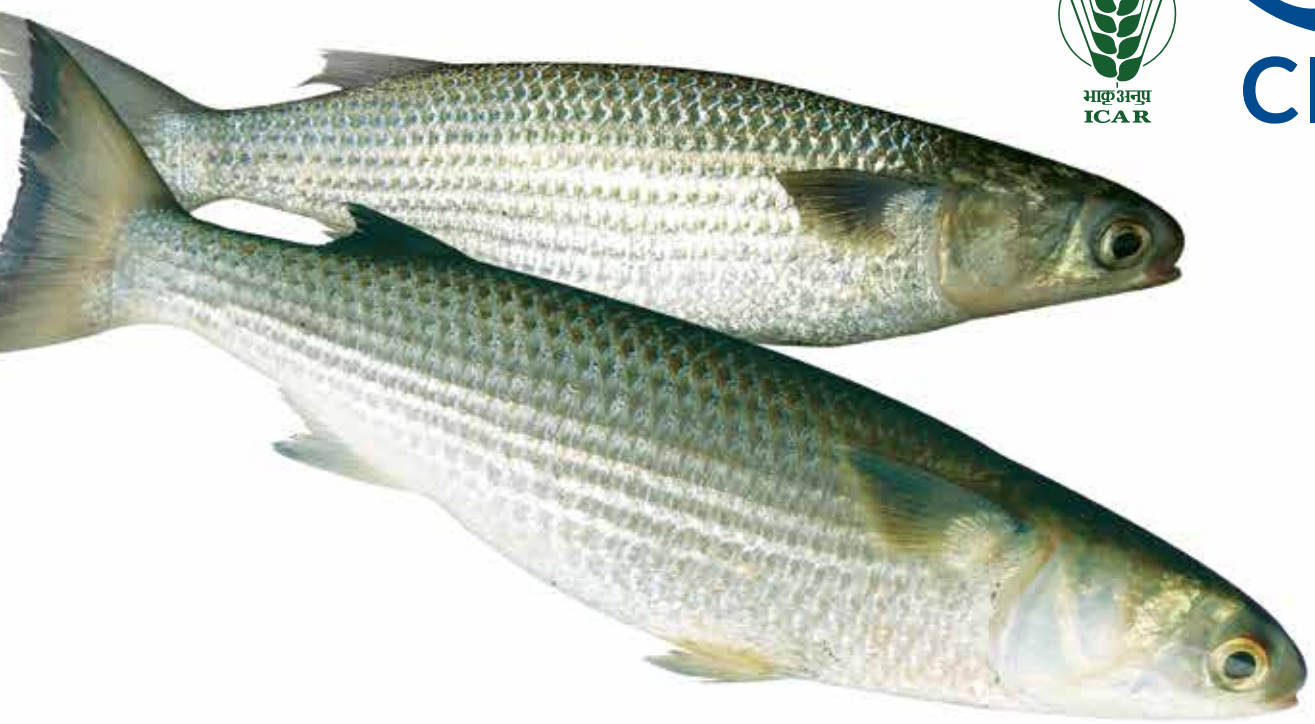
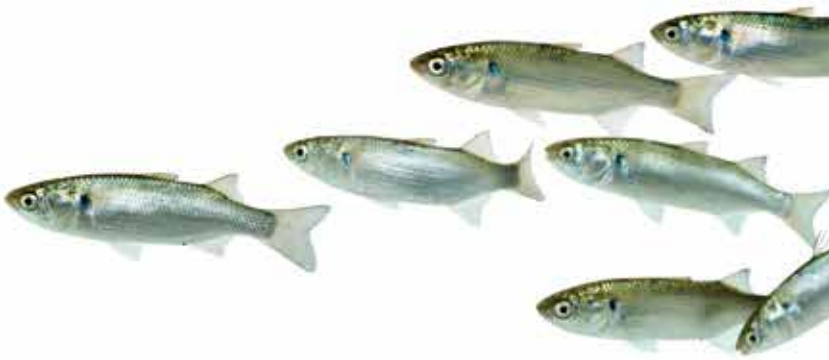
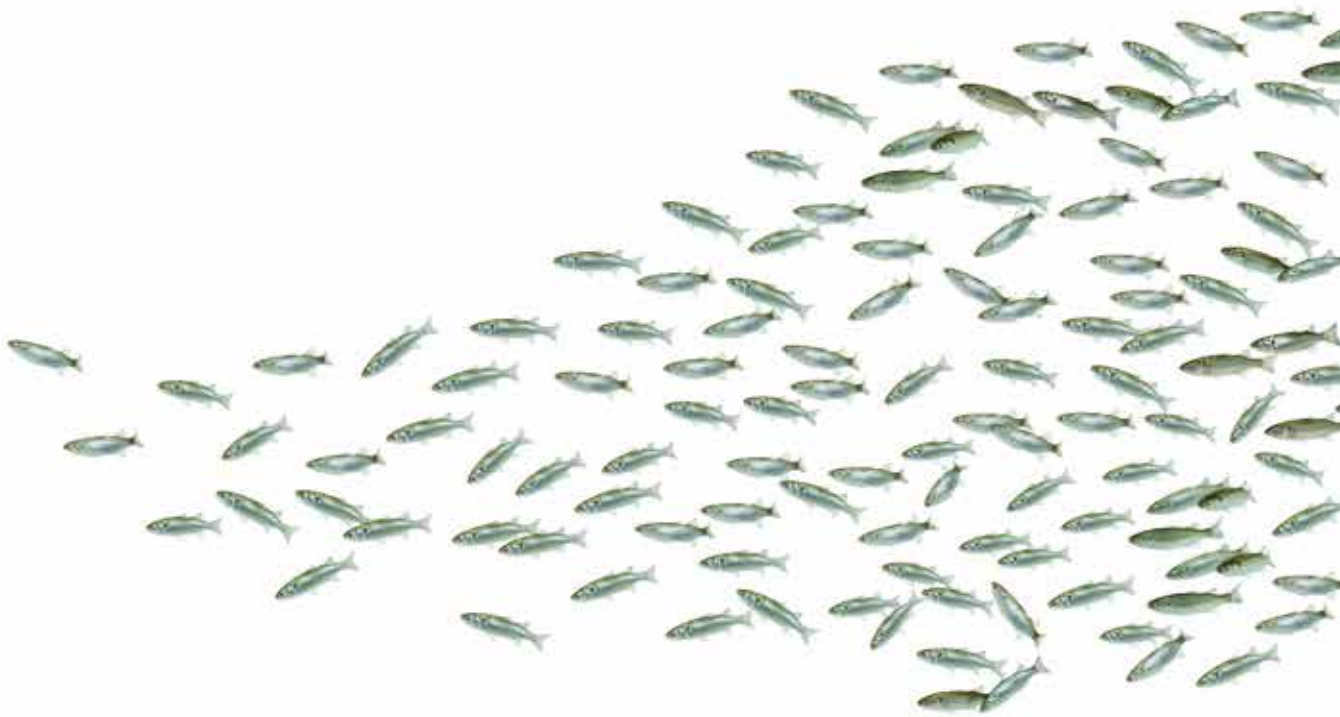




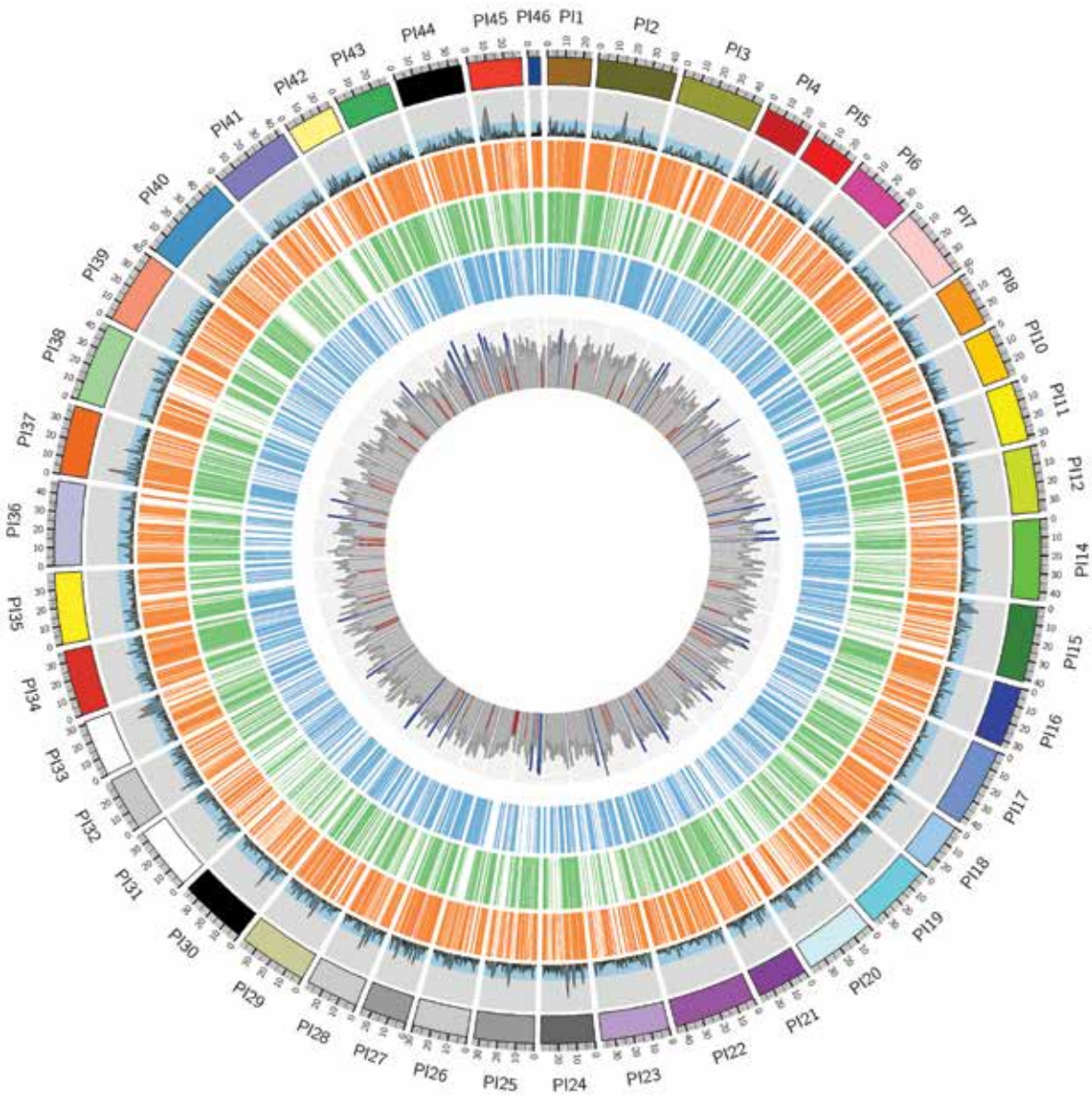
The first batch of hatchery produced grey mullet (*Mugil cephalus*) fingerlings at Muttukadu Experimental Station of CIBA



Annual Report 2019

ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

भा.कृ.अनु.प.–केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान



Circos plot of Indian white shrimp, *Penaeus indicus* depicting the alignments and structural variation

Grey mullet, *Mugil cephalus* is a brackishwater food fish suitable for farming in coastal waters. The fish has bred in captivity and young ones were successfully reared for the first time in India by CIBA. The maiden batch of hatchery produced grey mullet fingerlings at finfish hatchery, Muttukadu Experimental Station of CIBA.

ICAR-CIBA was awarded appreciation certificate for pro actively implementing ICAR Research Data Management Guidelines and uploading of publications and technologies for the last six years in KRISHI PORTAL.

भाकृअनुप
ICAR

CIBA

वार्षिक प्रतिवेदन

Annual Report 2019

भा.कृ.अनु.प.–केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद)

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

Chennai - 600028, Tamil Nadu, India

PUBLISHED BY

Dr. K.K.Vijayan
Director

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Dr K. K. Vijayan
Dr K. P. Kumaraguru vasagam
Dr J. Raymond Jani Angel

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Contents

Preface

By 2030, India's population is likely to reach 1.5 billion people, and it is projected to be the world's most populous country. Therefore, we need 40% more food to feed the growing population. Traditional food production sectors, such as terrestrial agriculture, have been stagnated owing to the difficulty in increasing the productivity, and non-availability of farming lands. Seafood, fish and shellfish from marine, brackish water and freshwater environment, has been the most preferred food to meet the food and nutritional security. It is a highly traded food commodity globally. Demand for seafood, across the world in both developed and emerging markets has been rising due to the obvious health benefits. In India, brackish water aquaculture, particularly shrimp farming is the economic engine of the aquaculture sector, with an all-time high production of about 8, 04, 000 mt, valued at Rs. 40,000 crores. ICAR-CIBA has been with the sector with its continuous effort in the area of technology backstopping with special reference to species diversification, hatchery production, nutrition and feed technology, aquatic animal health, genomics and social interventions.

The indicus genome with a length of 1.93 GB, nearly 80% of total length, was deciphered, and it is almost close to completion, with bioinformatic analyses. This genome sequence is found to be the best among the crustaceans including recently published *Penaeus vannamei* genome. *Penaeus indicus* genome would be useful not only for crustacean researchers but also across the research communities addressing the genetic improvement of other aquaculture crops.

When I look back to 2019, it was a rewarding year of achievements and positive partnership initiatives with stakeholders including farmers. Diversification of species and farming systems would provide sustainability and could add economic, social and ecological insurance to the aquaculture system. The expectation of aquaculture as an alternative solution to augment seafood production will only fulfill when fishes from the lower trophic levels come to the forefront of aquaculture. *Grey mullet, Mugil cephalus,* is perhaps the most widely distributed commercial species, and most favored aquaculture species across the globe. Although attempts to develop hatchery production of this species in the country started since 1970s, the science of hatchery propagation of grey mullet is still enigmatic. The reproduction and breeding of this species have remained a challenge due to the extremely short 'breeding window', and quirks in the breeding and larval biology of this species. Thus the species remained far from commercialization. We at CIBA were successful in the captive breeding of this species during the past couple of years, while in 2019, success was achieved in completing the larval rearing cycle with the production of grey mullet fry in captivity. Though it has to be repeated, and scaled-up, the process is inching a step closer towards the scaling up of fingerling production. This promising result would enable us to further refine the hatchery technology of this important brackish water species, followed by the development of the farming of this most sought after brackishwater fish.

The current exclusive reliance of the Indian shrimp farming sector on the exotic *Penaeus vananmei,* with a single species focus, is not a sustainable model. In recent years, the vannamei farming sector is constrained by emerging diseases and declining production performance. In this context, domestication and genetic improvement of native Indian white shrimp, *Penaeus indicus,* as an alternative have been recognized as a national priority. As the first step in this direction, two domesticated lines (G1 and G2) of *P. indicus* have been developed, using the wild and clean broodstock from Chennai coast, where the G2 lines showed a better reproductive performance than G1 line. It indicates that species is amenable for the breeding and domestication, and the preliminary results point towards a promising selective breeding program with the native Indian white shrimp, through a flagship program.

In the days ahead, in any farming system, novel initiatives and technologies need to be knowledge and science-driven. The integration of a genomic toos in the breeding program of terrestrial agriculture crops has already become routine. Nevertheless, genomic understanding of most aquaculture species is at its early phase. In this context, we have taken up the task of unraveling the genome of Indian white shrimp, which would be of use in the proposed stock improvement program of *P. indicus* with a length of 1.93 GB, nearly 80%

of total length, was deciphered, and it is almost close to completion, with bioinformatic analyses. This genome sequence is found to be the best among the crustaceans including recently published *P. vannamei* genome. *Penaeus indicus* genome would be useful not only for crustacean researchers but also across the research communities addressing the genetic improvement of other aquaculture crops.

Most brackish water farmed species need external inputs that typically include fishmeal from small pelagic forage fish. Although fishmeal has been well known for palatability and its efficiency in supplying protein and fatty acid requirement of farmed aquatic species, the global production of fishmeal remained stagnated, and its use in aquafarming on a sustainable mode is debated. This has sparked a search for alternatives. Krill meal from captured raw Antarctic krill (*Euphausia superba*) has become one natural substitute based on its nutritional profile, and it is considered that one of the truly sustainable marine protein resources. In our study, fishmeal was partially substituted by krill meal and confirmed that shrimp fed with krill supplemented diet enhances the growth and survival performance of *P. vannamei,* though the cost of the krill meal is on the higher than the fishmeal. In another study in search of a cost effective alternative for fishmeal, the use of black soldier fly meal (*Hermetia illucens*), as a protein source has provided promising results. These results are opening a new path in search of sustainable protein solutions for the aqua feed industry.

During the initial phase of the brackishwater aquaculture sector, development was skewed towards the high-valued export-oriented crop, and, therefore, it was, mostly involved by reasonably resourceful farmers. Thus, most marginalized coastal poor was excluded from the development. In order to involve these people, the research group at NGRC-Gujarat, KRC-West Bengal, and social science group developed integrated brackishwater fish farming system (IFF). The model at NGRC comprises farming and nursery rearing of sea bass, scat, polyculture of milkfish, pearl spot and goat and poultry at the dyke. The successful demonstration of nursery rearing, polyculture and livestock culture in IFF pond resulted in a revenue generation of ₹ 500,000/ year. This workable model developed by CIBA scientists will provide self-employment opportunities and livelihood support to rural and coastal poor.

The challenges due to the disease problems and crop failures have always been the most important threat to the aquaculture industry particularly, brackishwater shrimp farming since its inception. The disease situation is changing rapidly in an unpredictable way due to international trade and globalization. In this context, the use and application of surveillance and reporting are the way forward, and our aquatic animal health group has been continuously involved in this program, operating on a national level. EHP and WSSV are continued to be serious constraints to shrimp production systems, and economic analysis indicated that economic loss due to EHP and WSSV in Indian shrimp farming alone were about ₹1904 crores and ₹1681 crores respectively. The disease surveillance project is building the essential information required for the formulation of management measures to mitigate the impact of diseases.

The research output of ICAR-CIBA, in peer reviewed publication, has averaged 54 per year for the last five years, and it is pleasing to note that the majority of the publications in peer-reviewed core journals with high impact factor. Our research has always been industry-driven, and has always been tried to involve and drive

with the industry/farmer partnership. During the period between April 2019 and December 2019, we have made seven partnership agreements with private farmers, industry and government.

I am writing this preface for the Annual report of 2019 in the bleak days of COVID 2019, which has already grown as a global pandemic since February 2020, creating uncertainties in every sphere of human life, where aquaculture sector is no exception. While I am confident about our work and achievements, the post COVID period would be challenging. Brackishwater aquaculture, particularly the shrimp industry is contented with multiple challenges associated with inputs and related logistic constraints, labour shortages, issues in the marketing and economic woes. Although challenges are many, there are still possibilities, often adverse circumstances trigger innovation and powerful catalysts for new opportunities. Constraints in the export markets are the potential driver for a focus on domestic markets, and its benefits to small traders as wells as the consumers. "Hope is the strong inducement".

CIBA reaffirms its role in this unprecedented time to mitigate the impact of COVID 2019 by providing innovative technological solutions that reduce the overall negative effects, policy options, novel training models and ways to connect with stakeholders and farmers.

As the Council has made changes in the reporting period, from academic year to calendar year, this report presents salient accomplishments of the institute during the year 2019 (April to December). The period between January 2019 and March 2019, has been excluded, as it was already reported in the previous annual report of CIBA (2018-2019). I sincerely hope that the readers of this report will find it useful and offer, valuable suggestions on our research and development work, and such inputs are invaluable for continuous refinement and improvement of our work.

I am happy to present the CIBA annual report that highlights the research achievements of 2019. The achievements provide here are just glimpses, and I invite readers to go through the detailed report.

We thankfully acknowledge all our stakeholders and farmers who have supported us, and their trust in our mission enables our effort. I am immensely grateful to Dr Trilochan Mohapatra, the Director-General of ICAR, Secretary, DARE, without his professional supports all these research performance, and achievements would not have been possible. We are deeply indebted to Dr J. K. Jena, Deputy Director General (Fisheries) for his keen support, enthusiasm and timely help in pursuing our goals.

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

Thank you very much for joining this journey.

K.K.Vijayan
Director

कार्यकारी सारांश

मछली प्रजनन और बीज उत्पादन

हैचरी उत्पादित कुल 2,17,154 सीबास के बीज आंध्र प्रदेश, तमिलनाडु, महाराष्ट्र, कर्नाटक, केरल, गोवा और गुजरात के 20 किसानों और उद्यमियों को आपूर्ति किए गए और रु 7,58,250 बिक्री के माध्यम से राजस्व के रूप में प्राप्त किया गया।

हैचरी से उत्पादित कुल 91500 मिल्कफिश के बीज किसानों को आपूर्ति की गई और बीज बिक्री के माध्यम से रु 267 लाख राशि प्राप्त किया गया।

ग्रे मुलेट के कैप्टिव फ्राई उत्पादन में सफलता प्राप्त हुई। LHRH खुराक के 14 घंटे के बाद एक मादा (ABW, 800 g; oocyte size, 530 µm) और दो नर ग्रे मलेट के जोड़े में प्रजनन दर्ज किया गया। 30,000 लार्वा को लाइव और कृत्रिम फीड का उपयोग करके पाला गया। 40 दिनों के पालन के बाद, लार्वा 16.65 of 1.12 मिमी के फ्राई आकार तक पहुंच गया और 110 अंगुलियों का रखरखाव किया जा रहा है।

पर्लस्पॉट के लार्वा के विकास चरणों का अध्ययन किया गया। तीसरे दिन पोस्ट-हैच ने notochord flexion, प्रारंभिक मुंह खोलने और पेक्टोरल फिन कलियों की उपस्थिति के संदर्भ में सबसे अधिक चिह्नित परिवर्तन दिखाए। जर्दी थैली अवशोषण आठ दिन तक पूरा हो गया था। 20 dph, y = 0.0556x + 1.22, R2 = 0.98 के बाद उच्चतर वृद्धि देखी गई।
जुलाई 2019 के दौरान hCG हार्मोन @ 1500 IU / किग्रा शरीर के वजन को प्रशासित करके मैंग्रोव रेड स्नैपर लुत्जानुस अरेंजिमैकुलैटस की कैप्टिव ब्रीडिंग प्राप्त किया गया। 36 घंटे के बाद सफल स्पॉनिंग देखी गई और कुल 2.2 लाख अंडे क्रमशः 70% और 75% के निषेचन और हैचिंग दर के साथ पैदा हुए। कुल 1.1 लाख लार्वा प्राप्त किए गई और इसकी औसत लंबाई 1.70 मिमी थी। लार्वा को 10 दिनों तक पोस्ट हैच तक पाला गया।

सिल्वर मूनी (*मोनोडैक्टाइलस आर्गेन्टियस*) में कुल 14 प्रजनन किए गए, जिनमें से 11 स्पॉनिंग सफल रहे। स्पॉनिंग प्रति अंडे के अंडे निषेचन के साथ 1500 से 4000 की संख्या से थे और हैचिंग की दर क्रमशः

60-80% और 55-85% थी। कुल 22,000 लार्वा प्राप्त किए जा सकते हैं और पालन का काम चल रहा है। सुंदरबन के निचले खारे (10 - 20 पीपीटी) क्षेत्रों के लिए स्पोत्तेद स्कैट ब्रूडस्टॉक पालन को मानकीकृत किया गया । परिपक्व अंडाशय की मादा को जून - अक्टूबर से प्राप्त किया गया। अक्टूबर के मध्य के दौरान, एक जोड़ी को सफलतापूर्वक 5 ± 0.38 % निषेचन दर और 43 ± 4.64% हैचिंग दर के साथ 1.2 लाख अंडे देने के लिए प्रेरित किया गया था।

हिलसा (*टेन्यूलोसा इलिशा*) का डोमेस्तिकेश्न, (एफ 1-स्टॉक), दो प्रकार के रियरिंग सिस्टम जैसे कि रीसर्क्युलेटरी एक्वाकल्चर सिस्टम (आरएएस) और ब्रेकिश पॉन्ड सिस्टम में करने का प्रयास किया गया । कुल 2000 एफ 1 हिल्सा उप-वयस्क (कुल लंबाई, 15-22 सेमी; वजन, 11-18 ग्राम) इन प्रणालियों में कृत्रिम फ़ीड के साथ खिलाकर उन्हें व्यवहार्य कैप्टिव ब्रूडस्टॉक के रूप में बनाए रखा जा रहा है।

