Deboral Vimala**
- 2nd IAEC meeting as a Main Nominee of CCSEA on 23rd February, 2022 at BCG Vaccine Laboratory (BCGVL), Guindy, Chennai, Tamil Nadu.- **Dr. R. Ananda Raja**
- Webinar on 'Strengthening Science-Policy interface for sustainable future' conducted by ICAR-NRCE, Hisar on 28th February, 2022- **Dr. M. Poornima**
- 'NFDB–PMMSY sponsored National workshop on Capture Fisheries (Biotoxin-Safety Hazards)' during 17-18th March, 2022 held at CAS in Marine Biology, Annamalai University, Parangipettai as a resource person.- **Dr. R. Ananda Raja**
- Community Development related programme organized by NEWS at Pachim Dwarikapur, Pathar Pratima as Chef guest on 22nd March, 2022- **Dr. Debasis De**
- Virtual workshop on 'Diversifying crustacean culture-developing future climate resilience' including presentations and panel discussion jointly organized by ICAR-CIBA, India, University of Southampton, UK and Pirbright Institute, UK during 22-23 March, 2022- **Dr. M. Poornima, Dr. Debasis De, Dr. S.K. Otta**
- Presented a paper entitled "Effect of Fish Waste Hydrolysate as plankton booster in the growth of Indian white shrimp, *Penaeus indicus*" in the 1st Indian Fisheries Outlook 2022 (IFO-2022) organized at ICAR-CIFRI, Barrackpore from 22-24th March 2022. – **Shri. K.P. Sandeep**
- 1st Indian Fishereis Outlook 2022 (IFO22) on Priming Indian Fisheries in attaining sustainable develipmet goals' organized by ICAR-CIFRI, Barackpore, during 22-24 March, 2022- **Mr. T. Sathish Kumar, Dr. J. Raymond Jani Angel**
- 30th Academic Council Meeting of KUFOS, Kerala held on 25 March 2022 - **Dr. S.K. Otta**
- Advisory committee meeting of NASF project "Captive breeding of Hilsa , *Tenualosa ilisha*-Phase II" on 26-27 April, 2022 at CIFRI,

Barrackpore- **Dr. Debasis De, Dr. T.K. Ghoshal**

- 12th Indian Fisheries & Aquaculture Forum organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TNJFU) & Asian Fisheries Society Indian Branch (AFSIB) during 5-7 May, 2022- **Dr. M. Muralidhar, Dr. M.S. Shekhar, Dr. K. Ambasankar, Dr. Satheesha Avunje, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. P. Ezhil Praveena, Dr. M. Poornima, Mr. T. Sathish Kumar, Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. P. Nila Rekha, Dr. S. Kannappan, Dr. A. Panigrahi, Dr. Shyne Anand, Dr. T.N. Vinay, Dr. N.S. Sudheer, Dr. S.K. Otta, Dr. Sujeet Kumar, Dr. Vidya Rajendran, Dr. Debasis De, Shri. T. Sivaramakrishnan, Mr. Jose Antony, Mr. R. Aravind, Mr. I. F. Biju, Dr. Sherly Tomy, Shri J. Ashok Kumar, Dr. Vinaya K.K., Dr. Sivamani B., Dr. J. Raymond Jani Angel, Dr. K.P. Jithendran**

- Presented a paper entitled 'Enhancing the growth of *Etroplus suratensis* using fish waste hydrolysate as plankton booster in outdoor tank systems" in the 12th Indian Fisheries & Aquaculture Forum organized by Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TNJFU) & Asian Fisheries Society Indian Branch (AFSIB) during 5-7 May 2022.- **Dr. K.P. Sandeep**

- Participated and presented an abstract titled "Effect of different diet on growth, survival and molting pattern of mud crab Scylla serrata" in the 12th Indian Fisheries and Aquaculture Forum jointly organized by Asian Fisheries Society Indian Branch and Tamil Nadu Dr. J. Jayalalitha Fisheries University held during 5-7th May 2022 at Chennai.- **Shri. I.F. Biju**

- Attended & presented an abstract on "Effect of sex ratio on successful captive breeding of estuarine goby fish knight goby (*Stigmatogobius sadanundio*)" in the 12th Indian Fisheries and Aquaculture Forum jointly organized by Asian Fisheries Society Indian Branch and Tamil Nadu Dr. J. Jayalalitha Fisheries University held during 5-7th May 2022 at Chennai.- **Ms. Babita Mandal**