फिंगरलिंग के उत्पादन के लिए नर्सरी पालन प्रदर्शन

महाराष्ट्र सरकार के तहत सिंधुदुर्ग जिला में मैंग्रोव सेल प्रोजेक्ट से महिला स्वयं सहायता समूहों की भागीदारी के साथ नर्सरी पालन, पूर्व-विकसित और समुद्री मछली के पिंजरे पालन को विकसित करने का प्रयास किया गया । महिला स्व-सहायता समूहों ने पिंजरे में उन्नत फिंगरलिंग से सीबास बिक्री के माध्यम से 12.75 लाख रुपये का राजस्व अर्जित किया।

पिंजरों में मिस्टस गुलियो की नर्सरी पालन (हैपा: 2 × 1 × 1 मीटर) चार आहार आवृत्तियों (1, 2, 3 और 4 बार / दिन) के साथ 300 फ्राई / हैपा में 60 दिनों में एक दिन में 3 बार खिलाने से बेहतर एफसीआर और उत्तरजीविता के साथ उच्चतम वृद्धि हुई (1.30 ± 0.32 ग्राम)।

नर्सरी पालन पद्धति / हिलसा की तकनीक विकसित की गई। इस प्रणाली में, लगभग 5000 फ्राय
(3-7 सेमी, 0.18-2.4 ग्राम) का मिट्टी के तालाब में 90 दिनों के लिए नर्सरी पालन करने से 2-3 % उत्तरजीविता प्रतिशत प्राप्त किया गया।

ग्रो-आउट कल्चर मॉडल का विकास

मिल्कफिश को बढ़ावा देने के लिए, भारत के पश्चिमी तट में, केरल के कोल्लम में चिरैयांकीज़ किसान सहकारी समिति में

मत्स्य विभाग के सहयोग से एक मोनोकल्चर प्रदर्शन किया गया था। 2400 मिल्कफिश सीड (tl.2.5 cm, 36 dph) को 1 एकड़ क्षेत्र में स्टॉक किया गया था, जिसमें लवणता 15-23 पीपीटी थी, जिसके परिणामस्वरूप 90% उत्तरजीविता रहने के साथ 1 टन मिल्कफिश (ABW 550 g; MBW 750g) का कुल उत्पादन हुआ था।

मिल्कफिश पालन के गुणित स्टॉकिंग और हारवेस्तिङ्ग (MSMH) में, 7500 और 15000 नंबर / हेक्टेयर स्टॉकिंग घनत्व के साथ दो उपचारों ने 3.0 टन / हेक्टेयर, BCR 1.50 के मुकाबले उच्च घनत्व 3.8 टन / हेक्टेयर , BCR 1.66 में उच्च उत्पादन प्रदर्शित किया।

तालाब में मिल्कफिश के 2+ वर्ष के 500-700 ग्राम (70 नं) और 1100-1200 ग्राम (30 नं) ब्रूडस्टॉक को विकसित किया गया।

उत्तर प्रदेश के मथुरा में इनलैंड नमकीन तालाबों में 200 DOC के लिए मिल्कफिश ग्रो आउट कल्चर को सफलतापूर्वक संचालित किया गया । कुल 3.0 टन मिल्कफिश को 71% उत्तरजीविता प्रतिशत की दर से हार्वेस्ट किया गया । हार्वेस्ट मिल्कफिश दिल्ली के विभिन्न मछली बाजारों में बेची गई, जहां उन्होंने रु 120 - 180 / किलोग्राम के साथ शुद्ध रिटर्न रु 207, 650 अर्जित किया।

रोगज़नक़ स्क्रीनिंग के लिए नैदानिक तरीके

एक मोनोक्लोनल एंटीबॉडी-आधारित अप्रत्यक्ष एलिसा को विकसित किया गया और एशियाई सीबास में नर्वस नेक्रोसिस वायरस के खिलाफ प्रतिरक्षा प्रतिक्रिया का पता लगाने और इसे अनुकूलित करने के लिए विकसित किया गया था।

नर्वस नेक्रोसिस वायरस के कैप्सिड प्रोटीन से युक्त एक पुनः संयोजक प्रोटीन वैक्सीन विकसित किया गया। एशियाई सीबास ब्रोडस्टॉक के लिए अंतःशिरात्मक रूप से प्रशासित किया गया था

नर्वस नेक्रोसिस वायरस के कैप्सिड प्रोटीन से युक्त एक पुनः संयोजक प्रोटीन वैक्सीन विकसित किया गया और एशियाई सीबास ब्रूडस्टॉक में इनट्रापेरीटोनिली इंजेक्शन के रूप से देने पर एक महत्वपूर्ण प्रतिरक्षा प्रतिक्रिया को प्रेरित करने के लिए पाया गया।

मेजबान और रोगज़नक़ के बीच की गतिशीलता की समझ और समय के साथ इसकी भिन्नता

मेजबान और रोगज़नक़ के बीच परस्पर क्रिया गतिशील और संक्रमण के दौरान बदलती है। इसलिए, WSSV संक्रमण के तंत्र को पूरी तरह से समझने के लिए, संक्रमित झींगा में जीन अभिव्यक्ति में इन गतिशील परिवर्तनों को चिह्नित करना आवश्यक है। RSS-seq दृष्टिकोण WSSV- चुनौती वाले झींगा और नियंत्रण झींगा के बीच, संक्रमण के विभिन्न चरणों में, 1.5, 18 और 56 घंटे के बाद संक्रमण (एचपीआई) के पेनेअस वनामे के गलफड़ों में जीन अभिव्यक्ति में विपरीत बदलाव के लिए इस्तेमाल किया गया था। अभिव्यक्ति के 9 अस्थायी पैटर्न में समूहीकृत लगभग 5097 विभेदित जीन (डीईजी), की पहचान की गई थी। 63 डीईजी दो अलग-अलग लौकिक अभिव्यक्ति प्रोफाइल और शेष डीईजी के साथ वायरल जीन थे, जिन्हें विभिन्न मार्गों में वर्गीकृत किया गया था, जिसमें बताया गया था कि संक्रमण के दौरान कितनी सेलुलर प्रक्रियाएं गतिशील थीं। ये डेटा नया सेलुलर कार्यों में अंतर्दृष्टि प्रदान करते हैं जो संक्रमण के दौरान प्रभावित होते हैं और अंततः मेजबान और रोगज़नक़ के बीच की गतिशीलता और समय के साथ इसकी भिन्नता के बारे में हमारी समझ के लिए एक मूल्यवान संसाधन प्रदान करते हैं।

सिगनस जेवस में ओस्मोरगुलेटरी जीन की अभिव्यक्ति

ओस्मोरगुलेटरी जीन, प्रोलैक्टिन (प्रील) और प्रोलैक्टिन रिसेप्टर्स (प्रोलर) की अभिव्यक्ति एस. जेवस में गिल्स में अधिक थी, यह संकेत देता है कि यह ऑस्मोटिक-तनाव अनुकूलन के लिए एक प्रमुख ऑस्मोरगुलेटरी अंग है क्योंकि वे जलीय वातावरण के सीधे संपर्क में हैं।

WSSV की स्थिरता समरूप जीन से जुड़ी होती है

WSSV में राइबोन्यूक्लियोटाइड रिडक्टेस और थाइमिडाइलेट सिंथेटेज जैसे समरूप डीएनए संश्लेषण संबंधी एंजाइमों की उपस्थिति वायरल जीनोम प्रतिकृति, संक्रमण की दृढ़ता और मेजबान की एक विस्तृत श्रृंखला को संक्रमित करने की उनकी कार्यात्मक भूमिका को इंगित करती है।

WSSV जीनोम में हटाए गए हॉटस्पॉट्स

WSSV जीनोम में तीन विलोपन हॉटस्पॉट हैं जो wsv481 / wsv499, wsv237 / wsv241 और wsv178 / wsv180 हैं। कुछ आवृत प्रोटीन, VP41A, VP52A, VP35, और एक तत्काल-शुरुआती प्रोटीन की पहचान इन हॉटस्पॉट में मौजूद थी।

WSSV की पहचान के लिए पुष्ट मार्कर आइसोलेट्स

WSSV के केवल एक आइसोलेट में पूरी तरह से खो जाने वाले कोडिंग अनुक्रमों को अलग-थलग पहचान के लिए स्थानिक मार्कर के रूप में पहचाना गया। इन मार्करों का महामारी विज्ञान संबंधी जांच और निगरानी रोगज़नक़ आंदोलन में मूल्य होगा।

झींगा के लिए पहला ओपन-एक्सेस एसएनपी सर्च डेटाबेस

DbVAST डेटाबेस को क्रमशः पेनेअस इंडिकस और पेनेअस वनामे के लिए 27,991 और 21,970 SNPs के साथ विकसित किया गया है। यह एसएनपी की पहचान करने वाले उम्मीदवारों के लिए उपलब्ध है।

पेनेअस इंडिकस जीनोम का स्कैफोल्ड-लेवल असेंबली

पेनेअस इंडिकस का जीनोम 1.93 जीबी की लंबाई और 34 एमबी की एन 50 लंबाई 12,460 स्कैफोल्ड में इकट्ठा किया गया । हमारे ज्ञान से, इकट्ठे *पेनेअस इंडिकस* और जीनोम क्रस्टेशियंस के बीच सबसे अच्छा है, जिसमें हाल ही में प्रकाशित पी. वन्नमेई जीनोम है जो एन 50 आंकड़ों पर आधारित है।

सफेद मल सिंड्रोम से संक्रमित झींगा की आहारनली की माइक्रोबियल रचना

सफेद मल से संक्रमित झींगा की आहारनली की माइक्रोबियल संरचना से पता चलता है कि रोग समूह में माइक्रोबियल कालोनियों ज्यादातर

रोगजनक, श्लेष्म, काइटिन नाशक और विषाक्त पदार्थों के उत्पादन में शामिल होते हैं, जबकि नियंत्रण समूह में पाए जाने वाले सूक्ष्मजीव उपनिवेश ज्यादातर बायोरेमेडिएशन, चयापचय अपशिष्टों के खनिज से संबंधित प्रोबायोटिक प्रकृति के होते हैं।

विब्रियो एसपीपी का पैन-जीनोम विश्लेषण

पैन-जीनोम विश्लेषण के माध्यम से महत्वपूर्ण विब्रियो एसपीपी के जीनोम के डाउनस्ट्रीम विश्लेषण और पहचाने गए अद्वितीय जीन के परिणामस्वरूप 312 एंटीबायोटिक प्रतिरोध जीन, 4802 के साथ विष और एंटीटॉक्सिन सिस्टम के लिए 430 जीन कोडिंग और जीनोमिक आईलैंड्स और अद्वितीय जीन सेट से 4825 पुटीय विषाणुजनित जीन हैं।

एक्वासिम

तालाब के मापदंडों, मिट्टी, पानी, फ़ीड और मौसम के मापदंडों के अलग-अलग इनपुट के साथ बायोमास और नाइट्रोजन डायनामिक्स के अनुकरण के लिए "एक्वासिम" नामक एक सॉफ्टवेयर विकसित किया गया ।

पर्लस्पॉट मछली और पेनेअस इंडिकस का कर्योटाइपिंग

पर्लस्पॉट मछली के गुणसूत्र पैटर्न का अध्ययन कर्योटाइपिंग द्वारा किया गया। मछली की कोशिकाओं में 48 द्विगुणित गुणसूत्र (2n = 48) थे। इसमें मेटासेन्ट्रिक के 21 जोड़े, सबमेटेसेन्ट्रिक के दो जोड़े और सबटॉनेट्रिक की एक जोड़ी शामिल थी। पहचान किए गए गुणसूत्र पैटर्न माध्यमिक प्रजातियों की पुष्टि विधियों के रूप में उपयोगी होंगे। *पेनेअस इंडिकस* में 44 अगुणित गुणसूत्र पाए गए।

मछली के जीन के प्रवर्तक क्षेत्रों का प्रवर्धन और प्रतिरूपण

प्रमोटर जीन में से प्रत्येक के लिए क्षेत्र का लगभग 2.5 kb अपस्ट्रीम ट्रांसलेटरली साइट है, जिसमें से प्रत्येक के लिए Taube Nuss जैसे जीन, यूकेरियोटिक बढ़ाव कारक 1-गामा जीन और बीटा-एक्टिन - 1 जीन (3.5 kb) शामिल हैं। zebrafish और राइस-फिश की myosin प्रकाश श्रृंखला 2 जीन को स्वतंत्र रूप से जीन अभिव्यक्ति के अध्ययन के लिए क्लोनिंग वेक्टर Pmini T 2.0 में क्लोन किया गया था।

प्राथमिक कोशिका कल्चर का विकास

मिल्कफिश के मस्तिष्क, गुर्दे और यकृत और पर्लस्पॉट के मस्तिष्क और गुर्दे की प्राथमिक कोशिका कल्चर विकसित की गई और एक स्थिर कोशिका कल्चर विकसित करने के लिए कोशिकाओं को आगे पारित किया गया था।

एक्वास्टेट

एक्वास्टेट इंडिया 2019 के डेटाबेस को अद्यतन किया गया और प्रमुख सामग्री को CIBA वेबसाइट पर भी ऑनलाइन रखा गया था। भारतीय अर्थव्यवस्था में खारे पानी के जलीय कृषि पर अतिरिक्त अध्याय के साथ सजावटी मछली के उत्पादन और निर्यात, पेनेसियस जीनस वर्गीकरण शामिल थे।

आजीविका सुरक्षा

तमिलनाडु के तिरुवल्लुर और नागपट्टिनम जिलों में संसाधन-निर्बल एक्वाफ्रेम में एशियाई सीबास, मिल्कफिश और पर्ल स्पॉट की नर्सरी पालन जैसी प्रौद्योगिकी हस्तक्षेपों से प्रति किसान समूह को औसतन 7000 से 25000 रुपये की आय हुई।

पी. वन्नमेई पुरःस्थापना का प्रभाव

एसपीएफ़-पीवी एक उच्च मूल्य का निर्यात आइटम है। वित्तीय वर्ष 2017-18 के दौरान समुद्री खाद्य निर्यात के लायक 7 बिलियन अमरीकी डालर में से, स्तम्भित झींगा ने 5 बिलियन अमरीकी डालर का योगदान दिया, जिसमें मुख्य रूप से एसपीएफ़-पीवी शामिल हैं। भारत 36% बाजार हिस्सेदारी (एफएओ, 2019) के साथ वैश्विक झींगा बाजार का प्रमुख निर्यातक है। एसपीएफ-पीवी द्वारा उत्पन्न कुल आर्थिक अधिशेष 9 वर्ष (2009-10 से 2017-17) के दौरान अनुमानित रूप से रु 96,156 करोड़ है। रिटर्न की आंतरिक दर 51% अनुमानित है। उपभोक्ताओं और उत्पादकों के अधिशेष के बीच अनुमानित अनुपात 66% : 33% है। वर्ष 2018 में समाप्त होने वाले त्रयाब्द में,बायोसेक्योर स्थितियों के तहत कम होने वाली बीमारियों ने उत्पादकता को पूर्व 1.4 टी / हेक्टेयर की तुलना में 6.42 टी / हेक्टेयर बनाया है।

अपशिष्ट से धन

गांव में मछुआरों के लिए एक वैकल्पिक आजीविका गतिविधि के रूप में अपशिष्ट से धन की अवधारणा को प्रस्तावित किया गया। संस्थान ने मछली बाजारों से एकत्र किए गए कचरे से प्लैंकटन$^{प्लस}$ और हॉर्टि$^{प्लस}$ के उत्पादन के लिए चेन्नई में एक "मछली अपशिष्ट प्रसंस्करण इकाई" भी स्थापित किया है। इस तकनीक से देश भर में मछली बाजारों को साफ करने की क्षमता है और साथ ही चक्रीय अर्थव्यवस्था की अवधारणा के रूप में अपशिष्ट से धन का उत्पादन करने के लिए वैकल्पिक आजीविका प्रदान करने की क्षमता है।

केरल के कन्नूर जिले के झींगा पालन में प्रयुक्त स्रोत जल और तालाब मिट्टी के लक्षण

कन्नूर जिले के 56 मिट्टी और 80 पानी के नमूनों में से, लगभग 41 प्रतिशत मिट्टी चिकनी- दोमट की थी और उसके बाद दोमट (25%) थी। मृदा पीएच और कार्बनिक कार्बन क्रमशः 46 और 55 प्रतिशत मिट्टी में 7 और 0.5% से कम थी। कई मिट्टी में प्रति 100 ग्राम मिट्टी में 10 मिलीग्राम (54%) तथा 2 मिलीग्राम (84%) उपलब्ध नाइट्रोजन और फास्फोरस थे। कई स्रोत पानी में 7 (82%) से अधिक पीएच, 100 पीपीएम क्षारीयता (61%), 30 से कम NTU मैलापन (79%), 10 से 15 पीपीटी लवणता (62%), 100 से 200 पीएम कैल्शियम (57%) 600 -900 पीपीएम मैग्नीशियम (55%), और 80-10 पीपीएम पोटेशियम (57%) था।

लवणता में क्रमिक कमी से अवगत करणै पर झींगा की आयोनिक प्रोफाइल और एंजाइम गतिविधि

प्रशांत सफेद झींगा , *P.vannamei* को 24 घंटे के अंतराल पर धीरे-धीरे लवणता में कमी (25 पीपीटी से 5 पीपीटी) से कैल्शियम, मैग्नीशियम, पोटेशियम, सोडियम की आयनिक सांद्रता और Na-K-ATPase एंजाइम के गतिविधि में वृद्धि, वनामेई के अनुकूलनशीलता को दर्शाता है। झींगा (Ca> K> Na> Mg) एवम झींगा-सीरम (Na> Ca> K> Mg) का आयनिक प्रोफ़ाइल जल के आयनिक

प्रोफ़ाइल (Na> Mg> Ca> K) से अलग था।

कम खारे पानी में वनामेई पालन के लिये खनिजों की न्यूनतम इष्टतम सांद्रता

वनामेई के इष्टतम विकास के लिए Ca, Mg, K और Na की 150, 260, 120 और 1200 पीपीएम की न्यूनतम सांद्रता आवश्यक है ।, यह 2 पीपीटी मे 90 दिनों की पालन अवधि मे खनिजों की बदलती सांद्रता में उत्तरजीविता, वजन, विशिष्ट वृद्धि दर, परासरण और Na-K ATPase गतिविधि द्वारा पाया गया।

अलग-अलग सेलिनिटी के तहत टर्बिडिटी घटाने पर एजेंटों की क्षमता

पाली इलेक्ट्रोलाइट एप्लीकेशन @ ०.५ और १.२५ पीपीएम ने क्रमशः ५, १५ और ३० पीपीटी में ९ ०% मिट्टी की मैलापन को कम करता है । जो पॉली एल्यूमीनियम क्लोराइड (पीएसी) और फिटकिरी के साथ बराबर पर एक संभावित स्पष्टीकरण एजेंट के रूप में इस्तेमाल किया जा सकता है। ह पानी की गुणवत्ता के मापदंडों को प्रभावित नहीं करता है ।

विभिन्न मिट्टी में WSSV निष्क्रियता पर कैल्शियम हाइपोक्लोराइट की दक्षता में भिन्नता

WSSV युक्त मिट्टी को कैल्शियम हाइपोक्लोराइट @ 10, 20 और 30 पीपीएम क्लोरीन से ट्रीटमेंट के 24 घंटे के पस्चात अवशिष्ट क्लोरीन की मात्रा मृदा-जल माइक्रोकैम, दोमट बालू, सिल्टी मिट्टी, में दिखाई देती है। वनामेई पालन के दौरान दोमट रेत, दोमट-मिट्टी में WSSV निष्क्रियता के लिए 10 पीपीएम और 20 पीपीएम क्लोरीन की आवश्यकता होती है । फाइन मिट्टी की क्लोरीन की मांग मोटे मिट्टी वाली की तुलना में अधिक थी।

वनामेई में WSSV प्रेरित मृत्यु दर पर पानी के तापमान का प्रभाव

WSSV संक्रमण और रोग की प्रगति पर पानी के तापमान का प्रभाव बताता है की 33°C या उसके नीचे पानी के तापमान पर WSSV से संक्रमित वनामेई झींगा में WSSV प्रतिलिपि संख्या में तेजी से वृद्धि होती है । इसके विपरीत, 35°C पर, झींगा की कोई मृत्यु नहीं हुई और WSSV की प्रतिलिपि संख्या काफी कम रही । यह अध्ययन से वायरस के प्रति वनामेई झींगा की संवेदनशीलता या प्रतिरोध के बारे में जानकारी प्रदान करता है, हालांकि वायरस उच्च तापमान पर मेजबान में जीवित रह सकता है लेकिन रोग का विकास नहीं करता है।

वनामेई झींगा पर क्षारीयता और टर्बिडिटी स्ट्रेस का संयुक्त प्रभाव और WSSV के लिए इसकी संवेदनशीलता

वनामेई झींगा को क्षारीयता के तीन स्तरों 100, 300, 600 मिलीग्राम और टर्बिडिटी के तीन स्तरों 30, 60 और 120 NTU के संयोजन के प्रभाव के पश्चात WSSV से चैलेंज किया गया । इस अध्यन से पता चला की 1.2 - 5.7, 0.8 - 9.8, 4-17 गुना मृत्यु दर क्रमशः क्षारीयता, टर्बिडिटी और संयुक्त प्रभाव उपचार में पाया गया । संयुक्त उपचार के तहत अधिक स्ट्रेस देखा गया । कुल हेमोसाइट गिनती, फिनोल ऑक्सीडेज और सुपरऑक्साइड डिसम्यूटेज गतिविधि, गलफड़ों के रंग बदलने और SEM छवियों के आधार पर, यह स्पष्ट था कि 100 मिलीग्राम / एल. क्षारीयता, 120 एनटीयू टर्बिडिटी के कारण झींगा को अधिक स्ट्रेस युक्त और WSSV के लिए अतिसंवेदनशील पाया गया ।

मिल्कफिश के विभिन्न जीवन चरणों में तापमान संवेदनशीलता

मार्च से जून तक, जब तापमान ३०^{0}C से उप्पर रहता है तो मिल्कफिश लार्वा का उत्तरजीविता कम जाता है । अलप समय (७२) का हिट (२८, ३०, ३२ ओर ३४) सौक निम्न प्रकार की क्रमिक: 52%, 24% , 9.5% उत्तरजीविता को दर्शाता है । 28, 30, 32 और 34 बजे फ्राइ (30 dph) के साथ हीट शॉक स्टडी ने 34)C (52%) पर अधिकतम मृत्यु दर दिखाई, इसके बाद 32% पर 24% और पहले 72 घंटे के दौरान 30% पर 9.5% कम हो गया। इसलिये मिल्कफिश नर्सरी पालन के लिए 32^{0}C का तापमान उचित नहीं है।

ग्रीनहाउस गैसों के उत्सर्जन को रोकने के लिए आहार और सूक्ष्मजीव का हस्तक्षेप

कच्चे मूंगफली तेल केक (GNC) और ठोस किण्वित GNC @ 5, 7.5 और 10% के विभिन्न स्तरों को शामिल करके तैयार झींगा आहार बनाया गया जिसे 45 दिनों के लिए वनामेई लार्वा को खिलाया गया । ग्रीनहाउस गैसों के उत्सर्जन के माप के लिए प्रत्यके टैंक से ६ झिँगो को विशेष टैंक में डाला गया । अध्ययन से यह पता चला है कि नाइट्रस ऑक्साइड उत्सर्जन में काफी भिन्नता थी और, कार्बन-डाय-ऑक्साइड और मीथेन आहार उपचार से प्रभावित नहीं थे। बेसिलस @ 106 सी.एफ.यू / एम.एल. नाइट्रस ऑक्साइड और कार्बन-डाय-ऑक्साइड को काम करता है ।

मिट्टी और पीने के पानी की लवणता पर झींगा जलीय कृषि का पर्यावरणीय प्रभाव का आकलन

झींगा कृषि के प्रभाव की जांच करने के लिए जिला कलेक्टर के अनुरोध पर आंध्र प्रदेश के पूर्वी गोदावरी जिले में क्रमश: अप्पलागुप्तम, कात्रिकिकोना और काजुलुरु मंडप में क्रमशः अप्पेलागुप्तम, कटियरीकोना और काजुलुरु मंडप में बेमनापल्ली, चेयुरु जालुगुंटा और पेनुमल्ला में ईआईए अध्ययन शुरू किया गया । जल स्रोत, मिट्टी की लवणता, कृषि और नारियल के बगीचे झींगा कृषि के तालाबों के निकट और दूर स्थित झींगा फार्म तालाबों और नारियल के खेतों से दूर और दूर स्थित झींगा फार्मों के सेवन (स्रोत) और बहिर्वाह (डिस्चार्ज) के पानी के नमूनों का मासिक अंतराल पर विश्लेषण किया गया। प्रारंभिक परिणामों से संकेत मिलता है कि सैलिंइज़ेशन साइट विशिष्ट था और यह बताने के लिए ऐतिहासिक डेटा उपलब्ध नहीं है कि झींगा एक्काकल्चर सैलिनाइजेशन का कारण है और वर्तमान अध्ययन भविष्य की तुलना के लिए आधारभूत डेटा के रूप में काम कर सकता है।

भारतीय सफेद झींगा, *पैनियस इन्डिक्स* डोमेस्टिकेशन

विदेशी वनामेई झींगा पर उद्योग की वर्तमान विशेष निर्भरता गंभीर रूप से उभरती हुई बीमारियों और उत्पादन के प्रदर्शन को कम करने में विवश है। देशी *पैनियस इन्डिक्स* के बड़े पैमाने पर पालन और आनुवांशिक सुधार कार्यक्रम के प्रारंभिक चरण में, इस प्रजाति के पालतू लाइनों (G1 और G2) को विकसित किया गया है। इन पालतू लाइनों के विकास और

प्रजनन प्रदर्शन का अध्ययन किया गया और वाइल्ड ब्रूडस्टॉक के साथ तुलना की गई। G2 लाइनें G1 लाइनों की तुलना में तेज़ी से बढ़ीं, और पालन के 135 दिनों (नर्सरी के 45 दिनों सहित) के भीतर, 80% झिंगो ने संसेचन (इमप्रिगनाशन) प्राप्त किया । वर्तमान निष्कर्षों से पता चला है कि G2 लाइन G1 लाइन की तुलना में बेहतर प्रजनन प्रदर्शन दिखाया है जो इस परिकल्पना की पुष्टि करता है कि डोमस्टिकेशन के दौरान प्रजनन के मुद्दे कम प्रभवित होते हैं। पालतू लाइन का प्रजनन प्रदर्शन वाइल्ड ब्रूडस्टॉक की तुलना में थोड़ा कम है, और यह मुख्य रूप से वाइल्ड पकड़े गए जानवरों के शरीर के बड़े वजन (संभवतः अधिक उम्र) के कारण है। टैंक में पालन किये गये झिंगो का प्रजनन प्रदर्शन तालाब में पालन किये गये की तुलना में कम था, और इसलिए, टैंक में पालन प्रणाली को परिष्कृत करने के लिए आहार और अंतःस्रावी जोड़तोड़ किए जा रहे हैं।

भारतीय सफेद झींगा, *पैनियस इन्डिक्स* की प्रजनन परिपक्वता पर WSSV संक्रमण का प्रभाव

व्हाइट स्पॉट सिंड्रोम वायरस के लिए ब्रूडस्टॉक की स्क्रीनिंग पेनाइड हैचरी उत्पादन चक्र में सबसे महत्वपूर्ण कदम है। प्रजनन परिपक्वता / युग्मकजनन के दौरान इस वायरस की गतिशीलता पीढ़ियों के बीच वायरस के संचरण (ऊर्ध्वाधर संचरण) को समझने के लिए महत्वपूर्ण है। प्रजनन ऊतक (अंडाशय और शुक्राणुनाशक), निषेचित अंडे और लार्वा चरण (प्रोटोजोआ और मैसिस) WSSV के लिए दूसरे चरण के सकारात्मक ब्रूडर (प्लोपॉड नमूनों पर आधारित) का निदान किया गया था, और पता चला कि 50% से अधिक प्रजनन ऊतक WSSV से संक्रमित थे। हालांकि संक्रमण का स्तर विशेष रूप से अंडाशय और निषेचित अंडे पर बहुत कम पाया गया । इसके विपरीत पहले कदम पर पीसीआर पॉजिटिव वाइल्ड ब्रूडर्स ने अंडाशय को फिर से प्राप्त किया था जो दर्शाता है कि संक्रमण का उच्च स्तर अंतिम प्रसार अवधि में बाधा डालता है।

कैप्टिव रियार्ड भारतीय सफेद झींगा, *पैनियस इन्डिक्स* की आयु के संबंध में स्पर्मेटोफोर की गुणवत्ता

झींगा ब्रूडस्टॉक के प्रबंधन के लिए शुक्राणु की गुणवत्ता महत्वपूर्ण है। झींगा ब्रूडस्टॉक के प्रबंधन के लिए शुक्राणु की गुणवत्ता का अनुकूलन महत्वपूर्ण है। इसलिए लार्वा (30 दिन) से वयस्क (180 दिन) तक पूर्ण ब्रोडस्टॉक उत्पादन चक्र के दौरान भारतीय सफेद झींगा, *पैनियस इन्डिक्स* की शुक्राणु की गुणवत्ता पर आयु के प्रभाव का आकलन किया गया। स्पर्मेटोफोर की पहली अवलोकन 90 दिनों की उम्र में पाई गई और उच्चतम शुक्राणु गुणवत्ता सूचकांक 180 दिनों की उम्र में पाया गया।

बायोफलॉक आधारित भारतीय सफेद झींगा, *पैनियस इन्डिक्स* नर्सरी की पालन प्रणाली

दो चरणबद्ध उत्पादन प्रणाली, नर्सरी चरण और अंतिम उत्तपादन, को झींगा पालन के स्थायित्व के लिए महत्वपूर्ण रणनीति के रूप में मान्यता दी गई है। बायोफ्लोक आधारित प्रणाली को कम पानी के उपयोग के साथ गहन नर्सरी उत्पादन के लिए एक कुशल विधि के रूप में अच्छी तरह से स्वीकार किया गया है। आर्थिक रूप से व्यवहार्य और टिकाऊ बायोफ्लोक आधारित प्रणाली के मानकीकरण के लिए कई प्रयोग किए गए। पहले अध्ययन में, प्रोबायोटिक (*बेसिलस टकीलेंसिस*) के प्रभाव में वृद्धि, उत्तरजीविता और माइक्रोबायोटा के पूरकता पर बायोफ्लोक और प्रोबायोटिक्स के विभिन्न संयोजनों की जांच की गई। बायोफ्लोक और प्रोबायोटिक स्ट्रेन वाले सिस्टम ने बेहतर उत्पादन किया। इसके अलावा, जैव-तंत्र प्रणाली के तहत *पैनियस इन्डिक्स* पर विकास और प्रतिरक्षा संबंधी परिवर्तनों पर एंजाइमी उपभेदों (नोवोस्फिंगोबियम एसपी और मैरिनिलैक्टिबासिलस पीज़ोटोलरन्स) का प्रभाव मानकीकृत किया गया। बायोफ्लोक प्रणाली के साथ एम. पाईज़ोटोलरन ने बेहतर परिणाम उत्पन्न किए और झींगा की स्वास्थ्य स्थिति में सुधार किया। किसान के खेत में बायोफ्लॉक आधारित पालन-पोषण किया गया, जिसमें जीवन रक्षा दर: 92-94% थी; ABW: 4-5 सप्ताह में 0.26 ± 0.09 ग्राम पाया गया।

टैंक प्रणाली में भारतीय सफेद झींगा, *पैनियस इन्डिक्स* के नर्सरी पालन में पेरिफाइटोन चटाई का प्रभाव

एकुआमिमिक अवधारणा के सिद्धांत का पालन करके एक टैंक प्रणाली में *पैनियस इन्डिक्स* की पेरिफाइटोन आधारित नर्सरी किया गया । *पैनियस इन्डिक्स* (PL13) के पोस्ट लार्वा को एफ.आर.पी टैंकों में 1000 PL/m^3 की दर से एक महीने की अवधि के लिए 32 पीपीटी लवणता में पाला गया। समग्र परिणाम ने सुझाव दिया कि टैंक प्रणाली में एक्वामैट आधारित नर्सरी पालन *पैनियस इन्डिक्स* की वृद्धि और अस्तित्व को बढ़ा सकता है।

पोलिकिट की प्रजनन और हैचरी तकनीक

पोलिकिट लंबे समय से अपनी उच्च पौष्टिक प्रोफ़ाइल और परिपक्वता हार्मोन की वजह से दुनिया भर के झींगा हैचरी में परिपक्वता आहार के रूप में इस्तेमाल किया गया है। वाइल्ड पकड़े गए पोलिकिट में WSSV एवम EHP की उच्च घटनाओं के कारण पोलिकिट का वाइल्ड संग्रह गंभीर मुद्दा बन गया है। SPF पोलिकिट के विकास के लिए एक पूर्वापेक्षा के रूप में (पेरिनेसिस एसपी, नेमालिकैस्टिस एसपी, और मार्फिसा एसपी) प्रजातियों के लार्वा पालन प्रोटोकॉल को विकसित किया गया । पोलिकिट के अंडों से लेकर वयस्क तक का जीवन चक्र प्रयोगशाला में पूरा किया गया।

पैनियस इन्डिक्स का कोर आंत माइक्रोबायोटा

वाइल्ड और एक्वाकल्चर *पैनियस इन्डिक्स* के कोर आंत माइक्रोबायोटा का अध्ययन 16S rRNA उच्च-थ्रूपुट अनुक्रमण को नियोजित करने के लिए किया गया । फाइलम स्तर पर कोर माइक्रोबायोटा में मुख्य रूप से प्रोटीनोबैक्टीरिया, फ्यूसोबैक्टीरिया, टेनेरिक्यूट्स और फर्मिक्यूट शामिल थे, हालांकि वाइल्ड और जलीय कृषि (एक्वाकल्चर) के बीच उनके सापेक्ष प्रचुरता में महत्वपूर्ण अंतर पाए गए थे। वाइल्ड में प्रमुख फोटोबैक्टीरियम (29.5%)थी, इसके बाद प्रोपियोनिजेनियम (13.9%), हाइपोसायक्लिसस (13.7%) और विब्रियो (11.1%); एक्वाकल्चर के मामले में विब्रियो (46.5%) का वर्चस्व था, उसके बाद कैटेनोकोकस (14%), प्रोपियोनिजेनियम (10.3%) और फोटोबैक्टीरियम (8.7%) थे।

खेती में नर्सरी उत्पादित बीजों का प्रदर्शन

प्रत्यक्ष स्टॉकिंग की तुलना में नर्सरी उत्पादित झींगा के ग्रोथ प्रदर्शन का आकलन करने के लिए 80-85 दिनों की अवधि के लिए पेनासियस वनामेई को 28 nos/m^2 के स्टॉकिंग घनत्व पर स्टॉक किया गया। उपचार में शामिल हैं, टी 1: प्रत्यक्ष तालाब स्टॉकिंग, टी 2: बायोफ्लोक (0.5 ग्राम / टैंक) पुनर्व्यवस्थित झींगा और टी 3: बायोफलॉक (@ 1 ग्राम / टैंक) पलित झींगा। T1, T2 और T3 ने पालन के अंत में 11.36, 7.33 और 10.77 ग्राम का अंतिम ABW दर्ज किया और T3 (67%) और T1 (62%) और T2 (63%) के बाद अस्तित्व में उच्चतम था।

मिट्टी के केकड़ों और मिस्टस गुलियो की सह- पालन

पॉली कल्चर को प्राकृतिक संसाधन का सदुप्योग करने और तालाब की उत्पादकता में सुधार करने के लिए एक कुशल तरीका माना गया है। बॉक्स सिस्टम में मिट्टी केकड़े (*एस. ओलिविया*) की एम. गुलियो के साथ सह-पालन की गई । मिट्टी केकड़ा @ 50 nos / 100 $मी^2$ और गूलियो @ 5 nos / $मी^2$ के स्टॉकिंग घनत्व पर पाला गया । मिट्टी केकड़े का प्रारंभिक वजन 38.06 ग्राम और एम। गुलियो 0.45 ग्राम था । 65 DOC के बाद, मडक्रैब और गूलियो ने क्रमशः T1, T2 और T3 में 71.03, 72.90, 73. 42g और 1.8, 2.0 और 1.7g प्राप्त किया।

सुंदरबन, पश्चिम बंगाल के तालाब में एकीकृत बहु-ट्राफिक जलीय कृषि (एकीकृत मल्टी-ट्रॉफिक एक्वाकल्चर)

एकीकृत मल्टी-ट्रॉफिक एक्वाकल्चर (IMTA) मे एक जलीय प्रजाति के अपशिष्ट दूसरे का खाद और उर्वरक होता है । व्यावसायिक रूप से महत्वपूर्ण समुद्री शैवाल, *ग्रेसिलिरिया टेनुइस्टिपिटाटा* और दो व्यावसायिक रूप से महत्वपूर्ण मछली प्रजातियां यानि चांसोस चानोस (मिल्क फिश) और क्रैसोस्ट्रिया कटकेंसिस (खाद्य सीप) की खेती साथ- साथ की गई। परिणामों से पता चला कि समुद्री शैवाल का बायोमास उत्पादन मोनोकल्चर तालाब की तुलना में IMTA तालाब में काफी अधिक था ($p < 0.05$)।

संसाधनों की विशेषताओं और पर्यावरणीय परिस्थितियों का आकलन

जल निकाय और विभिन्न भूमि उपयोग वर्ग जैसे कि कृषि, जलीय कृषि, परित्यक्त जलीय कृषि, जल निकाय, मडफ्लैट, आरक्षित / स्क्रब वन, नमक पैन, परित्यक्त नमक पैन, रेत, स्क्रब / पहाड़ी, खनन / उद्योग और जल जमाव महाराष्ट्र के पांच तटीय जिलों के लिए मैप किया गया है। तमिलनाडु में खारे पानी के एक्वाकल्चर के विस्तार के लिए अप्रयुक्त भूमि संसाधनों की मैपिंग के लिए अध्ययन किया गया। तमिलनाडु के छह जिलों विल्लुपुरम, कुड्डुलोर, पुदुकोट्टई, टूथुकुडी, थिरुवरुर, और तंजावुर को भूमि और जल संसाधनों के लिए मैप किया गया था।

तमिलनाडु के तिरुवल्लुर और कांचीपुरम जिलों की लवणता मानचित्रण और मॉडलिंग

तटीय जलस्तर आधारित सतह और थिरुवल्लूर और कांचीपुरम जिलों की उपसतह लवणता मानचित्रण और मॉडलिंग, टिकाऊ खारे पानी के जलीय कृषि के लिए किया गया है। पानी की लवणता प्रोफ़ाइल प्राकृतिक पारिस्थितिकी तंत्र में विभिन्न प्रजातियों के लिए संभावित जलीय कृषि की पहचान करने में मदद करेगी।

विशेष फ़ीड घटक के रूप में अंटार्कटिक क्रिल का उपयोग

मछली का चूर्ण (6 और 12%) क्रिल का चूर्ण (0, 2, 4 और 6%) के समावेशन के प्रभाव का परीक्षण झींगा के ग्रोथ पर किया गया । 12% मछली का चूर्ण + 6% क्रिल का चूर्ण का कम्बिनेट्न सबसे अधिक (11.61 ग्राम) प्रदान कर्ता है । अध्ययन ने झींगा आहार में क्रिल भोजन के लाभकारी प्रभावों को साबित किया, और यह स्थापित किया कि 4% का समावेश स्तर न्यूनतम है।

नया फीड संघटक के रूप में ब्लेक सोल्डर फ़्लै (बीएसएफ) का उप्योग :

एक्वाफीड्स में बीएसएफ भोजन का उपयोग एक उभरती हुई अवधारणा है, जहां बायोवेस्ट को उपयोगी बायोमास में कुशलतापूर्वक परिवर्तित किया जाता है, जिसके परिणामस्वरूप स्वच्छ वातावरण और बायोमास का प्रभावी उपयोग होता है। बीएसएफ (20-25 दिन पुरानी) की पोषक संरचना से पता चला कि इसमें 23-27% वसा के साथ 40-45% प्रोटीन होता है । बीएसएफ भोजन का उपयोग मछली के भोजन के लिए एक स्थायी विकल्प के रूप में किया जा सकता है और इसे सफेद झींगा, *पी. वन्नमेई* के आहार में बिना किसी हानिकारक प्रभाव के 15% तक शामिल किया जा सकता है।

सफेद झींगा में दिन और रात की फिडिग का निष्कर्ष

दिन हो या रात, समय खिलाने के विकल्प पर हितधारकों के बीच सक्रिय बहस होती है । हमने कैप्टिव स्थिति के तहत व्हाइट लेग झींगा में एक सुनियोजित प्रयोग किया। प्रयोग के परिणामों ने दिन और रात दोनों को लगातार कवर करने वाले झींगा के साथ बेहतर प्रदर्शन दिखाया, प्रदर्शन लगभग दिन या रात में खिलाए गए उपचार के समान है।

प्लैंकटनप्लस ने किसान तालाब में टाइगर झींगा और सफेद झींगा के साथ आशाजनक परिणाम दिखाए:

प्लैंकटनप्लस, तालाब में प्राथमिक उत्पादकों और ज़ोप्लांकटॉन की उत्पादकता बढ़ाने के लिए एक पोषक तत्व से भरपूर तरल उत्पाद है। इसका उपयोग टाइगर झींगा में अंतिम भार में 1.5 ग्राम का अधिक भर देता हे। इसी तरह, पश्चिम बंगाल में, प्लैंकटनप्लस के उपयोग पर 7.24 टी / हेक्टेयर का उच्चतम उत्पादन हासिल किया गया था।

जुवेनाइल मिल्कफिश और तेल सार्डिन के तुलनात्मक पोषक तत्व की रूपरेखा

मिल्कफिश हरे पानी आधारित पालन मॉडल में उच्च घनत्व में विकसित करने की क्षमता के आधार पर एक आशाजनक मछली की प्रजाति है। इस सब पर विचार करते हुए, इस मछली को सार्डिन के विकल्प के रूप में बढ़ावा देने की गुंजाइश है, अगर दोनो का पोषक तत्व मेल खाते हैं। आकार समूहों के बावजूद तेल सार्डिन मछलियां में EPA और DHA बेहतर पाई गईं, जबकि मिल्कफिश में एराकिडोनिक और पामिटिक एसिड का अनुपात अधिक था। मिल्कफिश 50 से 150 ग्राम और 20 ग्राम सार्डिन की का उप्योग वयस्क मानव के लिए ईपीए + डीएचए की दैनिक जरूरतों को पूरा करने के लिए पर्याप्त है।

पॉलीकल्चर सिस्टम में प्लैंकटन प्लस का प्रभाव

टाइगर झींगा और मिल्कफिश के पॉलीकल्चर का शून्य जल विनिमय प्रणाली सिस्टम में (500 L आउटडोर FRP टैंकों) में 70 दिनों का परीक्षण किया गया। महत्वपूर्ण वृद्धि (P <0.01) प्लेंक्टन प्लस और फीड के साथ व्यवहार किए गए टाइगर झींगा के विकास मापदंडों (ADG, SGR और बायोमास लाभ) में देखी गई थी। मिल्कफिश के मामले में, जब प्लैंकटन प्लस के साथ फ़ीड खिलाया गया तो 27% अधिक वृद्धि दिखा । यहां तक कि 40 पीपीएम प्लैंकटन प्लस के सप्लीमेंट के साथ 20% फ़ीड में कमी केवल फ़ीड के साथ खिलाए जाने पर समान वृद्धि दिखाई दी । सभी वृद्धि मापदंडों (ADG, SGR और बायोमास लाभ) फ़ीड और प्लेंक्टन प्लस के साथ काफी अधिक थे (p <0.01) ।

केकड़े के लिए फ़ीड

मिट्टी के केकड़े के लिए औपचारिक फ़ीड (स्काइला ऑलवेसिया) का मूल्यांकन किसानों की तालाब में बॉक्स संस्कृति प्रणाली में किया गया था और पारंपरिक रूप से इस्तेमाल की जाने वाली ट्रिश मछली की तुलना में मिट्टी केकड़े के पालन और परिपक्वता के लिए पेलेट फीड एक बेहतर और आर्थिक विकल्प पाया गया था।

मिल्कफिश लार्वा के आहार में मकई के तेल के साथ मछली के तेल के मिश्रण का प्रभाव

मछली के तेल और मकई के तेल के विकास, पाचन एंजाइम गतिविधि और फैटी एसिड संरचना पर प्रभाव की जांच के लिए एक परीक्षण आयोजित किया गया । दोनों तेल के संयोजन मिल्कफिश लार्वा में महत्वपूर्ण रूप से उच्च अस्तित्व और वृद्धि देते हैं

डब्ल्यू. एस. एस. वी. और ई.एच.पी. भारतीय झींगा पालन के लिए बड़े खतरे हैं

2015-2019 के दौरान तमिलनाडु और आंध्र प्रदेश के 703 पेनेअस वनामेई फार्मों में किए गए रोग निगरानी से पता चलता है कि *एंटरोसाइटोज़ून हेपटोपेनेई* (ईएचपी) और व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्यूएसएसवी) से झींगा पालन को सबसे अधिक खतरा है। इसके अलावा, वर्ष 2019 में 180 वनामेई फार्मों में किए गए रोग निगरानी से पता चला कि डब्ल्यू. एस. एस. वी. की व्यापकता - 6%, ई.एच.पी. - 27%, आई. एच. एच. एन. एन. वी. - 3% और और आई. एम. एन. वी. - 3% है। जबकि इन फार्मों में ए. एच. पी. एन. डी., टी. एस. वी. और वाई. एच. वी. जैसी बीमारियों का पता नहीं चला। भारतीय झींगा पालन में ई.एच.पी. और डब्ल्यू. एस. एस. वी. के कारण अनुमानित आर्थिक नुकसान का विश्लेषण क्रमशः 1904 करोड़ और 1681 करोड़ था इसके अलावा, 2017-18 के दौरान 11 लाख मानव दिनों का रोजगार नुकसान हुआ।

ई.एच.पी. संक्रमण गुजरात के झींगा खेतों में व्यापक रूप से फैला हुआ है

भारत के पश्चिम तट पर स्थित गुजरात राज्य के छह तटीय जिलों जैसे मटवाड़, सांबापुर, ओंजल, पनार, मेंधर बाट और नवसारी में जांच की गई सभी अठारह झींगा खेतों में ईएचपी से संक्रमित पाया गया। सभी अठारह झींगा फार्म सफेद मल सिंड्रोम (डब्ल्यू. एफ. एस.) से प्रभावित थे, और सात फार्म आकार भिन्नता से प्रभावित थे। हालाँकि, ये सभी फार्म डब्ल्यू. एस. एस. वी., ए. एच. पी. एन. डी. और आई. एच. एच. एन. एन. वी. के लिए नकारात्मक पाए गए थे।

हरियाणा के अंतर्देशीय लवणीय क्षेत्रों के झींगा खेतों में ईएचपी संक्रमण दर्ज किया गया

उत्तर भारत के अंतर्देशीय लवणीय क्षेत्रों में झींगा पालन हरियाणा, पंजाब और राजस्थान जैसे राज्यों में तेजी से उभर रहा है । इन राज्यों में ईएचपी संक्रमण का पता लगाने के लिए परिछन किया गया । हरियाणा राज्य में दो खेतों में हल्के संक्रमण (दूसरा चरण) का संकेत बीज जनित संचरण का सुझाव देता है।

ब्रैकिशवाटर एक्वाटिक एनिमल डिजीज (एन.आर.एल.डी.) के लिए राष्ट्रीय रेफरल प्रयोगशाला

सी. आई. बी. ए., चेन्नई के ब्रैकिशवाटर एक्वाटिक एनिमल डिजीज (एन.आर.एल.डी.) के लिए राष्ट्रीय रेफरल प्रयोगशाला, ने 2019 के दौरान एक्वाटिक क्वारंटाइन एवं सर्टिफिकेशन सर्विसेज (AQCS, GOI) (चेन्नई, हैदराबाद, कोलकता और नवी मुंबई) के अंतर्गत 56 नमूनों का परीक्षण किया, जिसमे आर्टीमिया सिस्ट (नमकीन झींगा अंडे), जमे हुए ऊतक, क्रिल, फ़ीड के नमूने शामिल थे इसके अतिरिक्त ब्रूडस्टॉक गुणन केंद्र (BMC) से 24 सैम्पल्स को भी ओ. आई. ई. सूचीबद्ध रोगजनकों के लिए परिछित किया गया । इसके अलावा, किसानों से 56 नमूने (55 पीएल नमूने और एक केकड़ा नमूना) को तालाब में स्टॉकिंग से पहले ओ. आई. ई. सूचीबद्ध बीमारियों के लिए परीक्षण किया गया। किसान तालाबों से 13 मिट्टी के नमूने और हैचरी से दो ब्रूडर्स का परीक्षण भी ईएचपी के लिए किया गया।