- Stakeholder's consultation workshop & NAC-CSA Meeting – Study on Climate Smart Aquaculture organised by Technology Information, Forecasting & Assessment Council (TIFAC) in association with National Academy of Agricultural Scientists at New Delhi on 11th May 2022 - **Dr. M. Muralidhar**

- National Symposium on 'Self-Reliant Coastal Agriculture' organsied by CCARI, Goa during May 11-13, 2022 - **Dr. M. Poornima, Dr. Sujeet Kumar**

- Understanding virulence and siderophore system of luminescent bacterial pathogen *Vibrio campbellii* National Symposium on 'Self-Reliant Coastal Agriculture' May 11-13, 2022 at CCARI, Goa - **Dr. Sujeet Kumar, Dr. Vidya Rajendran, Dr. P.S. Shyne Anand, Dr. K.P. Jithendran**

- Virtual workshop on trademark search for start-ups and MSMEs by ASSOCHAM, India on 12 May, 2022- **Dr. M. Poornima**

- Consultation meeting by DBT for call on proposal in the area of Aquaculture and Marine Biotechnology on 17 May 2022 – **Dr. M.S. Shekhar, Dr. J. Raymond Jani Angel**

- Inspection of Second Sub-Committee of the Committee of Parliament on Official Language at Taj Coromandel Hotel, Chennai held on 18 May 2022 – **Dr. M.S. Shekhar Dr. J. Raymond Jani Angel, Dr. Sujeet Kumar**

- Attended & presented an abstract on "Effect of oocyte diameter on spawning and influence of stocking density on the juvenile production of spotted scat (*Scatophagus argus*)" in National seminar on Contemporary issues in Fisheries and Aquaculture organized by College of Fisheries, G. B. Pant University of Agriculture & Technology, Pantnagar held during 19–20 May, 2022 at Pantnagar, Uttarakhand - **Ms. Babita Mandal**

- Online National Conference on the protection of Traditional knowledge, Geographical indications and rights in indigenous people organised by CERIP and the DPIIT-IPR chair of National Law University and Judicial Academy, Assam on 27-28 May 2022. **Dr. S. Kannappan**

- 13th Asian Fisheries and Aquaculture Forum, held at Tainan, from 31st May to 2nd June 2022 (Online). **Dr. S. Kannappan**

- Attended Farmers Interaction Meet (Garib Kalyan Sammelan) addressed by Hon'ble Prime Minister of India at Indoor Stadium, Eastern Railways, Kolkata on 31.05.2022- **Dr. T.K. Ghoshal**