ईएचपी बीजाणुओं के अंकुरण को रोकने के लिए डिटर्जेंट का मूल्यांकन

जल-कृषि पद्धति में आमतौर पर इस्तेमाल किए जाने वाले डिटर्जेंट जैसे पोटेशियम परमैंगनेट, कैल्शियम हाइपोक्लोराइट, सोडियम हाइड्रोक्साइड, फॉर्मालिन और हाइड्रोजन पेरोक्साइड का मूल्यांकन ईएचपी बीजाणुओं की निष्क्रियता के लिए किया गया । पोटेशियम परमैंगनेट (10, 15, 20 पीपीएम), फॉर्मेलिन (100,150,200 पीपीएम), कैल्शियम हाइपोक्लोराइट (20, 30, 40 पीपीएम), सोडियम हाइड्रोक्साइड (3%, 3.5%), हाइड्रोजन पेरोक्साइड (3%, 4%, 5%) ईएचपी बीजाणुओं के के अंकुरण को रोकने में प्रभावी पाया गया।

दक्षिण 24 परगना, पश्चिम बंगाल में तिलापिआ लेक वायरस का पता चला

वर्ष 2019 के दौरान रामगंगा और सागर द्वीप, दक्षिण 24 परगना, पश्चिम बंगाल में 30 और 10% की मृत्यु दर वाले आठ तिलपिया (ओरोक्रोमिस मॉसंबिकस) तालावों में से दो में तिलापिआ लेक वायरस (टीआईएलवी) का पता चला। इसके पहले तमिलनाडु के वाइल्ड तिलापिआ, ओ.मॉसंबिकस और ओ. निलोटिकस में भी टीएलएलवी पाया गया था ।

सी. आई. बी. ए. के पिछले अध्ययनों से पता चला है कि टीआईएलवी को प्रायोगिक तौर पर सीबास में प्रेषित किया जा सकता है। यह अध्ययन सीबास पालन

में जैव सुरक्षा उपायों को अपनाने की आवश्यकता पर जोर देता है।

पेन-कल्चर पर्ल स्पॉट, एट्रोप्लस सुरार्टेंसिस में सी-लाइस का संक्रमण

तमिलनाडु के पोंनेरी गाँव में पर्ल स्पॉट, एट्रोप्लस सुरार्टेंसिस में बाह्य परजीवी कैलिगस मिनिमस के भारी संक्रमण के कारण मृत्यु दर्ज की गयी। इसके समाधान के लिए इमामेक्टिन बेंजोएट (ईएमबी) को लगातार सात दिनों तक इन-फीड ट्रीटमेंट ५० माइक्रोग्राम / किलोग्राम / प्रतिदिन मछली के शरीर के वजन की दर से दिया गया । इससे मछली में 100% उत्तरजीविता के साथ साथ 100% रिकवरी देखि गयी ।

एशियन सीबॉस लेट्स कैलकेरीफर में लरनियोसिस का संक्रमण

एशियन सीबॉस (लेट्स कैलकेरीफर) के नर्सरी पालन में लरनियोसिस के संक्रमण की वजह से मृत्यु दर्ज किया गया था। परजीवि की पहचान एंकर

वर्म, लर्नैआ साइप्रिनैसिया के रूप में की गई। इमामेक्टिन बेंजोएट (ईएमबी) को लगातार दस दिनों तक इन-फीड ट्रीटमेंट किया गया इससे मछली में 90% उत्तरजीविता में सुधार हुआ

मिल्कफिश के मस्तिष्क से नयी सेल-लाइन विकसित की गयी

एम. एफ. बी. -1 के रूप में नामित एक नई सेल लाइन को किशोर मिल्कफिश के मस्तिष्क से विकसित की गयी है। इसे L-15 मीडीयम और 20% एफ. बी. एस. की मदद से 27oC पर विकसित किया गया। इसकी प्राथमिक मोनोलेयर में फ़ाइब्रोब्लास्ट की आकृति की कोशिकाओं देखि गयी । एम. एफ. बी. -१ सेल लाइन का उपयोग नोडा वायरस के रोगजनन अध्ययन के लिए और मिल्कफिश को प्रभावित करनेवाली अन्य विषाणु रोगजनकों की पहचान, पृथक करने एवं अनुकूलित करने के लिए किया जा सकता है।

फिलामेंटस फेज का पता लगाने के लिए पीसीआर आधारित डायग्नोस्टिक विकसित किया गया

लाइसोजेनिक फिलामेंटस फेज विब्रियो कोलेरा और विब्रियो पाराहेमोलीटिकस जैसी कई विब्रियो प्रजातियों के विषैलापन में महत्वपूर्ण भूमिका निभाता है। विब्रियो हार्वेई क्लेड की प्रजातियों के बीच उनकी उपस्थिति का विश्लेषण करने के लिए, ज़ोट जीन के तीन अलग-अलग समूहों के 20 से अधिक अनुक्रमों को संरेखित करके प्राइमर विकसित किया गया। इन प्राइमरों का उपयोग कर पीसीआर की मदद से विब्रियो कैंपबेल्ली के 30 आइसोलेट्स में से बारह में फिलामेंटस फेज की उपस्थिति का पता लगाया गया।

एंगुइबैक्टिन आधारित सिडरोफोर प्रणाली का पता *विब्रियो कैंपबेल्ली* में लगा

एंगुइबैक्टिन प्रणाली आयरन के अधिग्रहण में महत्वपूर्ण भूमिका निभाता है और इसे विब्रियो वलनीफिकस में सबसे महत्वपूर्ण विषाणु कारक माना जाता है। उनकी उपस्थिति की जांच करने के लिए, *विब्रियो हार्वेई* क्लैड के 91 जीनोम का आनुवंशिक रूप से विश्लेषण किए गया। विश्लेषण से संकेत मिलता है कि *विब्रियो कैंपबेल्ली* के सभी आइसोलेटस में एंगुइबैक्टिन के संश्लेषण और उनके स्थानांतरण के लिए आवश्यक जीन मौजूद हैं। हालांकि, इस तरह के जीन को विब्रियो हार्वेई क्लेड की अन्य प्रजातियों में नहीं देखा गया।

विब्रियो हार्वेई क्लैड के विभेदीकरण और परिमाणन के लिए नैदानिक मार्कर्स की पहचान की गई

विब्रियो हार्वेई और *विब्रियो कैंपबेल्ली* के परिमाणन और हार्वी क्लैड की अन्य प्रजातियों के विभेदीकरण के लिए के पीसीआर टेस्ट विकसित करने के लिए नैदानिक मार्कर्स की एक विस्तृत खोज की गई। कुल 117 अलग-अलग संरक्षित जीन और 11नया लक्ष्य जीन की पहचान की गई। इन जीन प्राइमर के आधार पर *विब्रियो हार्वेई, विब्रियो कैंपबेलि* और विब्रियो ओवेन्सी के विभेदीकरण लिए पीसीआर टेस्ट विकसित किया गया।

एशियाई सीबास में वायरल नर्वस नेक्रोसिस के खिलाफ रिकम्बीनैंट प्रोटीन टीका विकसित हुआ

कैप्सिड प्रोटीन जीन पर आधारित एक रिकम्बीनैंट प्रोटीन वैक्सीन का विकास और मूल्यांकन सीबास फिंगरलिंग में किया गया था। एंटी-एनएनवी सीरम एंटीबॉडी का मूल्यांकन अप्रत्यक्ष एलिसा का उपयोग करके किया गया था। 18 दिनों के हैचिंग के पश्चात NNV के साथ चुनौती देने पर नियंत्रण (74%) की तुलना में रिकम्बीनैंट प्रोटीन टीकाकरण समूहों से प्राप्त लार्वा में बेहतर सापेक्ष प्रतिशत उत्तरजीविता (94%) थी।

फोटो-क्षरण और एल्यूमीनियम आधारित बेंटोनाइट और बायोचार उत्पाद द्वारा ऑक्सीटेट्रासाइक्लिन के बायोएकुमुलेशन का प्रतिबंधन

ऑक्सीटेट्रासाइक्लिन (ओटीसी) जलीय कृषि में रोग उपचार के लिए अनुशंसित रोगाणुरोधी पदार्थों में से एक है। भारत में ऐसी सिफारिश करने के लिए पर्यावरण में इसके परनेवाले प्रभाव का मूल्यांकन करने की आवश्यकता है। भारतीय परिस्थिति में फोटो-डीग्रेडेशन के माध्यम से ३० पीपीटी लवणता पर ओटीसी का दो घंटे में 85% गिरावट पाया गया। एल्यूमीनियम स्तंभित बेंटोनाइट (92%) और बायोचार (90%) बायोएकुमुलेशन को रोकने में सछम पाया गया।

पीनियस मोनोडॉन में आई.ए.पी. जीन का विश्लेषण

एपोप्टोसिस के अवरोधक प्रोटीन का समूह कोशिका मृत्यु को अवरुद्ध करता है। पीनियस मोनोडॉन में आई. ए. पी. जीन की पहचान 2-डी जेल इलेक्ट्रोफोरेसिस के द्वारा किया गया । कैटेचोल ओ-मिथाइलट्रांसफेरेज़ की पहचान आई. ए. पी. को dsRNA के द्वारा नॉकडाउन के 48 घंटे के पश्चात पता लगा । यह प्रोटीन सिग्नल ट्रांसडक्शन पाथवे, डीएनए मरम्मत और संश्लेषण, एपोप्टोसिस और सेल चक्र विनियमन में शामिल है।

Executive Summary

FINFISH BREEDING AND SEED PRODUCTION

Success was achieved in captive fry production of grey mullet, inching a step closer towards domestication. Volitional spawning was recorded in grey mullet female (ABW, 800 g; oocyte size, 530 µm) stocked with two milting males after 14 h of resolving dose of LHRHa administration. Newly hatched larvae 30,000 numbers were reared using live and artificial feeds). After 40 days of rearing, the larvae reached fry size of 16.65±1.12 mm (SL), and 110 fingerlings are being maintained.

Captive breeding of mangrove snapper *Lutjanus argentimaculatus* was achieved during July 2019 by administering hCG hormone @ 1500 IU/kg body weight. Successful spawning was observed after 36 hours and a total of 2.2 lakh eggs spawned with the fertilization and hatching rate of 70 % and 75%, respectively. A total of 1.1 lakh larvae obtained and reared up to 10 days of post hatch.

A total of 14 breeding trials conducted in silver moony (*Monodactylus argenteus*) with 11 successful spawnings helped to fine-tune the seed production technology. The fecundity varied between 1500 and 4000 numbers in each spawning with fertilization and the hatching rate varied from 60-80% and 55-85%, respectively.

Rearing of Hilsa, *Tenualosa Ilisha* (F1-Stock) was attempted in two types of rearing systems, recirculatory aquaculture system (RAS) and pond based rearing system. A total of 2000 hilsa sub-adult (Total length, 15-22 cm; weight, 11-18 g) is being maintained in these systems by feeding with artificial feed with a objective ofdeveloping them as viable captive broodstock.

A total of 2,17,154 seabass seeds produced from hatchery were supplied to 20 farmers and entrepreneurs from Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Kerala, Goa and Gujarat and an amount of Rs. 7,58,250 was realized as revenue through sales.

A total of 91500 milkfish seed produced from fish hatchery were supplied to the farmers and an amount of Rs.3.27 lakhs was realized through seed sales.

NURSERY REARING DEMONSTRATION FOR FINGERLING PRODUCTION

Demonstrated nursery rearing, pre-grow out and grow out cage culture of seabass with the participation of women self-help groups, from Sindhudurg Dist., Maharashtra under the Mangrove cell project, Govt. of Maharashtra. The women self-help groups generated revenue of Rs.12.75 lakhs through the sales from cage farmed seabass and advanced fingerlings.

Nursery rearing of *Mystus gulio* in net cages (hapa: 2×1×1 m) with four feeding frequencies (1, 2, 3 and 4 times/ day) at 300 fry/ hapa resulted in the highest growth (1.30±0.32 g) with better FCR and survival at 3 times feeding a day in 60 days.

Nursery rearing methodology/ technology of hilsa was developed. In this system, a 90 days nursery rearing in earthen pond produced around 5000 fry (3-7 cm, 0.18-2.4 g) with the survival percentage of 2-3%.

DEVELOPMENT OF GROW-OUT CULTURE MODELS

To promote milkfish, *Chanos chanos* farming in west coast of India, a monoculture demonstration was conducted in collaboration with the fisheries department at Chirayinkeezh farmers' co-operative society, Kollam, Kerala. Milkfish seed of 2400 numbers (tl.2.5 cm, 36 dph) were stocked in 1 acre area having salinity 15-23 ppt resulting

in total production of 1-tonne milkfish (ABW 550 g; MBW 750g) with the survival of 90%

In multiple stocking and multiple harvesting of milkfish culture, two treatments with 7500 and 15000 numbers/ ha stocking density exhibited higher production of 3.8 ton/ ha with BCR of 1.66 in the higher density compared to 3.0 ton/ ha with BCR of 1.50 in the low-density culture.

Milkfish grow out culture was successfully operated for 200 DOC in Inland saline ponds of Mathura, Uttar Pradesh. Total 3.0 t milkfish was harvested with 71 % survival rate. Harvested milkfish were sold in different fish markets in Delhi where they fetched a price of Rs. 120 – 180/Kg. The net return was Rs.207, 650.

DOMESTICATION OF INDIAN WHITE SHRIMP, *PENAEUS INDICUS*

The current exclusive reliance of shrimp industry on exotic *Penaeus vannamei* is severely constrained by emerging diseases and declining production performances. As an initial phase of the large scale domestication and genetic improvement program of native *Penaeus indicus*, domesticated lines (G_1 and G_2) of this species were developed. Growth and reproductive performance of these lines were studied; additionally these characteristics were compared with wild broodstock. Broodstock rearing was carried out in both earthen pond and indoor concrete tanks. The G_2 lines grew faster than G_1 lines, and within 135 days of culture (including 45 days of nursery), and 80% of animals attained impregnation. The current findings demonstrated that G_2 line showed better reproductive performance than the G_1 line corroborating the hypothesis that issues of reproduction become less problematic during the course of domestication. Reproductive performance of domesticated line is slightly lower than wild broodstock, and it is mainly due to the large body weight (possibly higher age) of wild caught animals. In order to circumvent the issues of biosecurity when broodstocks are grown in earthen ponds, an indoor sand lined recirculation systems was developed, and animals (G_1 lines) were reared. The reproductive performance of tank raised animals was lower than earthen pond system, and therefore, dietary and endocrine manipulations are being carried out to refine the system.

EFFECT OF WSSV INFECTION ON REPRODUCTIVE MATURATION OF INDIAN WHITE SHRIMP, *PENAEUS INDICUS*

Screening of broodstock for white spot syndrome virus is the most critical step in the penaeid hatchery production cycle. The dynamics of this virus during the reproductive maturation/gametogenesis is crucial for understanding the transmission of virus between generations, the vertical transmission. Reproductive tissues (ovaries and spermatophores), fertilized eggs and larval stages (protozoea and Mysis) of 120 of second step positive brooders (based on pleopod samples) were diagnosed for WSSV, and revealed that more than 50% of reproductive tissues were infected with WSSV. However the level of infection was found to be extremely low particularly in the ovaries in the advanced stage of gametogenesis and fertilized eggs. On the contrary first step step PCR positive wild brooders had regressed ovary indicating that higher level of infection hinders final ovarian maturation.

SPERMATOPHORE QUALITY IN RELATION TO AGE OF CAPTIVE REARED *PENAEUS INDICUS*

Optimization of sperm quality is a prerequisite for the management of shrimp broodstock. The in depth knowledge on sperm quality in relation to age is crucial in selecting males for breeding program or hatchery production. Therefore the effect of age on sperm quality of *P. indicus* during complete broodstock production cycle from juveniles (30 days old) to adult (180 days old), was assessed. The first occurrence of spermatophore was found at the age of 90 days and highest sperm quality index was found at the age of 180 days.

BIOFLOC BASED NURSERY REARING SYSTEM

Two phased production system, nursery phase and final grow out, has been recognized as in important strategy for sustainable intensification of brackishwater shrimp culture. Biofloc based system has been well acknowledged as an efficient method for intensive nursery production with less water usage. Several experiments were carried out to standardize economically viable and sustainable biofloc based system. In the first study, effect of probiotic (*Bacillus tequilensis*) supplementation on growth, survival and microbiota of *Penaeus indicus* reared in different combinations of

biofloc and probiotics were examined. The system having biofloc and probiotic strain produced better production. Further, effect of enzymatic strains (*Novosphingobium* sp. and *Marinilactibacillus piezotolerans*) on the growth and immunological changes on *P.indicus* under biofloc system was standardized. *M. piezotolerans* with biofloc system produced better results and improved the health status of the animal. Biofloc based rearing was carried out at farmer's field. Nursery trial with pre-grow-out culture were undertaken in field trials (2000 to 2500 PLs/ m3-3 weeks); -Survival rate: 92-94 %; ABW: 0.26 ±0.09 g; Pre-Growout-3-4 g in 4-5 weeks was observed.

EFFECT OF PERIPHYTON MAT FOR NURSERY REARING OF *P. INDICUS* IN TANK SYSTEM

Periphyton based nursery rearing of *P. indicus* were carried out in a tank system by following the principle of aquamimicry concept. Post larvae of *P. indicus* (PL13) were reared in FRP tanks at the rate of 1000 PL/m^3 for a period of one month at 32 ppt salinity in triplicate. The overall result suggested that aquamat based nursery rearing in tank based system can enhance the growth and survival of *P. indicus*. Hence the farmers can do nursery rearing in tank based system while preparing the pond for next culture and also reduce culture duration to maximize shrimp production.

BREEDING AND HATCHERY TECHNIQUES OF POLYCHAETES

Polychaetes have long been used as indispensible maturation diet in shrimp hatcheries due to its high nutritional profile and maturation inducing hormones across the world. Owing to the high incidence of WSSV, and EHP in wild caught polychaete, the wild collection of polychaete has become serious issue. As a prerequisite for the development of SPF polychaete the larval rearing and grow out protocol of potential polychaete candidate species (*Perinereis sp., Nemalycastis sp., and Marphysa sp*) were carried out. The life cycle of polychaete from eggs to adult was completed in the laboratory and described.

CORE GUT MICROBIOTA OF *PENAEUS INDICUS*

The core gut microbiota of wild and aquacultured P. indicus was studied employing 16S rRNA high-throughput sequencing. The core microbiota at the phylum level consisted mainly of *Proteobacteria, Fusobacteria, Tenericutes* and *Firmicutes*, although significant differences were found in their relative abundances between wild and aquacultured. The dominant genera in case of wild was *Photobacterium* (29.5%) followed by *Propionigenium* (13.9%), *Hypnocyclicus* (13.7%) and *Vibrio* (11.1%); in case of aquacultured it was dominated by *Vibrio* (46.5%) followed by *Catenococcus* (14%), *Propionigenium* (10.3%) and *Photobacterium* (8.7%).

PERFORMANCE OF NURSERY REARED SEEDS IN FARMING

Penaeus vannamei was stocked at a stocking density of 28 no's/ m2 for a period of 80-85 days in order to assess the growth performances of nursery reared shrimp compared to direct stocking. The treatment include, T1: direct pond stocking, T2: biofloc (0.5g/tank) reared shrimp and T3: biofloc (@1g/tank) reared shrimp. T1, T2 and T3 recorded final ABW of 11.36, 7.33 and 10.77 g at the end of culture and survival was highest in T3 (67 %) followed by T1 (62%) and T2 (63%).

CO-CULTURE OF MUDCRABS AND *MYSTUS GULIO*

Poly culture has been considered to be one of the efficient way to economize the natural resource, and improve the pond productivity. Co-culture of mud crab (*S. olivacea*) in box system is carried out with *M. gulio*. The stocking density of mud crab @50 no's/ 100 m and gulio @5 no's/ m^2. The initial weight of mud crab was 38.06 g and *M. gulio* was 0.45 g. After 65 DOC, mudcrab and *M. gulio* attained 71.03, 72.90, 73. 42g and 1.8, 2.0 and 1.7g in T1, T2 and T3 respectively.

INTEGRATED MULTI-TROPHIC AQUACULTURE IN TIDE FED POND OF SUNDARBAN, WEST BENGAL

Integrated multi-trophic aquaculture (IMTA) provides the by-products, including waste, from one aquatic species as inputs viz., feed and fertilizer to another. Commercially important seaweed, *Gracilaria tenuistipitata*, and two commercially important brackishwater species i.e. *Chanos chanos* (milk fish) and *Crassostrea cuttackensis* (edible oyster) were cultured along with *Gracilaria* sp. Results showed that biomass production of seaweed was significantly ($p < 0.05$) higher in IMTA pond compared to monoculture pond.

ASSESSMENT OF RESOURCE CHARACTERISTICS AND ENVIRONMENTAL CONDITIONS

The water bodies and different land-use classes such as agriculture, aquaculture, abandoned aquaculture, water bodies, mudflat, reserved/ scrub forest, salt pan, abandoned salt pan, sand, scrub/hill, built up, mining/industries and waterlogged have been mapped for five coastal districts of Maharashtra. The studies were carried out for mapping of unused land resources for the expansion of brackishwater Aquaculture in Tamil Nadu. Six districts of Tamil Nadu namely Villupuram, Cuddalore, Pudukottai, Toothukudi, Thiruvarur, and Thanjavur were mapped for land and water resources.

SALINITY MAPPING AND MODELLING OF THIRUVALLUR AND KANCHIPURAM DISTRICTS OF TAMIL NADU

Coastal watershed based surface and subsurface salinity mapping and modelling of Thiruvallur and Kanchipuram districts, has been carried out for sustainable brackishwater aquaculture. The salinity profile of the water will help to identify potential zones for different species to be raised as aquaculture species in natural ecosystem

DIAGNOSTIC METHODS FOR PATHOGEN SCREENING

A monoclonal antibody-based indirect ELISA was developed and optimized to detect and quantify immune response against Nervous necrosis virus in Asian seabass.

A recombinant protein vaccine consisting of the capsid protein of Nervous necrosis virus was developed and was found to induce a significant immune response when administered intraperitoneally to Asian seabass broodstock.

UNDERSTANDING OF THE DYNAMICS BETWEEN HOST AND PATHOGEN AND ITS VARIATION WITH TIME.

The interaction between host and pathogen is dynamic and varies during the course of infection. Therefore, in order to fully understand the mechanism of WSSV infection it is essential to characterize these dynamic changes in gene expression in infected shrimp. RNA-seq approach was used to contrast gene expression changes in gills of *Penaeus vannamei* at different stages of infection, namely 1.5, 18 and 56 hours-post-infection (hpi), between WSSV-challenged shrimps and control shrimps. About 5097 differentially expressed genes (DEGs), grouped in 9 temporal patterns of expression were identified. 63 DEGs were viral genes with two different temporal expression profiles and the remaining DEGs, grouped into different pathways, revealed how multiple cellular processes were dynamic during the course of infection. These data offer novel insights into the cellular functions that are affected during the course of infection and ultimately provide a valuable resource towards our understanding of the dynamics between host and pathogen and its variation with time.

EXPRESSION OF OSMOREGULATORY GENES IN *SIGANUS JAVUS*

The expression of osmoregulatory genes, prolactin (prl) and prolactin receptors (prlr), were higher in gills in *S. javus* indicating it to be a major osmoregulatory organ for osmotic-stress adaptation as they are in direct contact with the aquatic environment.

STABILITY OF WSSV IS LINKED TO HOMOLOGOUS GENES

The presence of homologous DNA synthesis related enzymes like ribonucleotide reductases and thymidylate synthetase in WSSV indicates their functional role in viral genome replication, persistence of infection and capacity to infect a wide range of host.

DELETION HOTSPOTS IN WSSV GENOME

The WSSV genome has three deletion hotspots which are wsv481/wsv499, wsv237/ wsv241 and wsv178/wsv180. Few envelope proteins, VP41A, VP52A, VP35 and an immediate early protein were identified to be present in these hotspots.

PUTATIVE MARKERS FOR IDENTIFICATION OF WSSV ISOLATES

The coding sequences that are completely lost in only one isolate of WSSV were identified as putative markers for isolate identification. These markers would have value in epidemiological investigations and monitoring pathogen movement.

FIRST OPEN-ACCESS SNP SEARCH DATABASE FOR SHRIMP

The dbVAST database has been developed containing about 27,991 and 21,970 SNPs for *P. indicus* and *P. vannamei* respectively and is available for identifying SNPs in candidate transcripts.

SCAFFOLD-LEVEL ASSEMBLY OF *P. INDICUS* GENOME

The genome of *P. indicus* with a length of 1.93 Gb and N50 length of 34 Mb was assembled in 12,460 scaffolds. To our knowledge, the assembled *P. indicus* genome is the best among crustaceans, including the recently published *P. vannamei* genome based on N50 statistics.

GUT MICROBIAL COMPOSITION OF SHRIMP INFECTED WITH WHITE FECES SYNDROME

Gut microbial composition of shrimp infected with White Feces Syndrome reveals that, the microbial colonies in disease group represent mostly pathogenic, mucin and chitin degrading and involved in producing toxins, while the microbial colonies found in control group are mostly related to bioremediation, mineralization of metabolic wastes and probiotic in nature.

PAN-GENOME ANALYSIS OF *VIBRIO* SPP

Downstream analysis of genomes of important *Vibrio* spp. through Pan-genome analysis and the identified unique genes resulted in 312 antibiotic resistance genes, 430 genes coding for toxin and antitoxin systems along with 4802, and 4825 putative virulent genes from genomic island regions and unique gene sets, respectively.

AQUASIM

Software named "**Aquasim**" was developed for simulating biomass and nitrogen dynamics with varying inputs of pond parameters, soil and water, feed and weather parameters.

KARYOTYPING OF *ETEROPLUS SURATENSIS* AND *P. INDICUS*

The chromosome pattern of pearlspot fish was studied by karyotyping. The fish had 48 diploid chromosomes (2n=48) in their cells. It consisted of 21pairs of Metacentric, two pairs of Submetacentric and a pair of Subtelocentric. *P. indicus* was observed to have 44 haploid chromosomes. The identified chromosome pattern would be useful as secondary species confirmation methods.

AMPLIFICATION AND CLONING OF PROMOTER REGIONS OF FISH GENES

Approximately a 2.5 kb of the region upstream of the putative translational start site for each of the promoter genes, including taube nuss-like gene, the eukaryotic elongation factor 1-gamma gene, and the beta-actin-1 gene (3.5 kb) from zebra fish and the myosin light chain 2 gene of rice fish were independently cloned into a cloning vector Pmini T 2.0 for gene expression studies.

DEVELOPMENT OF PRIMARY CELL CULTURE

Primary cell culture of Milkfish brain, kidney and liver and Pearlspot brain and kidney were developed and the cells were further passaged to develop a stable cell line.

AQUASTAT

The database on Aquastat India 2019 was updated and major content was put online also on the CIBA website. Additional chapters on brackishwater aquaculture contribution to the Indian economy. Production and export of ornamental fish and a note on clarification on Penaeus genus classification were included.

LIVELIHOOD SECURITY

Technology interventions viz.,nursery rearing of Asian seabass, Milkfish and Pearl spot in resource poor aquafarms in Tiruvallur and Nagapattinam districts of Tamil Nadu yielded an average income of Rs. 7000 to Rs.25000 per farmers group.

IMPACT OF *P. VANNAMEI* INTRODUCTION

SPF-PV is a high value export item. Out of 7 billion USD worth seafood exports during the financial year 2017-18, frozen shrimp contributed 5 billion USD, which consists mainly of SPF-PV. India was the lead exporter of the global shrimp market with 36% market share (FAO, 2019). The total economic surplus generated by SPF-PV is estimated at Rs.3, 96,156 crores during the 9 years (2009-10 to 2017-18). The Internal rate of Returns is estimated at 51%. The estimated ratio between consumers and producers surplus is 66%:33%. Reduced diseases under bio secure conditions have made per ha productivity to 6.42 t/ha in the triennium ending 2018 compared to 1.4 t/ha of pre vannamei scenario (before 2009).

WASTE TO WEALTH

Waste to wealth concept as an alternative livelihood activity for the fishers in their village was introduced. The institute has also established a "Fish Waste Processing Unit" at Chennai for the production of Plankton^{Plus} and Horti^{Plus} from fish waste sourced from fish markets.This technology has the potential to clean the fish markets across the country and also in providing alternative livelihoods to produce

wealth from waste as a concept of the circular economy.

CHARACTRISATION OF SHRIMP CULTURE SOURCE WATERS AND POND SOILS OF KANNUR DISTRICT, KERALA

Out of 56 soil and 80 water samples from Kannur District, Kerala about 41 per cent soils were of clay loam texture followed by loam (25%). Soil pH and organic carbon content were less than 7 and 0.5% in 46 and 55 per cent soils, respectively. Many soils had less than 10 mg (54%) and 2 mg (84%) available nitrogen and phosphorus per 100 g soil. Many source waters had pH greater than 7 (82%), less than 100 ppm alkalinity (61%), less than 30 NTU turbidity (79%), 10 to 15 ppt salinity (62%), 100 to 200 pm calcium (57%), 600 -900 ppm magnesium (55%), and 80-10 ppm potassium (57%).

IONIC PROFILE AND ENZYME ACTIVITY OF SHRIMP EXPOSED TO A GRADUAL REDUCTION IN SALINITY

An increase in Na-K-ATPase enzyme activity and ionic concentration of calcium, magnesium, potassium and sodium in Pacific white shrimp, *P.vannamei* exposed to a gradual reduction in salinity by 5 ppt from 25 to 0 ppt at 24 h interval, supports the adaptability of animals at lower salinities. The ionic profile of the animal (Ca>K>Na>Mg) was different from the profiles of the serum (Na>Ca>K>Mg) and the water medium (Na>Mg>Ca>K).

OPTIMAL CONCENTRATION OF MINERALS REQUIRED IN LOW SALINE *P. VANNAMEI* CULTURE SYSTEM

A minimum concentration of 150, 260, 120 and 1200 ppm of Ca, Mg, K and Na were required for optimum growth of *P.vannamei* as evidenced by the survival, weight gain, specific growth rate, thermal unit growth coefficient, osmolality and Na-K ATPase activity of the animals reared in 2 ppt at varying concentration of minerals for a period of 90 days.

EFFICIENCY OF CLARIFYING AGENTS ON TURBIDITY REDUCTION UNDER VARYING SALINITIES

Poly electrolyte application @ 0.5 and 1.25 ppm reduced 90% of the clay turbidity in 5 and 15 & 30 ppt, waters respectively and can be used as a potential clarifying agent on par with poly aluminium chloride (PAC) and alum, with an additional advantage of without affecting the water quality parameters such as pH and alkalinity unlike alum and PAC.

EFFICIENCY OF CALCIUM HYPOCHLORITE ON WSSV INACTIVATION IN SOILS VARYING IN TEXTURE

Bleaching of WSSV inoculated soils varying in texture (@ 105 copies/kg soil) with calcium hypochlorite @ 10, 20 and 30 ppm chlorine showed high residual chlorine content after 24 h in soil-water microcosm of loamy sand followed by silty clay and clay loam in all the chlorine treatments. *P.vannamei* reared in the microcosm revealed a chlorine requirement of 10 ppm for loamy sand and 20 ppm for clay loam and silty clay soils for WSSV inactivation. The chlorine demand of fine textured soil was higher than that of coarse textured soil and require higher dose of calcium hypochlorite for WSSV inactivation.

EFFECT OF REARING WATER TEMPERATURE ON WSSV INDUCED MORTALITY IN *P.VANNAMEI*

Effect of water temperature on WSSV infection and disease progression in shrimp *P. vannamei* showed a rapid increase in WSSV copy number in shrimp infected with WSSV and the host succumbed at or below 33°C. Contrastingly, at 35°C, no mortality of host occurred and WSSV copy number remained significantly low. The study provide information on susceptibility or resistance of host to the virus, though virus can survive in the host at higher temperature, does not develop disease.

COMBINED EFFECT OF ALKALINITY AND TURBIDITY STRESS ON *PENAEUS VANNAMEI* AND ITS SUSCEPTIBILITY TO WSSV

The shrimps exposed to three levels of individual alkalinity 100, 300, and 600 mg/L, three levels of turbidity 30, 60 and 120 NTU and combination treatments for three weeks and then challenged orally with WSSV showed 1.2 - 5.7 times, 0.8 - 9.8 times and 4-17 times more risk of dying in individual alkalinity, turbidity and combination treatments, respectively compared to control. Post stress WSSV challenged shrimps in individual alkalinity and turbidity treatment showed median survival (50% mortality) of 4 to 7 days and 3 to 7.5 days, respectively compared to combination treatments (2.5 to 4 days), indicating more risk of susceptibility under combined treatments. Based on total haemocyte count, phenol oxidase and superoxide dismutase activity, gills colour change and SEM

images of gills and carapace of the shrimps, it was evident that 100 mg/l alkalinity X 120 NTU turbidity treatment combination caused the animal to prone to more stress and resulted in reduced survival rate and highly susceptible to WSSV.

CHRONIC AND CYCLIC TEMPERATURE SENSITIVITY OF MILKFISH IN DIFFERENT LIFE STAGES

Newly hatched milkfish larvae (0 to 21 dph) stocked @ 2.5 larvae L-1 over three larval rearing cycles of each 21 days cycle during March to June 2019 coinciding with equinox and summer solstice showed reduced larval survival at water temperature above 30°C by reducing preying performance. A chronic heat shock study with fry (30 dph) at 28, 30, 32 and 34 oC showed maximum mortality at 34°C (52 %) followed by 24% at 32°C and below 9.5 % at 30°C during first 72 h and less recovery at higher tempaeratures after thermal stress. It is not advisable for Milkfish nursery rearing beyond 32°C water temperature. Stunted milkfishes are more temperature resilient as evidenced by 41 % survival even at 24 h chronic stress.

DIETARY AND MICROBIAL INTERVENTIONS FOR ABATEMENT OF GREENHOUSE GASES EMISSION

Shrimp diets prepared by incorporating various levels of raw groundnut oil cake (GNC) and solid state fermented GNC @ 5, 7.5 and 10% of each separately were fed to the juveniles of P. vannamei for 45 days of growth trail and then six shrimp were transferred to 100 litre FRP tank specifically designed for measuring the GHGs emission. Nitrous oxide emission was significantly different and, carbon-di-oxide and methane were not influenced by the dietary treatments. Bacillus strains @ 106 CFU/ml mitigated N2O and CO2.

ENVIRONMENTAL IMPACT ASSESSMENT OF SHRIMP AQUACULTURE ON SOIL AND DRINKING WATER SALINISATION

EIA study was initiated from November 2019 onwards in Bhemanapalli, Cheyyuru Jaligunta & Penumalla, and Uppumili Villages in Uppalaguptam, Katrenikona and Kajuluru Mandals respectively in East Godavari District, Andhra Pradesh on the request of District Collector, to investigate the impact of shrimp aquaculture on drinking water sources, soil salinization, agriculture and coconut gardens. Water samples from the intake (source) and outfall (discharge) of selected shrimp farms and soil samples from shrimp culture ponds, near and away from the shrimp farms at different distances towards paddy fields and coconut gardens were analysed at monthly intervals. Preliminary results indicated that salinization was site specific and historical data is not available to blame that shrimp aquaculture is the cause of salinization and the present study can serve as the baseline data for future comparison.

ANTARCTIC KRILL MEAL AS SPECIALITY FEED INGREDIENT

An 8 week long experiment with white leg shrimp in controlled indoor conditions in a flow through rearing system tested influence of krill meal inclusion (0, 2, 4 and 6%) at two levels of fishmeal inclusion (6 and 12%). Shrimp fed the 12% fishmeal + 6 % krill meal had highest weight gain of 11.61 g. The study proved the beneficial effects of krill meal in shrimp diets, and established that inclusion level of 4% is minimum to express the difference in the performance of shrimp irrespective of fishmeal level.

BLACK SOLDIER FLY (BSF) MEAL AS NOVEL FEED INGREDIENT

Use of BSF meal in aquafeeds is an emerging concept, where biowaste are converted in to useful biomass efficiently, which in turn result in clean environment and effective utilization of biomass. The nutrient composition of BSF meal (20-25 days old0 revealed that it had 40-45% crude protein with 23-27% crude lipid content. An eight - week feeding trial with white leg shrimps shown promising first-hand results. BSF meal can be used as a sustainable alternative to fish meal and it can be included upto l15% in the diet of white shrimp, *P. vannamei* without any deleterious effect.

CONCLUSION TO THE DAY AND NIGHT FEEDING DEBATE IN WHITE SHRIMP

There is active debate among the stakeholders on choice of feeding time day or night. We conducted a planned experiment in white leg shrimp under captive condition. Results of the experiment showed better performance with shrimps fed continuously covering both day and night, performance almost similar in the treatment fed either in day or night.

PLANKTON*PLUS* SHOWED

PROMISING RESULTS WITH TIGER SHRIMP AND WHITE LEG SHRIMP IN FARMERS POND

Plankton^{Plus} a nutrient rich liquid product for boosting productivity of primary producers and zooplanktons in a farmer pond showed an edge in growth performance of the tiger shrimp by a difference of 1.5 g in the final weight in 75 days on addition of the product at 30 ppm. Similarly, in West Bengal, a highest production of 7.24 t/ha was achieved on use of Plankton^{Plus}. However, it was only 6.30 t/ha with commercial feed. This could be attributed to the better primary productivity and zooplanktons in the treatment.

COMPARATIVE NUTRIENT PROFILING OF JUVENILE MILKFISH AND OIL SARDINES

Milkfish is a promising candidate in brackishwater by feeding in the bottom of food chain, fast growth rate and its capability to grow in high density in green water based rearing models. Considering all this, there is scope for promoting this fish as an alternate for sardines, if nutrient profiles matches with the sardine. Irrespective of size groups oil sardine fishes were found superior in EPA and DHA, whereas the proportion of arachidonic and palmitic acids were higher in milkfish. A serving of 50 to 150 g for milkfish or 20g of oil sardine is required to meet the daily needs of EPA+DHA for adult human being.

EFFECT OF PLANKTON^{PLUS} IN POLYCULTURE SYSTEM

A 70 days trial was conducted in 500 L outdoor FRP tanks to study the effect of Plankton^{plus} in polyculture system of *Penaeus monodon* and *Chanos chanos* in zero water exchange system. Significant increase ($P<0.01$) was observed in growth parameters (ADG, SGR and Biomass gain) of *Penaeus monodon* treated with Plankton^{plus} and feed. In the case of *Chanos chanos,* when fed with feed and Plankton^{plus} showed 27 % higher growth than the treatment given only feed. Even a 20% feed reduction with supplementation of 40 ppm Plankton^{plus} showed the similar growth when fed with feed only. All the growth parameters (ADG, SGR and Biomass gain) were significantly higher ($P<0.01$) in the treatment with feed and Plankton^{plus} when compared to treatments with feed only.

FEED FOR CRAB

Formulated feed for mud crab (*Scylla olevacea*) was evaluated in box culture system at farmers' pond and pellet feed was found to be a better and economic option for rearing and maturation of mud crab compared to conventionally used trash fish.

EFFECTS OF DIETARY BLEND OF FISH OIL WITH CORN OIL IN THE DIET OF MILKFISH (*CHANOS CHANOS*) LARVAE

A growth trial was conducted to investigate the effects of fish oil and corn oil on the growth, digestive enzymes activity and fatty acid composition of milkfish, *Chanos chanos* larvae Diet which had blended fish oil and corn oil shown significantly higher growth and survival of milkfish larvae than the larvae fed diet which contained either fish oil or corn oil as the dietary lipid source.

WSSV AND EHP ARE MAJOR THREATS TO INDIAN SHRIMP FARMING

Disease surveillance carried out in 703 *Penaeus vannamei* farms in Tamil Nadu and Andhra Pradesh during 2015-2019 suggests that *Enterocytozoon hepatopenaei* (EHP) and white spot syndrome virus (WSSV) pose greater threats. Further, the disease surveillance carried out in 180 vannamei farms in the year 2019 revealed that the prevalence of WSSV - 6%, EHP - 27%, IHHNV - 3% and IMNV - 3%. While diseases like AHPND, TSV and YHV were not detected in these farms. Analysis of economic loss estimated due to EHP and WSSV in Indian shrimp farming were ₹1904 crores and ₹1681 crores respectively in addition, employment loss of 11 lakh man days during 2017-18.

EHP INFECTION WIDESPREAD IN SHRIMP FARMS IN GUJARAT, WEST COAST OF INDIA

All the eighteen shrimp farms investigated in six regions such as Matwad, Sambapur, Onjal, Panar, Mendhar baat, Maroli of Navsari district, Gujarat were found to be infected with EHP. All the eighteen shrimp farms were affected with white faeces syndrome (WFS), and seven farms were affected with size variation. However, all these farms were found negative for WSSV, AHPND, and IHHNV.

EHP INFECTION RECORDED IN SHRIMP FARMS IN INLAND SALINE AREAS OF HARYANA

Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) continue to be a major disease limiting production in Indian shrimp farming sector. Investigation of EHP in low saline inland regions of north Indian

states Haryana, Punjab and Rajasthan revealed presence of EHP by second step PCR indicating mild infection in two farms in Haryana state suggesting seed borne transmission.

NATIONAL REFERRAL LABORATORY FOR BRACKISHWATER AQUATIC ANIMAL DISEASES (NRLD)

The NRLD during 2019 tested 56 samples from the Aquatic Quarantine and Certification Services (AQCS, GOI) (Chennai, Hyderabad, Kolkatta and Navi Mumbai), samples of *Artemia* cyst (Brine shrimp eggs), frozen tissue, Qrill TM, feed samples and 24 samples from broodstock multiplication centre (BMC) for OIE listed pathogens. In addition, 56 samples from the farmers (55 PL samples and one crab sample) prior to stocking ponds were tested for the OIE listed diseases. 13 soil samples from farmer's ponds and two brooders from the hatchery were also tested for EHP.

GERMINATION OF EHP SPORES CAN BE ARRESTED BY POTTASSIUM PERMANGANATE, CALCIUM HYPOCHLORITE, SODIUM HYDROXIDE, FORMALIN AND HYDROGEN PEROXIDE

Dinfectants commonly used in aquaculture practices were evaluated for inactivation of EHP spores. Viability of spores to germinate indicated by polar tubule extrusion also suggests their ability infect new hosts. Pottassium permanganate (10, 15, 20 ppm), Formalin (100,150,200 ppm), Calcium hypochlorite (20,30,40 ppm) , Sodium hydroxide (3%,3.5%), Hydrogen peroxide (3%,4%,5%) were found effective in arresting the polar tubule extrusion of EHP spores, suggested their usefulness in reducing EHP infectios.

TILAPIA LAKE VIRUS DETECTED AT SOUTH 24 PARGANAS, WEST BENGAL

During 2019, Tilapia lake virus (TiLV) was detected in two of the eight Tilapia (*Oreochromis mossambicus*) farms of Ramganga and Sagar Island with mortality rate of 30 and 10%, respectively. TiLV was also detected in wild tilapia, *O. mossambicus and O. niloticus* from Tamil Nadu. Previous studies at CIBA have showed that TiLV could be experimentally transmitted to seabass. The study emphasizes the need to adapt biosecurity measures in seabass farming.

SEA LICE, INFESTATIONS IN PEN-CULTURED PEARLSPOT, *ETROPLUS SURATENSIS*

Mortality of pearlspot, *Etroplus suratensis* in pen culture at Ponneri village, Tamil Nadu was found to be due to heavy infestation of external parasite, *Caligus minimus*. In-feed treatment with emamectin benzoate (EMB) at a dose rate of 50 µg kg^{-1} of fish body weight (BW) day^{-1} for seven consecutive days to the infested fish stock showed that there was 100% recovery with 100% survival.

LERNAEOSIS IN ASIAN SEABASS, *LATES CALCARIFER*

An outbreak of lernaeosis was recorded in nursery rearing of Asian Seabass (*Lates calcarifer*) associated with mortality. The parasites were identified as anchor worm, Lernaea cyprinacea. EMB incorporated feed administration for ten consecutive days improved fish survival by 90%.

A CELL LINE FROM MILKFISH BRAIN DEVELOPED

A new cell line designated as MFB-1 has been established from juvenile milkfish brain tissue. The milkfish brain tissues on primary culture with L-15 medium and 20% FBS at 27°C developed and formed a monolayer with the morphology of fibroblast like cells with 100% confluency. The MFB-1 cell line can be used for infectivity studies with noda virus and to adapt and isolate unknown viral pathogens infecting milkfish.

PCR BASED DIAGNOSTIC WAS DEVELOPED FOR DETECTION OF FILAMENTOUS PHAGES

Lysogenic filamentous phages play a crucial role in virulence of several Vibrio species such as *V. cholerae* and *V. parahaemolyticus*. To analyse their presence among the species of Vibrio harveyi clade, a set of degenerate primers were developed by aligning more than 20 sequences of three different clusters of zot gene. The PCR using these primers detected presence of filamentous phages in twelve out of screened 30 isolates of *V. campbellii*.

ANGUIBACTIN BASED SIDEROPHORE SYSTEM DETECTED IN *VIBRIO CAMPBELLII*

Anguibactin plays crucial role in iron acquisition and is considered as the most important virulence factors in *V. vulnificus*. To screen their presence, 91 genomes of *V. harveyi* clade were genetically analysed. The analysis indicated that all isolates of *V. campbellii* possess genes required for anguibactin synthesis and their

translocation. However, such genes were not observed in other species of Vibrio harveyi clade.

NOVEL DIAGNOSTIC MARKERS IDENTIFIED FOR DIFFERENTIATION AND QUANTIFICATION OF *VIBRIO HARVEYI* CLADE

For developing quantitative PCR for *V. harveyi* and *V. campbellii*, and differentiation of other species of harveyi clade, a pangenome wide search of novel diagnostic markers was carried out. A total of 117 differentially conserved genes and 11 novel target genes were identified. Based on these genes primer specifically identifying *V. harveyi, V. campbellii* and *V. owensii* were developed.

RECOMBINANT PROTEIN VACCINE AGAINST VIRAL NERVOUS NECROSIS OF ASIAN SEABASS DEVELOPED

A recombinant protein vaccine based on the capsid protein gene was developed and evaluated in seabass fingerlings. Anti-NNV serum antibodies were assessed using indirect ELISA. The larvae hatched from the recombinant protein vaccinated groups had higher immune response and had better relative percent survival (94%) compared to the control (74%) when challenged with NNV at 18 days post hatch.

PREVENTING BIOACCUMULATION OF OXYTETRACYCLINE BY PHOTO-DEGRADATION AND ALUMINIUM BASED BENTONITE AND BIOCHAR PRODUCT

Oxytetracycline (OTC) is one of the recommended antimicrobial substances for treatment in food production animals including aquaculture. Before such recommendations can be made for India there is a need to evaluate the fate of such substances in the receiving environmental. In Indian climatic conditions through photo-degradation OTC degrades (85%) in two hours at 30 ppt salinity. Aluminium pillared bentonite (92%) and Biochar (90%) were shown to adsorb and eliminate OTC from the system preventing bioaccumulation which enhances the environmental safety.

IAP GENE IN *PENAEUS MONODON* CHARACTERIZED

Inhibitors of apoptosis are a group of proteins that mainly act on the intrinsic pathway that block programmed cell death. The IAP gene in *Penaeus monodon* was characterized by 2-D gel electrophoresis. Catechol O-methyltransferase was detected 48 hours of IAP knockdown by dsRNA. This protein is involved in signal transduction pathways, DNA repair and synthesis, apoptosis and cell cycle regulation.

Introduction

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

The institute was established on April 1, 1987, and serves as the nodal agency for research and development of brackishwater aquaculture in the country. Over the last 30 years, ICAR-CIBA serves as the nodal agency for research and development of brackishwater aquaculture in the country. CIBA is an organization of international repute with a vision of environmentally sustainable, economically viable and socially acceptable brackishwater aquaculture. This institute is involved in R&D related to the production of seeds in finfishes and shellfishes, genetic improvement, cost-effective feeds, environment monitoring, farm and hatchery management, disease diagnosis, disease monitoring, and capacity enhancement and technology transfer. The headquarters of the Institute is located at Chennai with an Experimental Field Station at Muttukadu, about 35 km south of the city and two Regional Research Centres, one (KRC) at Kakdwip (West Bengal), famous for the delta region called Sundarbans, and other at Navsari, Gujarat.

The Kakdwip Research Centre of CIBA is situated about 100 km from Kolkatta, in West Bengal is considered an important landmark of Kakdwip, engaged in the development of culture technologies for crustaceans and finfish. Established as early as 1973 as the first-ever experimental brackishwater farm in the country with about 30 acres of land area under ICAR-CIFRI, the latter merged with ICAR-CIBA on 1st April 1987. Presently the Research Centre has fully developed farm facility, modern analytical laboratory, wet lab facilities, feed production etc. Now, this center is fully engaged in research and technology development for the benefits of brackishwater aquaculture farmers with particular reference to Eastern India.