- International Webinar on 'Viral Diseases of Aquatic animals' organized by Fish Health Section of the Asian Fisheries Society held on 1 June, 2022- **Dr. M. Poornima, Dr. R. Ananda Raja**
- Attended virtual meeting of 3rd Livelihood Working Group of SAIME project Organized by Nature Environment Wildlife Society (NEWS) on 01 June 2022- **Dr. Debasis De**
- International workshop on Healthy Shrimps in India on 10.6.2022 – **Dr. M.S. Shekhar**
- Awareness Programme on Efficient and balanced use of fertilisers (including Nano-Fertilisers) on 21 June 2022 in association with Krishi Vigyan Kendra (KVK), Kattupakkam, Tamil Nadu – **Dr. R. Saraswathy**
- Attended workshop and acted as panellist in Brackishwater Aquaculture products section of the workshop " Where Business meets Biodiversity: Scope & Challenges in Indian Sundarban in the context of Global Biodiversity Framework 2030-2050" Organized by Nature Environment Wildlife Society (NEWS) at Taj Bengal, Kolkata on 21 June 2022- **Dr. Debasis De**
- Aqua India 2022, the biennial premier aquaculture event organised by Society of Aquaculture Professionals during 23-25 June 2022 at Chennai - **Dr. M. Muralidhar**
- Online IP Awareness/Training program under the special mission called "National Intellectual Property Awareness Mission (NIPAM) organized by Office of Controller General of Patents, Designs and Trade Marks, Intellectual Property Office, India on 12 July, 2022 - **Dr. M. Poornima**
- 34th National Committee Meeting on Exotic Species – Department of Fisheries, Govt. of India held on 14 July 2022- **Dr. S.K. Otta**
- 94th ICAR foundation day and award ceremony at NASC complex, Delhi held on 16 July 2022– **Dr. Sujeet Kumar**
- Attended the 15th meeting of FAD 12 on Tuesday, 19 July 2022 at Manak Bhawan, BIS Headquarters, New Delhi.- **Dr. K. Ambasankar**
- Participated in the international conference on 'Harnessing Indian Agriculture for Indigenous and Global at NASC Complex, Pusa, New Delhi during 22-23 July, 2022 coordinated by the Division of Agricultural Extension, ICAR - **Dr. M. Kumaran**
- National webinar is scheduled on Non-conventional aquaculture systems ICAR- Central Marine Fisheries Research Institute (CMFRI) jointly with seven ICAR Fisheries Research Institutes (CIFE, CIFRI, CIFT, CIFA, CIBA, and NBFGR & DCFR) on 27 July, 2022- **Dr. M. Poornima**
- Second meeting of the Expert Committee to examine relevant aspects of the issue and make recommendation the import of shrimp broodstock from AHPND/EMS affected countries held on 23 August 2022- **Dr. S.K. Otta**
- Advances in Agriculture and Food System towards Sustainable Development Goals (AAFS2022), 22-24 August, 2022, University of Agricultural Sciences, Bangalore. – **Dr. M.S. Shekhar**
- Training Workshop for Vigilance Officers of ICAR Institutes organised by ICAR-NAARM, Hyderabad during 24-26 August 2022 - **Dr. M. Muralidhar**
- International brainstorming workshop on "Regulating the use of chemicals and veterinary medicine products (VMPs) in Indian aquaculture" organized by ICAR-CIBA at NAAS complex, New Delhi during 25-26 August 2022– **Dr. P.K. Patil, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. S.K. Otta, Dr. R. Saraswathy, Dr. Satheesha Avunje**
- Seventh National Agricultural Science Tamil Research Conference' organsied by Madras Veterinary College, Chennai during 2-3 September 2022 - **Dr. Deboral Vimala, Dr. R. Ananda Raja, Dr. P. Ezhil Praveena, Mr. T. Sathish Kumar, Dr. B. Sivamani**
- 35th National Committee Meeting on Exotic Species – Department of Fisheries, Govt. of India held on 5 September 2022- **Dr. S.K. Otta**
- Attended the 6th Meeting of the Fish, Fisheries & Aquaculture Sectional Committee, FAD 12 held on Monday, 05 September 2022 virtually - **Dr. K. Ambasankar**
- Review Meeting on the progress under Simulation Modelling Theme under NICRA Project at CSSRI, Karnal during 14-15 September, 2022 - **Dr. M. Muralidhar**
- Attended National Training

Workshop on "Quantitative Techniques in Assessing the Impacts of Climate Change in Agriculture" at TNAU, Coimbatore during 21-23 September, 2022 - **Dr. R. Geetha**

- National Conference on Sustainable Aquaculture for Atmanirbhar Bharat (Hindi) organised by ICAR-CIFA during 23-24 September, 2022 - **Dr. Sujeet Kumar.**
- Attended meeting of project members of DBT sponsored project on "Establishment of Bioresource complex at Ramanathapuram at VIT University, Vellore on 28 September, 2022 - **Dr. Debasis De**
- Consultation on LCA for crop production India under NICRA Project at MSSRF on 6 October, 2022 - **Dr. M. Muralidhar**
- Participated and presented a lead paper on "Smart shrimp aquaculture using mobile applications-An innovative approach" @ National Workshop on 'Shrimp farming: made better for the future', FCRI, Thalainayeru, TNJFU, Nagapattinam, Tamil Nadu, held on 7 October, 2022 (*Chola Aqua-2022*) - **Dr. M. Kumaran**
- Acted as External Member for Evaluation Committee of dissertations of PG Diploma programme at ICAR – CIFE, Kolkata Centre on 28 October 2022 - **Dr. T.K. Ghoshal**
- 36th National Committee Meeting on Exotic Species – Department of Fisheries, Govt. of India held on 2 November, 2022 - **Dr. S.K. Otta**
- 31st National congress of parasitology on global technological advancements in the diagnosis and sustainable control of parasitic diseases' organized by The Indian Society for Parasitology in collaboration with Directorate of Centre for Animal Health Studies, Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) and at Madras Veterinary College (MVC) during 10-12 November, 2022 - **Dr. R. Ananda Raja**
- International Veterinary Pathology Congress 2022 and 20th Electron Microscopy (TEM & SEM) workshop organized by Dept. of Veterinary Pathology, CoVSc., PVNRTVU, Hyderabad, during 17-20 November, 2022 - **Dr. R. Anandaraja, Dr. P. Ezhil Praveena**
- International seminar on 'Intervention for control of AMR: harnessing one health knowledge' and GAF8-The 8th Global Conference on Gender in Aquaculture and Fisheries on "Shaping the Future: Gender in Aquaculture and Fisheries at Kochi, Kerala during 21-23 November, 2022, India - **Dr. Sanjoy Das, Dr. T. Bhuvaneswari**
- Consultation meeting organized by Azim Premji Foundation (APF) with Civil Society Organizations/ NGOs and other stakeholders on Fisheries intervention in West Bengal with special reference to Sundarbans, West Bengal at Wipro Campus , Bidhan Nagar , Kolkata on 25 November, 2022- **Dr. T.K. Ghoshal**
- Presented a motivational speech to the employees of Chennai Petroleum Corporation Limited (CPCL), Chennai, on the topic "Entrepreneur skill in business" on 5th December, 2022 at CPCL office - **Dr. B. Shanthi**
- 5th Annual Review Meeting of Indian Network for Fisheries and Animals Antimicrobial Resistance (INFAAR), Kolkata, 6th December, 2022 - **Dr. T. Bhuvaneswari**
- Online International Conference on 'Responsible Aquaculture and Sustainable fisheries Interact (RASHI)' organized by College of Fisheries, Lembucherra, Tripura, 13-16 December, 2022 - **Dr. M. Poornima, Dr. S. Kannappan, Dr. T. Bhuvaneswari, Shri. I.F. Biju, Dr. B. Sivamani**
- Meeting convened by CAA regarding EHP positivity in imported broodstocks– 29 December, 2022 - **Dr. S. K. Otta**

INVITED LECTURES

- Delivered an Invited talk Health Management of Fishes and Shrimps in Aquaculture in general at Faculty of Fisheries Sciences, WB University of Animal & Fishery Sciences, Kolkata during a NFDB/MANAGE sponsored training on Pond management (Pre-stocking, Stocking and Post-stocking) on 4 January, 2022 – **Dr. Sanjoy Das.**
- Delivered an invited talk on 'Alternative Sustainable Livelihood Models for Coastal Communities' in the training programme on 'Fisheries Technologies for Alternative Livelihoods' organized by Gurunanak college (Autonomous) and G.N Centre for Research at Chennai on 12 January, 2022 - **Dr. Deboral Vimala**
- Invited talk entitled 'Genomics of Crustaceans and a case

study: *Penaeus indicus*' in a capacity building program "Virtual Regional Capacity Building Program on Application of Biotechnological Tools for Management of Aquatic Genetic Resource Management and Ex situ Conservation" organized by NBFGR, Lucknow, on 18 January, 2022 – **Dr. M.S. Shekhar**

- Delivered a lecture on 'Precision aquaculture – Disease diagnosis and health management' in ATAL FDP training program on 'Precision Agriculture and Nanotechnology: Making Agriculture Future Ready' organized by the Noida Institute of Engineering & Technology, Greater Noida during 20-24 January, 2022- **Dr. R. Anandaraja**

- Delivered a lecture on "Opportunity and livelihood options in Coastal Aquaculture", in national webinar conducted by MANAGE, Hyderabad, on 28 January, 2022. **Dr. A. Panigrahi**

- Delivered an invited talk on 'Nanotechnology based applications in Brackishwater Aquaculture' in Two day symposium on Nanotechnology Revolution organised online during 3-4 February, 2022 by Manipal Institute of Technology Bengaluru, India - **Dr. M. Poornima**

- Delivered a lecture on Biofloc Microbiome in the conference on 1st Indian Fisheries Outlook 2022: *Priming Indian Fisheries in Attaining Sustainable Development Goals*, at Barrackpore, Kolkata, 23rd March, 2022. **Dr. A. Panigrahi**