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

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

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

Of the 3.9 million ha of the brackishwater area estimated, 1.2 million hectares have been identified to be potentially suitable for brackish water farming. Additionally, about 9 million hectares of salt-affected inland soils in the hot semi-arid and arid eco-region of northern plains and central highlands in Haryana, Rajasthan, Punjab, Uttar Pradesh, Maharashtra, and Gujarat are found to be suitable for brackishwater farming. Estimates show that only 11% of the potential coastal area available is utilized for farming.

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

At CIBA, we support leading-edge science and research to develop customized technologies suitable for different agro-climatic conditions to grow sustainable aquaculture in India and reap its social, economic, and environmental benefits. The institute has been advocating diversification of brackishwater aquaculture with alternative shellfish and finfish species and optimally utilizing suitable brackishwater bodies with appropriate rearing systems through stakeholders' participation. We foster responsible aquaculture that provides safe, sustainable seafood; creates employment and business opportunities in coastal communities; and complements CIBA's comprehensive strategy for maintaining healthy and productive biological resources, ecosystems, and vibrant coastal communities.

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

VISION

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

MISSION

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

Mandates

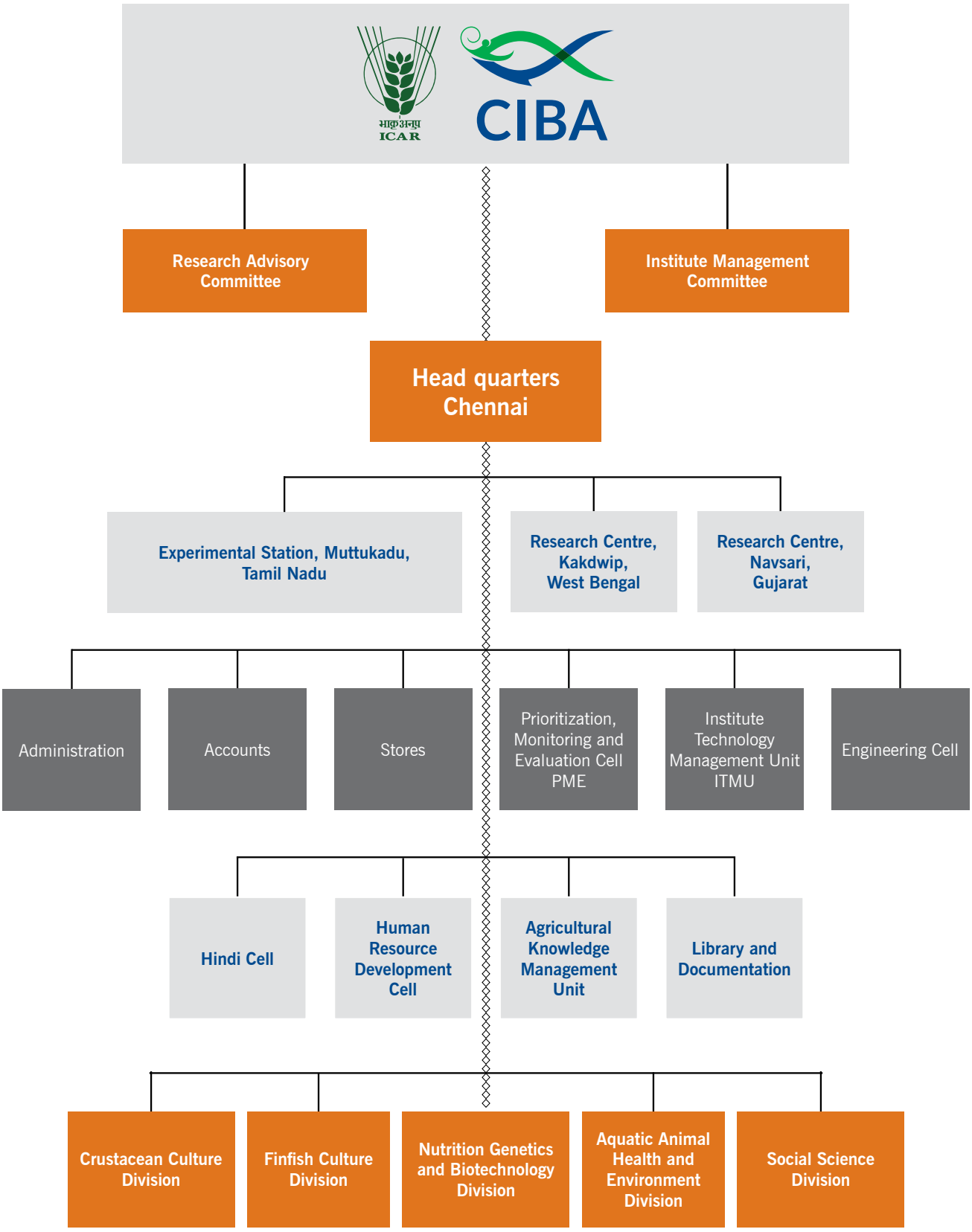
Basic, strategic and applied research for techno-economically viable and sustainable culture systems for finfish and shellfish in brackishwater.

Species and systems diversification in Brackishwater aquaculture.

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

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

Organogram


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

Unified budget of CIBA, Chennai for the year 2019

Rs. in lakhs

S. No.	Sub-Head	BE 2019	RE 2019-20	Actual expenditure (April 2019 - Dec. 2019)
	GRANTS FOR CREATION OF CAPITAL ASSETS (CAPITAL)			
1	Works - Office building	174.74	343.63	156.20
2	Equipments	62.15	61.16	31.01
3	Information Technonogy	15.00	14.65	9.69
4	Library Books and Journals	10.00	6.18	1.29
5	Furniture & Fixtures	0.00	4.27	1.18
	Sub-total (A)	**261.89**	**429.89**	**199.37**
	GRANTS IN AID - SALARIES (REVENUE)			
1	Establishment Expenses - Salaries	2129.33	2195.00	1826.95
	Sub-total (B)	**2129.33**	**2195.00**	**1826.95**
	GRANTS IN AID - GENERAL (REVENUE)			
1	Pension & Other Retirement Benefits	1609.50	1790.93	1489.42
2	Traveling Allowances	35.00	35.00	27.96
3	Research & Operational Expenses	209.00	209.00	152.75
4	Administrative Expenses	831.97	824.97	506.08
5	Miscellaneous Expenses (HRD & Others)	21.00	28.00	22.57
	Sub-total (C)	**2706.47**	**2887.90**	**2198.78**
	TSP			
1	Capital	18.00	18.00	13.92
2	Revenue	34.00	34.00	14.61
	Sub-total (D)	**52.00**	**52.00**	**28.53**
	SCSP			
1	Capital	27.72	27.72	1.75
2	Revenue	100.28	100.28	26.83
	Sub-total (E)	**128.00**	**128.00**	**28.58**
	GRAND TOTAL (A+B+C+D+E)	**5277.69**	**5692.79**	**4282.21**

Staff position

Position	Sanctioned	Filled	Vacant
Director (R.M.P)	1	1	0
Head of Divisions/Principal Scientist	5	1(Acting)	4
Senior scientists	10	6	4
Scientists	52	59	(+) 7
Technical Officers / Technical Assistants	25	22	3
Administrative Officer	1	0	1
Finance & Accounts Officer	1	1	0
Deputy Director (OL)	1	0	1
Assistant & Administrative Officer	3	3	0
Junior Accounts Officer	1	1	0
Private Secretary	1	1	0
Personal Assistants	2	2	0
Stenographers Gr.III	1	1	0
Assistants	7	6	1
Upper Division Clerks (UDC)	3	3	0
Lower Division Clerks (LDC)	5	2	3
Skilled Support Staff	28	23	5
GRAND TOTAL	**147**	**132**	**21**

On Going Research Project

CRUSTACEAN CULTURE DIVISION

INSTITUTE FUNDED PROJECTS

	Project Title	Funding	Project Team
1	Breeding biology, reproductive challenges and larviculture of candidate crustacean species of brackishwater aquaculture	**ICAR**	**PI: Dr. C.P. Balasubramanian** **Co-PIs:** Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. S. Kannappan, Dr. P. Nila Rekha, Dr. P. Shyne Anand, Ms. L. Christina, Dr. T.N. Vinay, Dr. N.S. Sudheer, Shri Jose Antony, Shri R. Aravind, Shri I.F. Biju, Dr. K.C. Neethu, Shri K.P. Sandeep
2	Novel approaches for technology refinement and upscaling of diversified systems and species of shrimp for sustainable development	**ICAR**	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. P. Nila Rekha, Dr. S. Kannappan, Dr. P. Shyne Anand, Ms. L. Christina, Shri R. Aravind, Shri Jose Antony, Dr. N.S. Sudheer, Shri I.F. Biju, Dr. T.N. Vinay, Dr. S. Sivagnanam, Shri S. Rajamanickam, Dr. K. Ambasankar, Dr. R. Geetha, Dr. T.K. Ghoshal, Dr. M. Kumaran, Dr. P. EzhilPraveena, Dr. Sanjoy Das, Dr.Suvana Sukumaran, Shri Pankaj Amrut Patil
3	Technological backstopping and promotion of sustainable aquaculture in west coast with particular reference to the state Gujarat	**ICAR**	**PI: Dr. C.P. Balasubramanian** **Coordinator: Shri Pankaj Amrut Patil** **Co-PIs:** Dr. M. Kailasam, Shri Jose Antony, Shri Tanveer Hussain, Dr. P.K. Patil, Dr. P. Mahalakshmi, Dr. R. Saraswathy, Dr. K. Ambasankar

EXTERNALLY FUNDED PROJECTS			
4	Healthy shrimp and 'GIFT' tilapia production through bio-floc based farming system: Development of technology and standard operating procedure	**DBT**	**PI: Dr. A. Panigrahi** **PI: Dr. S. Felix, VC, TNJFU** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. P. Nila Rekha, Dr. K.P. Kumaraguru Vasagam, Dr. Antony Cheryl, TNJFU, Dr. A. Gopalakannan, TNJFU
5	Optimization of aerators use to reduce production cost of shrimps under different brackishwater farming conditions	**NFDB**	**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. T. Ravisankar, Dr. M. Muralidhar, Dr. R. Saraswathy, Dr.AritraBera
6	Mapping of coastal resources and identifying suitable areas for expanding Integrated Multi-Trophic Aquaculture (IMTA) in Maharashtra	**IMTA Maharashtra**	**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. C.P. Balasubramanian, Dr. M. Muralidhar, Dr. K.P. Kumaraguru vasagam, Dr. P. Kumararaja, Shri Pankaj Amrut Patil
7	Identifying suitable brackishwater lands for increasing aquaculture area in the coastal areas of India with reference to environmental conditions and regulation using multi criteria decision support system	**ICAR**	**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. M. Muralidhar, Shri J. Ashok Kumar, Dr. R. Saraswathy
8	Coastal watershed based surface and subsurface salinity mapping and modelling of Thiruvallur and Kanchipuram districts, Tamil Nadu for sustainable aquaculture	**NABARD**	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. C.P. Balasubramanian

FINFISH CULTURE DIVISION			
INSTITUTE FUNDED PROJECTS			
9	Application of improved techniques for captive maturation, assessment of reproductive biology, system development of induced breeding, larval rearing and seed production of brackishwater candidate finfish species	**ICAR**	**PI: Dr. M. Kailasam** **Co-PIs:** Dr. M. Makesh, Dr. SatyanarayanSethi, Dr. K.P. Kumaraguru vasagam Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. AritraBera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Pankaj Amrut Patil, Shri Tanveer Hussain, Shri Dani Thomas, Shri R. Subburaj
10	Development and evaluation novel culture technologies for candidate brackishwater finfishes for sustainable aquaculture.	**ICAR**	**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Kailasam, Dr. SatyanarayanSethi, Dr. K.P. Kumaraguru vasagam Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. AritraBera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Tanveer Hussain, Shri Dani Thomas, Shri Pankaj Amrut Patil , Shri R. Subburaj
EXTERNALLY FUNDED PROJECTS			
11	Development of brackishwater aquaculture through optimisation of captive breeding protocols of potential and emerging ornamental fish species, technology transfer and livelihood generation	**ICAR**	**PI: Dr. M. Kailasam** **Co-PIs:** Dr. SatyanarayanSethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Smt. Babita Mandal, Shri Dani Thomas, Shri Tanveer Hussain, Dr. J. Raymond Jani Angel, Shri T. Sivaramakrishnan, Dr. K.C. Neethu

AQUATIC ANIMAL HEALTH AND ENVIRONMENTAL DIVISION

INSTITUTE FUNDED PROJECTS

12	Prevention and management strategies for viral, microbial and parasitic diseases of candidate species in brackishwater ecosystem	**ICAR**	**PI: Dr. S. V. Alavandi** **Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. P.K. Patil, Dr. S. K. Otta, Dr. Sanjoy Das, Dr. P. EzhilPraveena, Dr. R. Ananda Raja, Dr. Sujeet Kumar, Dr. T. Bhuvaneswari, Dr. Vidya Rajendran, Shri T. Sathish Kumar, Shri Mary Lini, Shri Joseph Sahaya Rajan, **Associates from other division** Dr. M. Makesh, Dr. N. Lalitha, Dr. Prem Kumar, Smt. Leesa, Priyadarsani, Dr. SatheeshaAvunje, Dr. B. Sivamani, Ms. Misha Soman, Dr. T.N. Vinay
13	Abiotic stress management for enhanced productivity and environmentally sustainable shrimp farming	**ICAR**	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Satheesha Avunje, Dr. Suvana Sukumaran, Dr. A. Nagavel, Dr. M. Jayanthi, Dr. J. SyamaDayal

EXTERNALLY FUNDED PROJECTS

14	National surveillance programme for aquatic animal diseases	**NFDB**	**PI: Dr. S. V. Alavandi** **Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. S.K. Otta, Dr. Sanjoy Das, Dr. Sujeet Kumar, Dr. P. EzhilPraveena, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja, Shri T. Sathish Kumar, Dr. Vidya Rajendran, Dr. Joseph Sahayarajan

15	All India network on fish health	**ICAR**	**National Coordinator: Dr. K.K. Vijayan** **PI: Dr. P.K. Patil** **Co-PIs:** Dr. S.V. Alavandi, Dr. S.K. Otta, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr.SatheeshaAvunje, Dr. M. Makesh, Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. C.V. Sairam, Dr. T. Ravisankar, Dr. R. Geetha
16	Consortium research platform on vaccines and diagnostics	**ICAR**	**Project Coordinator:** Dr. M. Makesh
	a. Development of RNAi –mediated prophylaxis and therapy of white spot syndrome virus (WSSV)		**PI: Dr. S.K. Otta** **Co-PIs:** Dr. S.V. Alavandi, Dr. M. Makesh
	b. Development of vaccine for betanoda virus infecting seabass, *Lates calcarifer*		**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Poornima, Dr. K.P. Jithendran, Dr. P.K. Patil, Dr. Sujeet Kumar
	c. Biocontrol of vibrios in shrimp hatcheries using bacteriophages		**PI: Dr. S.V. Alavandi** **Co-PIs:** Dr.SatheeshaAvunje, Dr. Vidya Rajendran, Dr. Sujeet Kumar, Dr. Joseph SahayaRajan
	d. Development of probiotics and immunostimulants for shrimp		**PI: Dr. P.K. Patil** **Co-PIs:** Dr. S.V. Alavandi, Dr.SatheeshaAvunje, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja

	e. Development of improved diagnostics to existing and emerging pathogens of shrimp and fish		**PI: Dr. M. Makesh** **Co-PIs:** Dr. S.V. Alavandi, Dr. P. Ezhil Praveena, Dr. M. Poornima, Dr. S.K. Otta, Shri T. Sathish Kumar, Dr. Vidya Rajendran, Dr. Joseph SahayaRajan
	f. Development of prophylactic strategies for the control of *Enterocytozoon hepatopenaei* (EHP)		**PI: Mr. T. Sathish Kumar** **Co-PI:** Dr. Joseph SahayaRajan
	g. Development of diagnostics for differentiation and quantification of pathogenic Vibrio harveyi clade species		**PI: Dr. Sujeet Kumar** **Co-PI:** Mr. T. Sathish Kumar, Dr. Joseph SahayaRajan
17	Network project on antimicrobial resistance	**ICAR**	**PI: Dr. S.K. Otta** **Co-PIs:** Dr. Satheesha Avunje, Dr. Vidya Rajendran
18	National Innovations in Climate Resilient Agriculture (NICRA)- Development of adaptation strategies and mitigation options for climate resilient and carbon neutral aquaculture		**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. M. Jayanthi , Dr. J. SyamaDayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Dr. S.K. Otta, Shri J. Ashok Kumar, Dr. N. Lalitha, Dr. P. Kumararaja, Dr.AritraBera, Dr.SatheeshaAvunje, Dr.SuvanaSukumaran , Dr. A. Nagavel

NUTRITION, GENETICS & BIOTECHNOLOGY DIVISION

INSTITUTE FUNDED PROJECTS			
19	Application of advanced molecular and bioinformatic tools for improvement of brackishwater fish and shell fish	**ICAR**	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr.K.K. Vijayan, Dr. Sherly Tomy, Shri J. Ashok Kumar, Dr. K. Vinaya Kumar, Dr. B. Sivamani, Dr. J. Raymond Jani Angel, Ms. Misha Soman
20	Novel approaches for development and improvement of sustainable shrimp and fish feeds	**ICAR**	**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru vasagam, Shri K.P. Sandeep, Smt. Leesa Priyadarsani, Shri T. Sivaramakrishnan
EXTERNALLY FUNDED PROJECTS			
21	Outreach activity on fish feeds and nutrient profiling of brackishwater fish and shrimp	**ICAR**	**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru vasagam, Smt. Leesa Priyadarsani, Shri T. Sivaramakrishnan
22	Whole genome sequencing of Indian white shrimp *Penaeus indicus*	**ICAR**	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. C. P. Balasubramanian, Shri J. Ashok Kumar, Dr. K. Vinaya Kumar, Dr. S.K. Otta

23	Poverty alleviation through prevention and future control of the two major socio economically important diseases in Asian aquaculture	**DBT**	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. K.K. Vijayan, Dr. K. Vinaya Kumar, Mr. T. Sathish Kumar
24	Metagenomic investigations on white feces syndrome in shrimp aquaculture	**ICAR**	**PI: Shri J. Ashok Kumar** **Co-PIs:** Dr. S.V. Alavandi, Dr. M. Shashi Shekhar, Dr. K. Vinaya Kumar, Dr. Joseph Sahaya Rajan, Dr. M. Grover

SOCIAL SCIENCES DIVISION

INSTITUTE FUNDED PROJECTS

25	Research on socio-economics, frontline extension and information technology for sustainable brackishwater aquaculture sector	**ICAR**	**PI: Dr. C.V. Sairam** **Co-PIs:** Dr. T. Ravisankar, Dr. B. Shanthi, Dr. D. Deboral Vimala, Dr. M. Kumaran, Dr. P. Mahalakshmi, Dr. R. Geetha, Dr. K.C. Neethu

EXTERNALLY FUNDED PROJECTS

26	Brackishwater cage culture with multi-trophic candidate species diverse rearing systems for alternate livelihood and societal development in Maharashtra	**Mangrove cell Maharashtra**	**PI: Dr. C.V. Sairam** **Co-PIs:** Dr. M. Kailasam, Dr. C.P. Balasubramanian, Dr. Pankaj Amrut Patil, Shri Tanveer Hussain, Shri T. Sivaramakrishnan, Shri K.P. Sandeep

27	Cage culture in brackishwaters of Puducherry and karaikal regions of Puducherry Union Territory A - feasibility study	**FIMSUL**	**PI: Dr. M. Kumaran** **Co-PIs:** Dr.M. Jayanthi, Dr. D. Deboral Vimala, Dr. C.V. Sairam, Dr. M. Muralidhar, Dr. K.P. Kumaraguru vasagam, Smt. Babita Mandel, Shri R. Subburaj
28	Knowledge and Economic Empowerment of women, tribal and their families in coastal villages of Tamil Nadu through adoption of brackishwater aquaculture and allied technologies integrated with societal development programmes	**CPCL**	**PI : Dr. B. Shanthi** **Co-PI : Dr. C.V. Sairam** Shri T. Sivaramakrishnan
29	Sustainable livelihood models for resource poor fish farmers/fisher folks in Nagapattinam district of Tamilnadu for doubling their income	**CPCL**	**PI : Dr. D. Deboral Vimala** **Co-PI :** Dr.C.V.Sairam, Dr. M.Kumaran, Dr. K.P. Kumaraguru vasagam, Dr.P.Nila Rekha, Dr.P.Mahalakshmi, Smt. Babita Mandal
30	Development and Validation of Smart Aquaculture Model (SAM): Application of ICT and Data analytics for sustainable shrimp aquaculture	**NASF**	**PI : Dr. M. Kumaran** **Co-PI :** Dr. M. Muralidhar, Dr. D. Deboral Vimala, Dr. K. Ambasankar, Dr. P. Mahalakshmi, Shri J. Ashok Kumar, Dr.T. Sathish Kumar, Shri Jose Antony, Shri S. Nagarajan

KAKDWIP RESEARCH CENTRE

INSTITUTE FUNDED PROJECTS			
31	Development and dissemination of economically viable and sustainable brackishwater aquaculture technologies for livelihood improvement of small and marginal farmers of Indian Sundarban	**ICAR**	**PI: Dr. Debasis De** **Co-PIs:** Dr. T. K. Ghoshal, Dr. Sanjoy Das, Dr. G. Biswas, Dr. Prem Kumar, Ms. L. Christina, Smt. Leesa Priyadarsani, Smt. Babita Mandal
EXTERNALLY FUNDED PROJECTS			
32	Elucidation of molecular mechanism of dopamine action on final oocyte maturation of Goldspot mullet (*Lisa parzia,* Hamilton, 1822)	**DBT**	**PI: Dr. Prem Kumar** **Co-PIs:** Dr. G. Biswas, Dr.T.K. Ghoshal
OTHER PROJECTS			
33	Agri-Business Incubation centre (ABI) at CIBA, Chennai	**NAIF - ICAR**	**PI: Dr. P.K.Patil** **Co-PI :** Dr. K.P. Kumaraguru vasagam, FCD Dr. T. Ravisankar, SSD **Divisional Members** Dr. R. Geetha, SSD Dr. T.N.Vinay, CCD Dr. J. Raymond Jani Angel, NGBD (Genetics) Dr. K.P. Sandeep, NGBD (Nutrition) Shri. Dani Thomas, FCD
34	Intellectual property Management and Transfer/ Commercialization of Agricultural Technology Scheme (Up-scaling of existing components i.e. Intellectual property Right (IPR)	**NAIF - ICAR**	**Dr. P.K. Patil, OIC** **Divisional Members** Dr.K.P.Kumaraguru vasagam, FCD Dr. T. Ravisankar, SSD **Divisional Members** Dr. R. Geetha, SSD Dr. T.N.Vinay, CCD Dr. J. Raymond Jani Angel, NGBD (Genetics) Dr. K.P. Sandeep, NGBD (Nutrition) Shri Dani Thomas, FCD

Research Highlights

Brackishwater Production System Research

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

Brackishwater Production System Research

PENAEUS INDICUS

Optimizing farming practices for *P. indicus* is important for commercial farming operations that demand continuous production. During the current year several on station and field level experimental and demonstration trials were carried out. A grow out production experimental trial of *P. indicus* was carried out in Navsari Gujarat Research Centre Farm (Matwad Village, Navsari, Gujarat) India to study the growth characteristics, lunar growth rhythms and economics of the species.