- Delivered an invited key note lecture on "Recent Developments and Aquapreneurship Opportunities in Brackishwater Aquaculture" in the National Conference on Recent trends and future aspects of Livestock production & Entrepreneurship on 1-2 April, 2022 organized by the Department of AgroSciences, Uttaranchal P.G. College of Biomedical Sciences & Hospital, Dehradun- **Dr. K. Ambasankar**

- Delivered lecture on "Shrimp Seed Quality & Role of Broodstock" organized by Aqua International, Update Knowledge on Aquaculture and AI Awards 2022 on 6 April, 2022 at Chennai - **Dr. A. Panigrahi**

- Delivered an invited lecture on "Impact of climate change on Aquaculture: Adaptation strategies in the session IV: Impact of climate change on aquaculture, Poultry and animal food resources" in the National virtual Seminar on Climate Change Concerns: Challenges for Agriculture Sector and Food Nutrition Security organised by ICAR-Indian Institute of Millets Research and Karnataka Agri-Professional Association during 14-15 May, 2022 - **Dr. M. Muralidhar**

- Delivered lead lecture on Brackishwater Aquaculture opportunities and challenges in Sundarban and acted as panelist in Brackishwater Aquaculture products section of the Workshop "Where Business meets Biodiversity: Scope & Challenges in Indian Sundarban in the context of Global Biodiversity Framework 2030-2050" organized by Nature Environment Wildlife Society (NEWS) at Taj Bengal, Kolkata on 21 June, 2022 - **Dr. Debasis De**

- Delivered lecture in National webinar on "Technological interventions for sustainable aquaculture" at School of Fisheries, Centurion University of Technology and Management, Odisha on 29th June, 2022. **Dr. A. Panigrahi**

- Delivered an Invited expert lecture on 'Water and Soil quality management' in the training program on 'Better Management Practices in *Penaeus vannamei* farming' organised by AU-Avanti Aquaculture Skill Development Centre, Visakhapatnam during 9 – 11 July, 2022- **Dr. M. Muralidhar**

- Invited as a Special Guest for the inaugural function of the training program and delivered an lecture on 'Water and Soil quality management' in the 'Hands on training on water & soil analysis and disease management' organised by AU-Avanti Aquaculture Skill Development Centre, Visakhapatnam during 6-15 September, 2022 - **Dr. M. Muralidhar**

- Delivered a lead lecture entitled " Recent developments in Aquaculture with emphasis on Fish as a Healthy food" in the National seminar on "Recent Biotechnological Advances in Health and Management Practices to Augment Productivity of Livestock and Poultry" during 22-24 September, 2022, organized by SVSBT at Veterinary College and Research Institute, Tirunelveli, Tamil Nadu- **Dr. K. Ambasankar**

- Delivered lecture on 'Viral diseases of shrimp' and 'Histopathology' in the skill development program by AU-Avanti Aquaculture Skill Development Centre,

Vishakhapatnam, Andhra Pradesh on 18 October, 2022 - **Dr. R. Anandaraja**

- Guest lecture delivered on topic of "Lipids and fatty acids in fish nutrition: Basic and recent trends" to Bachelor of Fisheries Science students at TNJFU-Dr. MGR Fisheries College and Research Institute, Thalainayeru on 18 October, 2022- **Shri. T. Sivaramakrishnan**

- Delivered a talk in Tamil to the aquaculture farmers on shrimp culture with CAA regulations with PMMSY details at KVK Kattupakkam on 21 October, 2022. **Dr. S. Kannappan**

- Delivered lecture on 'Diseases of shrimp', 'Hematology' and 'Histopathology' in the skill development program by AU-Avanti Aquaculture Skill Development Centre, Vishakhapatnam, Andhra Pradesh on 31 October and 1st November, 2022. - **Dr. R. Anandaraja**

- Delivered an invited lead lecture entitled "Entrepreneurial Opportunities in Aquaculture with special focus on Nutrition and Feed technology" in the International Conference of Animal Nutrition Society of India held during November 16-18, 2022 at Ludhiana - **Dr. K. Ambasankar**

- Delivered a lead lecture as a 'Key Speaker' in the National Workshop PONSHRIMP' 22 conducted by FCRI, Ponneri with the theme "Shrimp Culture towards Reassuring Environment and Nutrition Sustainability on 30 November, 2022- **Dr. K. Ambasankar**

- Delivered an invited talk on 'Importance of Soil in Aquaculture' organized by TNJFU-Institute of Fisheries Post Graduate Studies, Chennai on 5 December, 2022 – **Dr. R. Saraswathy**

- Delivered talk in Bio-floc technology for large scale fish and shellfish production in training program on 'Recirculating Aquaculture System for Intensive Farming of Fishes' at ICAR-Directorate of Coldwater Fisheries Research, Bhimtal on 8 December, 2022 - **Dr. A. Panigrahi**

- Delivered a talk on 'Post-harvest processing of fish during farming for enhancing fish consumption and quality retention in the shrimp culture and disease management in inland saline areas' on 12 December 2022 for the in-service staff of Department of Fisheries, Haryana - **Dr. S. Kannappan**

- Delivered an invited lecture on 'Water and Soil quality management in shrimp culture ponds' in the training program' organised by AU-Avanti Aquaculture Skill Development Centre, Visakhapatnam during 6-15 December, 2022 - **Dr. M. Muralidhar**

EXHIBITION

- ICAR-CIBA participated in the 29th Flower festival organized by Kakdwip Agri-horticultural society at Bidhan Maidan, Kakdwip held during 1-8 January, 2022.

- ICAR-CIBA participated in Agrivision 2022 organized by Evasions Business Solution Pvt. Ltd. at Ravenshaw University, Cuttack, Odisha, held during 6-8 March, 2022.

- ICAR-CIBA participated in the exhibition event of 12th Indian Fisheries Aquaculture Forum organized by the Tamil Nadu Dr. J. Jayalalithaa Fisheries University (TNJFU) at Chennai held during 5-7 May, 2022.

- ICAR-CIBA participated in the exhibition event of the third edition of TechBharat-2022 at CSIR-Central Food Technology Research Institute, Mysore held during19-21, May, 2022.

- ICAR- Central Institute of Brackishwater Aquaculture (ICAR- CIBA) participated in the 13th Krishi Fair 2022, a National level Agricultural Exhibition organized by the Shree Shrikshetra Soochana (SSS), a non-profit NGO at Puri, Odisha, held during 20-24 June, 2022.

- ICAR-CIBA participated in an exhibition event of the 19th International edition of 'Mega Goa World EXPO AND Summit 2022' jointly organized by the Chamber for impex, traditional and integrated health and Trinity group at Dr. Shyama Prasad Mukherjee AC Stadium, Panaji, Goa held during 4-6 August, 2022.

- Kakdwip Research Centre of ICAR-Central Institute of Brackishwater Aquaculture (KRC of ICAR-CIBA) participated in the 25th National Agricultural Exhibition held at Central Park, Salt Lake City, Kolkata held during 24-27 August, 2022.

- ICAR-Central Institute of Brackishwater Aquaculture participated in the exhibition conducted on the side-lines of National Symposium on 'Fisheries and Aquaculture for Livelihood and Nutritional Security' organized by ICAR-

Directorate of Coldwater Fisheries, Bhimtal, Nainital during 18-19 November, 2022.

- ICAR-Central Institute of Brackishwater Aquaculture participated in the exhibition conducted at the sidelines of Global Conference on Gender in Aquaculture and Fisheries (GAF8) on Shaping the Future: Gender Justice for Sustainable Aquaculture & Fisheries jointly organized by ICAR-Central Institute of Fisheries Technology, Society of Fisheries Technologists (INDIA), Gender in Aquaculture and Fisheries section of Asian Fisheries Society held during 21-23 November, 2022.

CIBA IN MASS MEDIA

- From Fish Waste to Community Wealth: A grassroots project in India is turning fish guts that once polluted beaches into a useful commodity. Hakai Magazine. 17 March 2022. Available at https://hakaimagazine.com/article-short/from-fish-waste-to-community-wealth/
- Dr. B. Shanthi presented a programme on the topic 'Empowerment of coastal and tribal families through brackishwater aquaculture technologies integrated with agro-based technologies' in Makkal TV on 18 June 2022.

75th Anniversary Celebrations of Indian Independence at CIBA

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