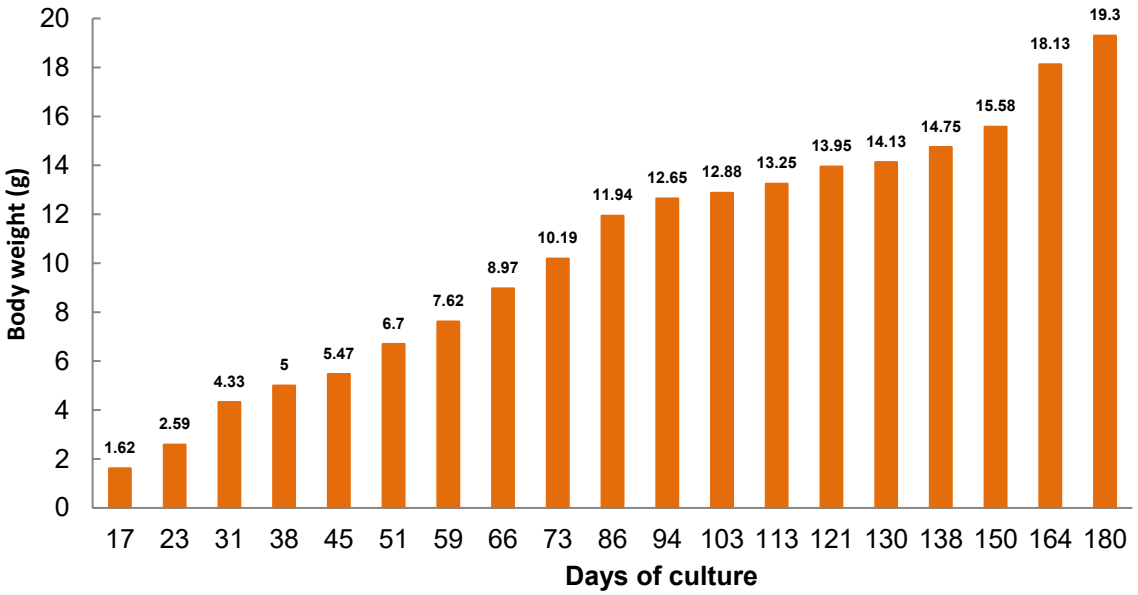
Disease free *P. indicus* post larvae (PL) were produced using wild caught brood stock screened for viral pathogens and shipped to Gujarat. Grow out trial was carried out in a 0.4 ha (4000m^2) earthen pond. Post larvae of *P. indicus* (TL: ~10.9 mm; BW: ~14.7) was shipped from Chennai at a salinity of 30 ppt. Seed stock was acclimatised to the grow out pond salinity of 47 ppt. The shrimp were stocked at a density of 32 PL/m^2 , and fed using a commercial white leg shrimp feed (CIBA-Vanami^{plus}) containing 35% crude protein. Sampling to evaluate the relationship between lunar phases and growth increments were carried out on days at or adjacent to various lunar phases. Shrimp were reared for a period of 144 days during the present grow out trial. Salinity during the culture period increased to 53 ppt by 10 DOC before reducing to 12 ppt (115-120 DOC) and further increasing to 14.5 ppt at the time of harvest (144 DOC). At the end

of 144 DOC, shrimp attained a mean body weight of 16.55±0.31 g. The present grow out trial of *P. indicus* in Gujarat resulted in a total production of 2053 Kg of shrimp with a survival rate of 97.2%, which transforms to a productivity of 5.13 mt/ha/crop.

Length-weight relationship of farmed shrimp during the culture period followed the equation of, $W=0.0053L^{3.07}$ (n=1075, R^2=0.99), wherein slope of the regression equation, i.e. b=3.07, indicates a positive allometric growth pattern. Fulton's condition factor during the culture ranged from 0.599 to 0.6482 indicating normal growth of shrimp, even at high densities. Shrimp production from the grow out pond resulted in a total revenue of ₹ 6,36,430 against a total production cost of ₹ 5,87,258, ensuing a net profit of ₹ 49,171/acre/crop, which transforms to a total revenue of approximately ₹ 2.5 lakhs/ha/year. The present trial indicates that *P. indicus* can be used as species for shrimp aquaculture in Gujarat. Although, Indian white shrimp demonstrates a lower growth rate as compared to the exotic *P. vannamei* (which is genetically improved for growth) its high survival rate, excellent market value and reasonable productivity give conclusive evidence on its potential future in the Indian shrimp industry.

In a parallel experiment carried out in Kakdwip Research Centre of CIBA: *P. indicus* PL were stocked in low saline ponds at a stocking density of 12 PL/m^2. After 180 days of culture the shrimp attained final ABW of 19.3 g, with a survival of 80% and production of 1375 kg/ha.

Production performance of *Penaeus indicus* culture in Gujarat



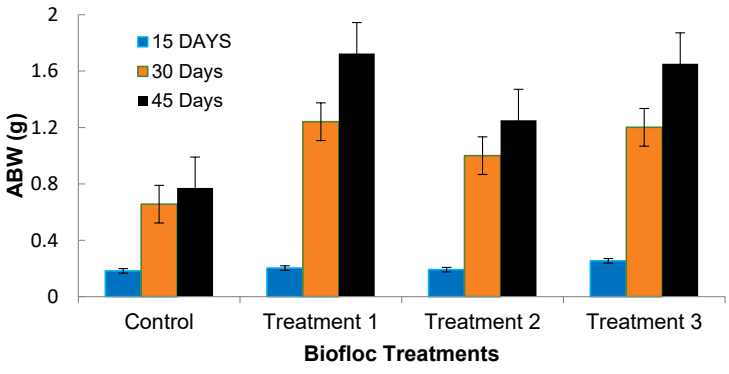
Growth of *P. indicus* in KRC ponds

EFFICACY OF CARBON SOURCE SUPPLEMENTATION IN BIOFLOC SYSTEM

The experiment was conducted for eight weeks, in a 100 L fiber-reinforced plastic (FRP) tanks at Muttukadu experimental station of ICAR-CIBA. *P. vannamei* juveniles (0.11±0.02 g) were stocked at the rate of 400 PL/m3 into assigned experimental tanks. The experiment consists of 4 treatments varied in using different carbon sources for the development and maintenance of biofloc and a control (without Biofloc/Carbon Source) in triplicates viz. T1 (Tapioca) T2 (Rice bran), C3 (wheat flour), T4 (Rice flour), and a control treatment C (without Biofloc/Carbon source). The growth performance was showing a significant difference ($p < 0.05$) and the ABW and SGR of animals in biofloc treatments were significantly higher than control. The total heterotrophic counts of biofloc treatments were significantly higher than control conversely; the total vibrio load was lower in all the biofloc tanks than control at ($p < 0.001$). Based on the morphological difference, the colonies were differentiated, further isolated and identified. Totally, 55 colonies were isolated from all the treatments and control experimental water samples. Among that, selected colonies were identified using a molecular method. The 16s rRNA sequence was subjected for the homology search to BLASTn Tool and the sequences were submitted to GenBank. (Accession Number MK966343- MK966378; MK966415- MK966416)

EFFECT OF PROBIOTIC SUPPLEMENTATION ON THE GROWTH, SURVIVAL AND MICROBIOLOGICAL ANALYSIS OF SHRIMP *PENAEUS INDICUS* REARED BIOFLOC IN SYSTEM

A 45 days experiment was carried out to evaluate the effect of live *Bacillus tequilensis* supplementation on the growth, survival and beneficial microbial



Effect of different biofloc conditions on growth and survival of shrimp *P. indicus*

diversity on *Penaeus indicus* culture under biofloc system was investigated. The experimental variations includes, Treatment 1 (Biofloc + probiotic strain), Treatment 2 (only probiotic strain), Treatment 3 (only biofloc) and control (no biofloc). The growth and survival of the shrimp was continuously increasing with different days of culture. The growth was higher in all the biofloc treatments when compared to control and highest growth was observed in biofloc combined with probiotic strain.

The total viable count showed that treatment 1 showing more bacterial diversity than other treatments. Totally 65 different morphologically different bacterial strains were isolated from each sampling. Among the 65 strains, amylase producers are dominant populations (55 strains) followed by protease producers (38 strains). In the case of control group less diversified bacterial flora and only two different strain was isolated namely *Halomonas meridiana* and *Bacilllus marisflavi*. In treatment 1 animals harbored five different variety of bacterial strains including *Bacillus jeotgali, Bacillus tequilensis, Bacilllus marisflavi, Bacilllus maritimus* and *Halomonas meridiana*. In treatment 2, *Bacillus coahuilensis, Bacillus tequilensis* and *Exiguobacterium profundum* strains were identified. Treatment 3 (bilofloc alone) harbored different strains such as *Salinicoccus* sp., *Pseudomonas stutzeri* and *Micrococcus* sp. which is not observed in other treatments.

EFFECT OF ENZYMATIC STRAINS ON THE GROWTH AND IMMUNOLOGICAL CHANGES ON *P. INDICUS*

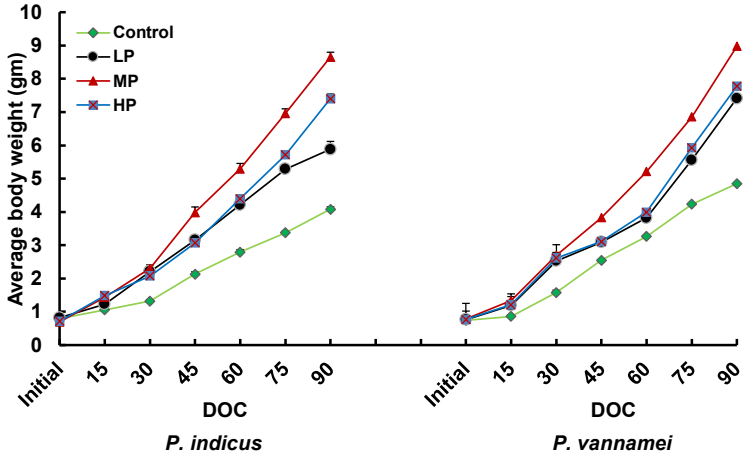
CULTURE UNDER BIOFLOC SYSTEM.

A 45 days experiment was conducted with *P. indicus* (1.0 ± 0.1g) to evaluate the effect of two bacterial strains *Novosphingobium* sp. and *Marinilactibacillus piezotolerans*. The experimental variations are CW1 (*Novosphingobium* sp. in clear water), BFT 1 (*Novosphingobium* sp. + biofloc), CW2 (*M. piezotolerans* in clear water), BFT 2 (*M. piezotolerans* + biofloc) and the treatment devoid of these strains and biofloc was taken as control (C). The effect of these two strains selected was studied for the culture of *P.indicus* in biofloc system and the results compared with clear water system culture. Comparing these two strains, *M. piezotolerans* with biofloc system is more effective than the other treatments. Also the survival rates also more in strains supplemented treatments than the control (82%). The survival rate were 85, 90, 86 and 91% respectively for CW1, BFT1, CW2 and BFT 2.

The growth was higher in all the biofloc treatments when compared to control and highest growth observed in biofloc combined with probiotic strain

COMPARATIVE STUDY OF BIOFLOC-REARED PACIFIC WHITE SHRIMP *PENAEUS VANNAMEI* AND INDIAN WHITE SHRIMP *PENAEUS INDICUS*

A study was conducted to evaluate and compare the growth performance and innate *Penaeus vannamei* and India white shrimp *Penaeus indicus* reared under biofloc technology with different dietary protein levels (Low-25%, Medium-30% and High-35%). As prophenoloxidase (proPO) activity is an important parameter in immune response of shrimp, we focused on the dynamics



Average body weight of *P. indicus* and *P. vannamei* on biofloc based shrimp culture with low, medium and high protein diet. Data represents mean ± SD of all the treatments (n=50). LP – low protein; MP – Medium protein; HP – High protein.

of prophenoloxidase induced by three different activators (Sodium dodecyle sulfate, (SDS, Trypsin & Laminarin). At the end of the experiment, the effect of activators on proPO activity in serum, plasma and hemocyte lysate (HLS) was evaluated in both the species under conventional and biofloc systems with graded proteins. This experiment lasted for a month as nursery rearing followed by 60 days of grow-out culture. There was no significant difference ($p<0.05$) in growth performances of both the species reared under biofloc, whereas control group exhibited lower growth. Significantly higher average body weight (ABW), survival and specific growth rate (SGR) were observed in medium protein groups reared under biofloc than the other biofloc groups and control. The medium protein groups also showed significantly lower ($p<0.01$) TAN, NO_2-N, and NO_3-N levels compared to other treatments and the control exhibited considerably higher TAN, NO2-N and NO_3-N levels.

EFFECT OF PERIPHYTON MAT FOR NURSERY REARING OF *P. INDICUS* IN TANK SYSTEM

Periphyton based nursery rearing of *P. indicus* was carried out in a tank system by following the principle of aquamimicry concept. Post larvae of *P. indicus* (PL13) stocked in FRP tanks at the rate of 1000 nos/m^3 for a period of one month at 32 ppt salinity in triplicate. Aquamat with an area of 30 cm^2 (3 no each) was installed in each tanks to develop the periphyton. Animals were fed with combination of cyclopoid copepod (*Dioithona* sp), *cladocera* sp (*Eurycercus berinji*), Rotifers (*Brachionus* sp) at the rate of 5-10 no / PL and microalgae includes *Chaetoceros* sp and *Thalassiosira* sp (100000 cells/ml with daily). Fermented juice prepared using soya bean flour (5g/ton), molasses (50ml/ton) and yeast (5g/ton) was applied fortnightly, and fed with 100%, 75% and 50% shrimp starter feed Highest growth was observed in the treatment fed with 100% shrimp starter feed and aquamat (7.51±0.8 cm) with maximum percentage survival (82.75%). Periphyton composition

Table 2. Total length, average weight and percentage survival of nursery reared *P. indicus* in tank system (30 DOC)

Characteristics	100% Shrimp feed+mat	75% Shrimp feed+mat	50% Shrimp feed+mat	100% Shrimp feed (Control)	Mat +No Shrimp feed
Total length (cm)	7.51 ± 0.8^a	7.34 ± 0.75^a	7.4 ± 0.8^a	6.59 ± 0.5^b	5.1 ± 0.3^c
Weight (gm)	2.92 ± 0.5^a	3.18 ± 0.65^b	3.47 ± 0.8^b	3.02±0.6b	$1.5\ \pm0.09^c$
Survival (%)	82.75	71.25	57.90	76.50	41.50

Aquamat (Before)

Aquamat (After 60)

Aquamat before and after the nursery rearing period

revealed that Bacillariophyceae dominated in aquamat followed by Chlorophyceae and Cyanophyceae. The overall result suggested that aquamat based nursery rearing in tank, and therefore, farmers can do nursery rearing in tank based system while preparing the pond for next culture and also reduce culture duration to maximize shrimp production.

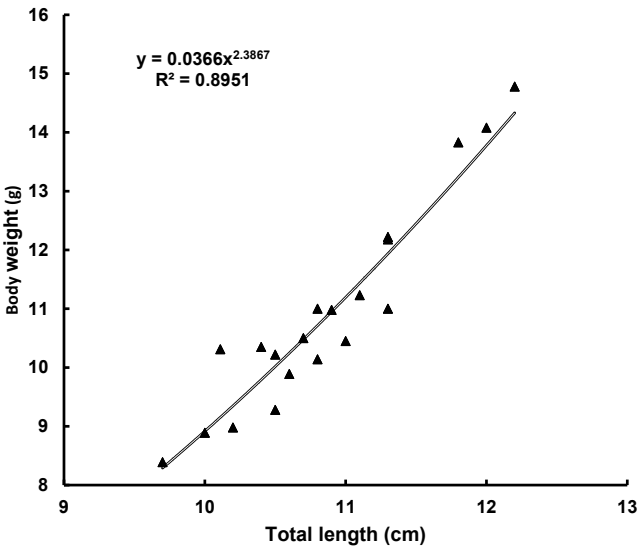
PENAEUS VANNAMEI

An experiment was carried out to develop a tank based small scale production unit for *P. vannamei*, which could be served as a prototype for homestead aquaculture of this species. *Penaeus vannamei* PL were stocked in the 35 mt cement tank at a stocking density of 60 PL/m^3. Animals were reared for a period of 100 days without water exchange under semi floc condition, and fed with formulated feed vannami^{plus}. At the end of the 100 days of rearing, animals attained mean weight of 10.93 ± 0.38 g, and survival of 56%, and production of 18.4 kg. This system could be further refined and commercialized.

OCCURRENCE AND POPULATION STRUCTURE OF *PENAEUS VANNAMEI* IN PULICAT LAKE

The presence of non-native white-leg shrimp, *Penaeus vannamei* was reported for the first time from Pulikat lake. This open thelycum species is originally from the eastern Pacific. Shrimp is caught regularly by the fishers, although daily catches are below three to five, These animals were kept separately

a)



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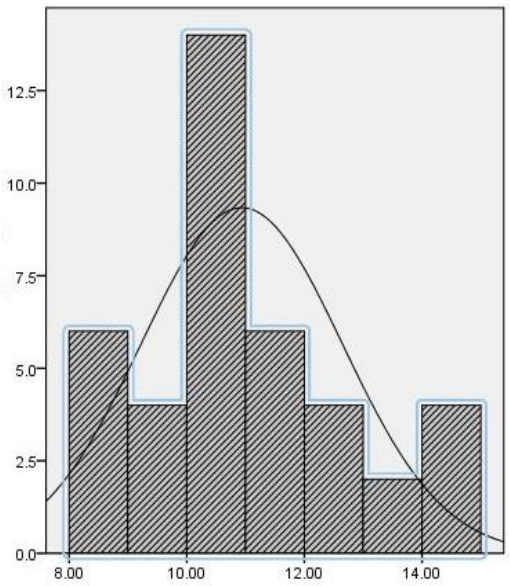
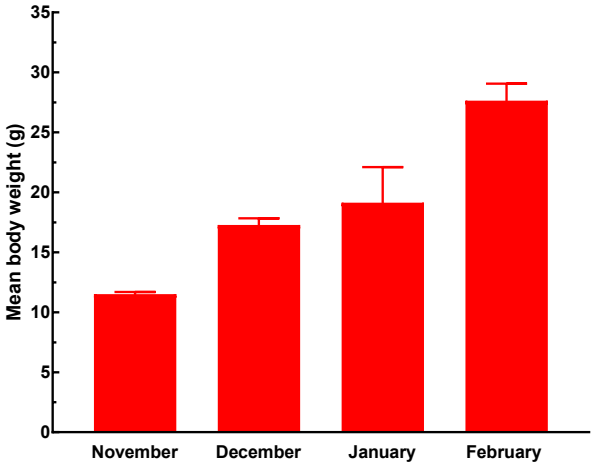


a) Length weight relationship and b) Size frequency distribution of harvested *Penaeus vannamei*



Mean body weight of *Peaneus vannamei* during different months

Culture of *Scylla olivacea* and *Mystus gulio*

and biweekly the samples were analysed to understand the population structure. Mean body weight in November was 11.51 ± 0.18 g and it grows to 27.65 ± 1.48 g in February indicating a growth pattern

CO-CULTURE OF MUD CRAB, *SCYLLA OLIVACEA* AND *MYSTUS GULIO*

Aquaculture using regionally important species is one of the strategies for diversifying aquaculture production. Mud crab *S. olivacea* and brackishwater catfish, *M. gulio* are economically important species in West Bengal. In order to optimize the production technique of these species, a co-culture experiment on mud crab (*S. olivacea*) in cages were carried out with *M. gulio*. Mud crabs were stocked at a density of 50 crabs/m^2 whereas *M. gulio* were stocked at 5 fish/m^2. under three treatments: direct stocking of mud crab in ponds along with gulio, stocking of mud crab in floating boxes and stocking of mud crab in sinking boxes. The initial weight of mud crab was 38.06 g and *M. gulio* was 0.45 g. After 65 of rearing mud crabs attained 71 to 73 g body weight without any significant change in the body weight among the treatment without significant difference among treatments.

EVALUATION OF MOULTING FREQUENCY OF JUVENILE MUD CRAB, *SCYLLA SERRATA*

In order to evaluate the moult frequency and growth increment per moult a sixty day experiment was carried in indoor tanks (100 L) with different substratum PVC hide outs and sand substratum and different water levels. No significant effect of substrate or

Mud crab *S. olivacea* and brackishwater catfish, *M. gulio* are economically important species in West Bengal

culture medium on growth and moulting with an average number of days/moulting of 33.6 ± 9 days. Of the total experimental animals 41% animals were moulted with an average weight gain per moulting of 87.3 ± 3.21 g (74.7%).

MILK FISH

DEVELOPMENT OF ECONOMICALLY VIABLE MULTIPLE STOCKING AND MULTIPLE HARVESTING (MSMH) MODEL FOR MILKFISH CULTURE

Milkfish is an ideal species for low input based culture. For small and traditional ponds, productivity could be increased by adopting MSMH model. Moreover, regular harvesting at certain intervals would provide returns that can meet the daily needs of the farmer. Therefore, to evaluate the economic viability of this model in brackishwater ponds, a trial was conducted with two stocking densities (7500 and 15000/ ha). Milkfish fingerlings (10-12 g) were stocked and reared in fertilized ponds (500 m^2) fed with CIBA formulated feed (CP 30%; Price: Rs. 35/ kg) @3-4% of body weight daily. After 90 days, fish were harvested when they attained 120 g and were restocked with same quantity of advanced fingerlings (30-50 g)

Milkfish farming at Chirayinkeezh farmers' co-operative society, Kollam, Kerala

at 15 days intervals keeping the total number of fish same to that of initial stocking. In 180 days, this model yielded higher production of 3.8 ton/ ha in the high density stocking compared to 3.0 ton/ ha in the low density stocking. This model with higher density had a BCR of 1.66 suggesting its suitability over the lower density system with a BCR of 1.50.

MONOCULTURE OF MILKFISH IN FARMERS' CO-OPERATIVE SOCIETY IN COLLABORATION WITH FISHERIES DEPARTMENT, KERALA

Aiming for species diversification and sustainable aquaculture, CIBA has standardized mass scale seed production and long distance transportation protocol of milkfish. In recent years there is an increased demand for hatchery produced milkfish seed for monoculture and mixed farming among farmers from pan India. During this year we have observed maximum seed demand from west coast of India in the states of Kerala and Gujarat. West Bengal tops the list in milkfish seed demand on east coast. To promote milkfish, *Chanos chanos* farming in west coast of India, a monoculture demonstration was conducted in collaboration with fisheries department at Chirayinkeezh farmers' co-operative society, Kollam, Kerala. Initially 2400 milkfish seed (2.5 cm, 36 dph) were stocked in hapa and pen based enclosed nursery at one side of culture pond for 45 DOC and around 2000 number, 10- 15 g size fingerlings were stocked for grow out farming in 1 acre area having salinity of 15-23 ppt. During culture milkfish were fed with indigenous feed (24-28 % protein) @ 3-5 % body weight twice a day. After culture for 7 months, a total production of 1 ton milkfish (ABW 550 g; MBW 750g) with 90% survival was obtained. Partially harvested fishes were sold at the rate of Rs. 240/- kg at farm gate.

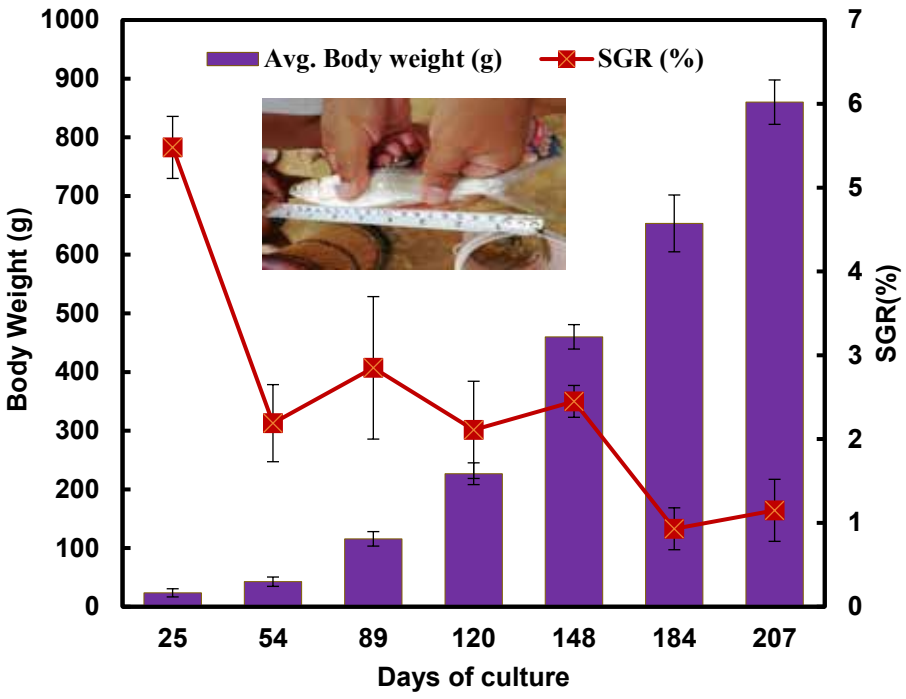
MILKFISH GROW OUT CULTURE FOR INCOME GENERATION IN INLAND SALINE PONDS OF MATHURA, UTTAR PRADESH

Brackishwater aquaculture is a profitable venture to utilize salt affected farms with available saline groundwater. In recent years, many areas in India's northern states have reported changing salinity profile of groundwater as well as soil. These soils and groundwater generally have high iron content with salinity ranging from 7 – 20 ppt due to which they cannot be utilized for horticulture/ agriculture purposes. ICAR-CIBA is exploring these areas for profitable aquaculture ventures. Milkfish grow out culture can be a model for farmers having inland saline water. To evaluate the production performance of milkfish in earthen pond of

In recent years there is an increased demand for hatchery produced milkfish seed for monoculture and mixed farming among farmers from pan India

Water quality parameter during culture

Month	Salinity (ppt)	Total alkalinity (mg/L)	Total hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	pH
May	15	126	6700	1000	1020	10.5	7.3
June	13	142	6500	900	1000	10.1	7.5
July	14	142	6100	1050	1000	10.4	7.4
August	12	167	5000	950	1015	10.5	7.5
September	11	224	4700	560	801	8.6	8.2
October	10	220	4400	600	704	8.5	7.5
November	10	220	4400	610	700	8.3	7.4



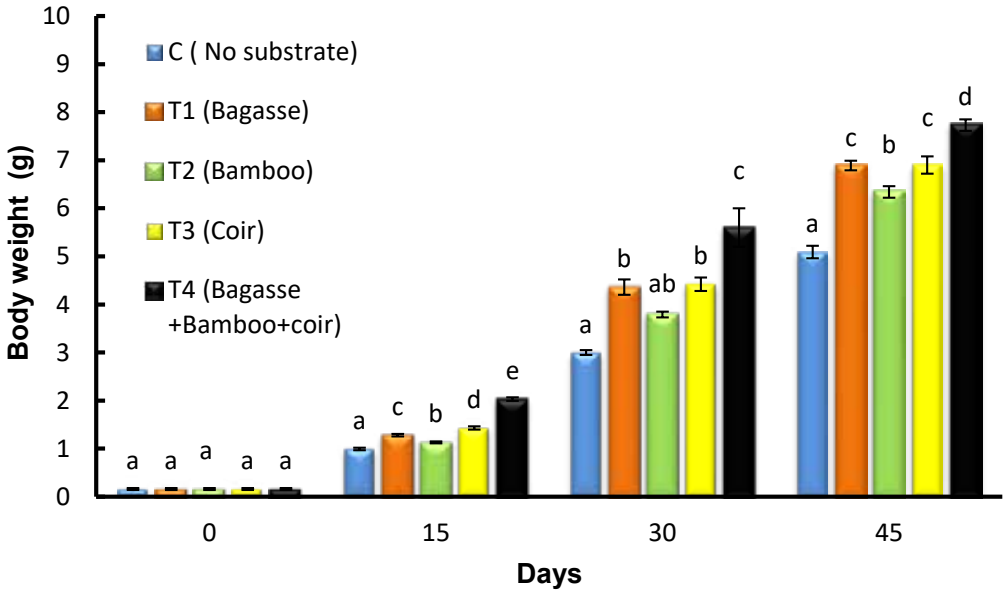
Harvest performance of milkfish in Inland saline waters in Uttar Pradesh

inland saline area, an 8 months long grow out culture was carried out in 0.3 ha pond of M/s Dhruv Agrotech at Mathura, Uttar Pradesh initiated in the month of May 2019 with a stocking density of 17 fry /m^2 in earthen pond. Water salinity ranged from 10 – 15 ppt during the grow out operation. After 200 DOC, farmed fishes were partially harvested to sell in different markets to explore price index and consumer acceptability. A total 3.0 tons of milkfish was harvested after completing the culture operation with an average body weight of 860 g (500 g to 1.3 Kg) and final SGR of 1.15%. Final survival rate was 71 %. Milkfish prices were Rs. 180, 150 and 120 in Gazipur, CR park and Agra fish market respectively. The net return was Rs. 2,07,650 and the total operational cost was Rs. 93,350 and the realized BCR was 1.85. In future, milkfish grow out culture (monoculture/polyculture) can be replicated in different inland saline farms to popularize this profitable venture and to sensitize the fish consumers in northern states of the country.

DEMONSTRATION CUM EXPERIMENT ON PERIPHYTON BASED NURSERY REARING OF MILKFISH USING DIFFERENT SUBSTRATES IN HAPAS

A total of 4000 hatchery produced milkfish fry (2.68 ±0.06 cm & 0.160±0.02 g) were supplied from ICAR – CIBA Chennai for demonstration cum experiment on periphyton based nursery rearing of milkfish in hapas in high saline waters of Gujarat under tribal sub plan project. An eight member self-help group comprising of 6 women and 2 men were formed for demonstration of periphyton based nursery rearing of milkfish in hapas at NGRC – CIBA Matwad farm. Demonstration cum experiment was carried out in 2000 m2 pond in which hapas (2x1x1 m) were installed and provided with different substrates for periphyton growth using PVC frame. The experimental set up consisted of 5 treatments with triplicates, T1 (Sugarcane bagasse), T2 (Split bamboo substrate), T3 (coir rope), T4 (sugarcane + split bamboo + coir), T5 (no substrate, regular cleaning of hapas to avoid periphyton growth). In each hapa 266 milkfish fry were stocked and fed with CIBA nursery feed @ 8 % body weight twice a day. At the end of 45 days of experiment the results revealed that growth parameters of milkfish showed

ICAR-CIBA is exploring these areas for profitable aquaculture ventures. Milkfish grow out culture can be a model for farmers having inland saline water



Growth of milkfish in different periphyton substrate

Beneficiaries involved in nursery rearing of Milkfish

Milkfish fingerlings at the end of 45 days of experiment

a significant difference ($p<0.05$) among the treatments . The highest mean total length 9.76 ± 0.13 cm and bodyweight 7.73 ± 0.12 g was observed in the treatment provided with substrate combination of sugarcane, split bamboo and coir for periphyton growth as compared to other treatments. The salinity ranged from 47 – 26 ppt during the experiment. The self-help group members were able to sell 3800 milkfish fingerlings @ Rs.15/fingerling and earned Rs. 57,000/cycle.

EVALUATION OF GROWTH PERFORMANCE OF INDIAN WHITE SHRIMP AND MILKFISH IN A LOW INPUT BASED POLYCULTURE SYSTEM WITH VARIED STOCKING RATIOS

Polyculture of Indian white shrimp with milkfish is considered as sustainable and economically viable model of farming system. Milkfish can be used as secondary crop along with shrimp to reduce the cost of production. Moreover,

milkfish with illophagic feeding habit, consumes excessive organic matter thereby reduces dissolved nutrients and improves water quality. Field trials were carried out to evaluate growth parameters of *Penaeus indicus* and *Chanos chanos* stocked in varied ratios. *P. indicus* and milkfish were stocked in 3 ratios i.e. 13 shrimp : 0.32 milkfish/ m^2 in 1250 m^2 pond, 9 shrimp : 0.92 milkfish/m^2 in 650 m^2 pond and 57 shrimp : 8 milkfish/ m^2 in 105 m^2 pen. The milkfish fingerlings (11 -12 cm & 13 – 15 g) were stocked after 50 DOC of *P. indicus*. At the end of 180 days of culture *P. indicus* attained 17.5 – 18.5 g body weight with 82 % survival rate in both 1250 and 650 m^2 ponds. Whereas, milkfish attained 300 - 350 g in 120 days with a survival rate of 90 %.

From the study, it was found that the stocking ratio of 13:0.32/m^2 and 9:0.92/m^2 was found to be ideal for polyculture of *P. indicus* with milkfish.

Polyculture of Indian white shrimp with milkfish is considered as sustainable and economically viable model of farming system

Harvested milkfish and *P. indicus* from polyculture pond

Growth performance of *P. indicus* and milkfish in polyculture pond

Farming system	Earthen pond	Earthen pond	Pen
No/m²	9 shrimp: 0.92 milkfish/m²	13 shrimp : 0.32 milkfish/ m²	57 shrimp : 8 milkfish/ m²
Area	650 m²	1250 m²	105 m²
Indian white Shrimp			
DOC	ABW (g)	ABW (g)	ABW (g)
0	0.2	0.2	0.2
180	17.69	17.54	11.36
Survival rate (%)	83.05	84.96	85.5
Production (kg)	102	270	58
Milkfish were introduced after 50 DOC of P indicus			
Initial length and weight	12.19 cm & 14.57 g	12.19 cm & 14.57 g	12.19 cm & 14.57 g
Final length and weight (120 days)	33.5 cm & 315 g (250 -360 g)	33 cm & 280 g (210 – 330 g)	25.5 cm & 110 g (70 – 120 g)
Production (kg)	132.5 kg	87.5 kg	60 kg
Survival rate (%)	90	95	93

MILKFISH (*CHANOS CHANOS*) SEED REARING AND CAPTIVE BREEDING TAKEN UP IN COLLABORATIVE MODE WITH RAJ HATCHERIES (BENGAL) PVT. LTD., EAST MIDINIPUR DISTRICT, WEST BENGAL

West Bengal is vested with enormous brackishwater resources of almost over four lakh hectare and provides tremendous opportunity to undertake milkfish farming. A value chain was established where hatchery produced seeds were provided to farmers of West Bengal for the last five years successfully demonstrating the culture at farmer's field as well as at Kakdwip Research Centre of CIBA. Raj Hatcheries (Bengal) Pvt. Ltd., East Midinipur district, West Bengal signed a two-phase agreement with ICAR-CIBA for technical support on Milkfish (*Chanos chanos*) seed rearing and captive broodstock development. In first phase, ICAR-CIBA hatchery produced fertilized eggs of milkfish will be transported to the client by air and larval rearing will be undertaken. With CIBA's technical cooperation and inputs four 20 ton capacity RCC tanks painted with yellow colour epoxy and having permanent roof structure and aeration have been constructed to assist improved larval rearing of milkfish. Live feed units also have been established. Yearly 3.2 lakh fry can be produced from client's facility from 1 million fertilized eggs in 4-5 cycles. At KRC of CIBA around 100 number of sub-adult milkfish are being maintained and fed with Milkfish Brood^{Plus} to develop as broodstock. 30 of them have attained 1.1-1.2 kg body weight and will be transported to Raj Hatchery pond facility having year round 28-30 ppt salinity for future captive breeding. The seed rearing facility would meet the milkfish seed requirement of the traditional water bodies, *bheries* of West Bengal to a great extent.

SEA BASS

CAGE CULTURE OF CANDIDATE SPECIES IN CREEK AS AN ALTERNATE LIVELIHOOD FOR COASTAL FISHER FOLKS OF SINDHUDURG

Cage culture of Asian seabass was successfully demonstrated by installing 68 cages in creeks of Sindhudurg, Maharashtra. 220 farmers of Sindhudurg were provided skill development training through demonstration and under the various culture trials of the project. A total revenue of Rs. 12.75 lakhs was generated by the SHG beneficiaries through demonstration trials of seabass nursery, pre-grow out, cage culture and pond culture trial of seabass and milkfish. Unutilized and untapped brackishwater water bodies were utilized for sustainable development of brackishwater aquaculture. Scientific and technical assistance was provided to Mangrove Foundation for installation of more than 180 cages in all coastal districts of Maharashtra, and for the establishment of a multispecies Hatchery in Sindhudurg.

ASIAN SEABASS NURSERY REARING IN HAPPAS BY THE MANGROVE COASTAL COMMUNITY FOR THE LIVELIHOOD SECURITY IN SINDHUDURG, MAHARASHTRA

Seabass seed 15000 numbers (1.2-2.0 cm) from CIBA seabass hatchery were provided to SHGs of Redi Village Vengurla, Sindhdurgh and stocked at a density of 500 per happa. The fry were fed with CIBA formulated seabass larval feed (0.2 mm-1.2 mm) @ 8-10% body weight two times a day. Regular grading was done at an interval of four days to separate shooters and to maintain uniform size. During grading, men removed fishes from happas for grading and cleaned the happas while women graded the fish. After nursery rearing of 75-90 days, SHG sold a total of 2500 stockable fingerlings @ Rs. 44 per fingerling for cage culture. From this the SHGs generated a total revenue of Rs. 1.10 lakh.

DETAILS OF ICAR-CIBA CAGE CULTURE UNITS, MANPOWER EMPLOYED AND REVENUE GENERATED IN SINDHUDURG, MAHARASHTRA THROUGH CIBA TECHNOLOGY INTERVENTION

Sr. No	Units	Units	Total Beneficiaries	Women	Men	Income Generation (Rs.)
1	**Cage Culture**	65	208	08	200	Rs. 9, 69,700/-
2	**IMTA**	03	12	06	06	Rs. 3,06,000/-
3	**Total**	68	220	14	206	Rs. 12,75 700/-

Scientific and technical assistance was provided to Mangrove Foundation for installation of more than 180 cages in all coastal districts of Maharashtra

HILSA

DOMESTICATION AND DEVELOPMENT OF HILSA, *TENUALOSA ILISHA* F1-STOCK IN RECIRCULATORY AQUACULTURE SYSTEM (RAS) AND BRACKISHWATER POND SYSTEM (BPS)

Domestication is a yearlong process in which fish is adapted to controlled conditions. Domesticated fish stocks are usually preferred for breeding and seed production purposes globally due to its adaptive nature and easy handling. With this background, domestication of hilsa, *T. ilisha* in Recirculatory Aquaculture System (RAS) and Brackishwater Pond System (BPS) for broodstock development was attempted. Reinforced Cement Concrete (RCC) tank having water holding capacity of 50000 L was constructed and fitted with following components: ante tank (egg collection tank), electric water pump (2 HP), rapid sand filter (800 mm diameter x 812 mm height) and biological filter. BPS was bleached, limed and fertilized with fermented mustard oilcake. To raise the fingerlings of hilsa, oozing male (270±5.0 g) and

female (780±15 g) were collected from Hooghly River and bred through dry-stripping method. After hatching, larvae were reared for three months in earthen nursery ponds (100 m^2) for 90 days or till attained fingerling size of 4.32±0.73 cm, 0.69±0.55 g; size range: 3.5 to 5.13 cm; 0.26-1.37 g). During the course of nursery, salinity was gradually increased from freshwater to 7 ppt. These fingerlings were stocked @ 2 numbers / m^2 in RAS unit and BPS. Water quality parameters were monitored regularly in both the system. To compensate the evaporation loss, water was added at monthly interval. BPS, was limed @250 Kg/ha and fertilized with mustard oil cake @100 Kg/ha at monthly interval. Fish were fed with pellet feed developed by CIBA @ 10% of biomass daily.

After, 7 months of rearing, size in BPS (Total length, 15-22 cm; weight, 11-18 g) was larger than RAS (total length13-15 cm and 9-11 g). In conclusion, **a total of more than 2000 F1 hilsa**

Hilsa F1 captive stock

RAS for broodstock development of Hilsa

Hilsa, sub-adult

Hilsa Broodstock RCC tank (50 T)

sub-adult were developed and domesticated in RAS and BPS, which will help in the development of captive brood stock of Hilsa for controlled breeding.

MYSTUS GULIO

STANDARDIZATION OF FEEDING PROTOCOL FOR NURSERY REARING OF *MYSTUS GULIO* IN NET CAGES

Brackishwater catfish, *Mystus gulio* has good market demand as a high value species in Eastern India. Nursery rearing in net cages is advantageous to other methods as it is easy to manage, and requires less space and capital investment. Among the different feed management protocols proven to maximise the benefit of feeding, feeding frequency and ration size play an important role in regulating the feed intake, growth and waste outputs of fish. Optimizing feeding frequency may minimise feed wastage, leading to improvement in culture environment and reduction in size heterogeneity. After acclimatization, hatchery produced twelve-day old fry (0.02 g/ 12 mm) were stocked in net cages (2×1×1 m) at 300 number/ cage. Feeding frequencies of one (T1), two (T2), three (T3) and four (T4) times per day with a CIBA formulated feed (CP 30%, Lipid 6%; Price: Rs. 35/ kg) was fed. Fish performances in net cages were evaluated in terms of final length (mm), weight (g), percentage weight gain (PWG, %), specific growth rate (SGR, %/day), survival (%), feed conversion ratio (FCR) and coefficient of variation on final weight (CV_{hw}). After 60 days, fry attained significantly higher growth of 1.30±0.32 g at 3 times

Performances of brackishwater catfish, Mystus gulio fry under different feeding frequencies.

Variable	T1	T2	T3	T4
Final length (mm)	42.7±2.4^{c}	46.4±2.7^{b}	50.1±2.6^{a}	47.5±2.7^{b}
Final weight (g)	0.78±0.16^{d}	0.98±0.22^{c}	1.30±0.32^{a}	1.10±0.31^{b}
PWG (%)	3833.3±857.8^{c}	4783.3±625.2b^{c}	6416.7±76.4^{a}	5400.0±250.0^{ab}
SGR (%/ day)	6.09±0.36^{c}	6.47±0.22b^{c}	6.96±0.02^{a}	6.68±0.08^{ab}
FCR	2.94±0.68	2.61±0.28	2.03±0.05	2.31±0.13
Survival (%)	69.0±1.4^{b}	71.7±1.5^{b}	85.0±2.4^{a}	88.7±2.2^{a}
CVhw	0.374±0.057	0.184±0.141	0.205±0.183	0.283±0.010

Means with different superscripts differ significantly in a row (P<0.05); Values are mean ± SD of three replicates.

feeding a day compared to other groups (P<0.05). Percentage weight gain and specific growth rate were significantly higher in T3 (P<0.05), while there was no significant variation (P>0.05) between T3 and T4. Moreover, higher survival in 3 and 4 times feeding differed significantly from that of 1 and 2 times feeding a day (P<0.05). Considering this fact, this study suggests that in brackishwater net cage rearing, *M. gulio* fry can achieve maximum growth, survival and better feed conversion when they are fed a diet containing 30% crude protein with three times feeding daily.

The findings of this study are new for this species and have practical significance as a major step for establishing *M. gulio* seed rearing package of practice, and would benefit the nursery operators.

EFFECT OF STOCKING DENSITY AND SOIL BASE IN PRODUCTION OF MYSTUS GULIO ADVANCED FINGERLINGS IN TANK SYSTEM

Brackishwater catfish, *M. gulio* is a bottom dwelling fish that thrives well in muddy sediment. Role of bottom sediment on the performances on this species in tank system is unknown. Moreover, lack of information on *M. gulio* advanced fingerlings production method especially in indoor tank necessitates for carrying out a well-designed trial. Therefore, this study evaluated the effects of stocking density in presence or absence of soil base on the performances of *M. gulio* fingerlings in indoor rearing tanks for 60 days. The experiment had a 3×2 factorial design with three levels of stocking density (200, 400 and 600 fish/ m^{3}) and two levels of soil base (with and without) in triplicates. *M. gulio* fry (45.2±0.5

Effects of stocking density and soil base on the performance parameters of *Mystus gulio* fingerlings based on two-way repeated measures ANOVA.

Variable	Means (Tukey Test)					Significance (P value)		
	Stocking density (SD, no./m^{3})			Soil base				
	SD200	SD400	SD600	Without	With	SD	SB	SD×SB
AvL (mm)	61.59±1.19^{a}	56.88±1.20^{b}	56.94±1.19^{b}	58.58±0.97	58.36±0.97	*	NS	NS
ABW (g)	3.05±0.13	2.76±0.13	2.72±0.13	2.69±0.11	3.00±0.11	NS	NS	NS
Survival (%)	98.3±1.9^{a}	94.2±1.8^{ab}	89.7±1.9^{bc}	92.6±1.5	95.6±1.5	*	NS	NS

*P<0.05, NS= Not significant

mm/0.96±0.02 g) were stocked in 100 L tanks and fed with a formulated diet containing 30% crude protein. Increasing the stocking density from 200 to 600 fish/ m^3 significantly decreased the size (average total length) and survival ($P<0.05$). Insignificantly lower survival was observed in treatment without soil base compared to that in treatment with soil base. The interaction effect of stocking density and presence or absence of soil base was not positive for growth and survival of *M. gulio* advanced fingerlings. This study suggests that stocking density of 200 fish/ m3 with soil base in tanks would be appropriate for raising *M. gulio* advanced fingerlings in brackishwater indoor seed rearing system.

LOW-SALINE BREEDING OF ORANGE CHROMIDE AND MARKETING THROUGH FARMER'S PARTICIPATION

To explore the ornamental fish market of orange chromide in Eastern India, hatchery produced fry were transferred to KRC. Forty numbers of fry were handed over to an ornamental fish farmer of Kamarhat, Kakdwip, who further reared it with floating pellet feed in a low saline pond at 5 ppt. This stock started pond breeding after 3 months when they attained 7-8 g. In 8 months, he produced 4000 seeds with good colour development and sold 500 of them (Avg. wt. 5 g) in Kolkata market @Rs.15-20/ piece. It indicated good market potential for this species in Eastern India.

The interaction effect of stocking density and presence or absence of soil base was not positive for growth and survival of M. gulio advanced fingerlings

Pond reared orange chromide

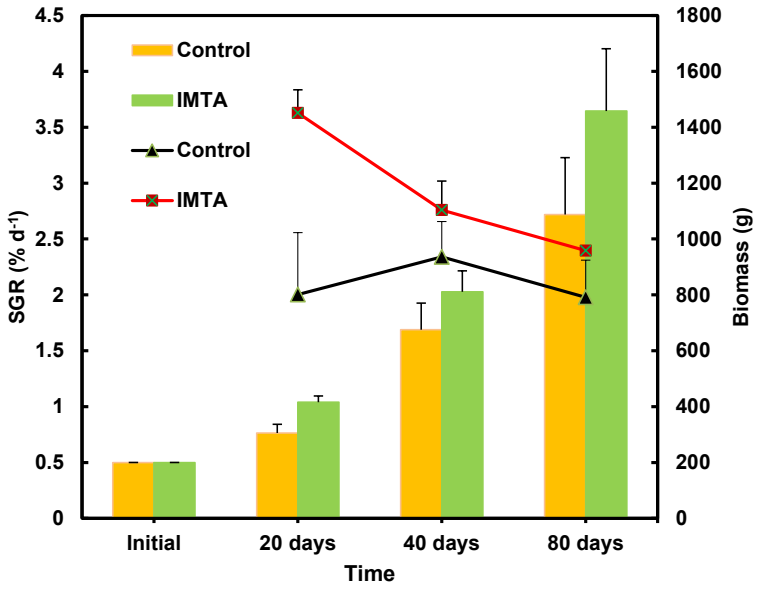
SEAWEED

GROW OUT PRODUCTION PERFORMANCE OF *GRACILARIA TENUISTIPITATA* IN BRACKISHWATER AQUACULTURE PONDS.

Aquaculture potential of *Gracilaria tenuistipitata* was evaluated by carrying out on station trial at MES, CIBA, Chennai. Three systems of culture: rope culture, cage and pond bed were studied in 100 m^2 earthen pond, stocking density was 25 g/m^2, and the experimental duration was one month. Significantly highest production was obtained in the rope culture trial (1500 kg/ha) followed by net cages (1125 kg/ha) and pond bottom culture (450 kg/ha)

INTEGRATED MULTI-TROPHIC AQUACULTURE

A short-term trial of IMTA was conducted in tide-fed pond of Sundarban, West Bengal. Two ponds were selected in which one pond served as control for monoculture of commercially important seaweed, *Gracilaria tenuistipitata* and another pond was used for IMTA. Two commercially important brackishwater species: *Chanos chanos* (Milk fish) and *Crassostrea cuttackensis* (edible oyster) was cultured along with *Gracilaria*. Water quality and biomass of *Gracilaria* was measured at 20 days intervals for 40 days of culture. Average salinity was 5 ppt. Results showed that biomass production of seaweed was significantly ($p < 0.05$) higher in IMTA pond compared to monoculture pond. From initial 202 ± 0.735 g (50 g m^{-2}) to 725.42 ± 63.05 g and 891 ± 33.02 g was obtained in control and IMTA pond respectively during 40 days of culture. Specific growth rate of seaweed was also found higher in IMTA pond (3.73 ± 0.09 % /day) compared to monoculture pond (3.18 ± 0.22 % d^{-1}). A productivity of 1,040 kg/ha/20 days can be harvested at a single crop and



Temporal variation of biomass production (mean ± SE, n = 5) of Gracilaria tenuistipitata in control and IMTA pond. Different lower case letters indicate statistical significance ($p < 0.05$) between two culture systems.

approximately 12.48 ton/ha of seaweed can be obtained along with fish and oyster annually.

INTEGRATED MULTI TROPHIC CAGE CULTURE IN CREEK

To develop and propagate family farming models of candidate finfish and shellfish species in west coast of India, IMTA cage culture was initiated in Gad creek of Malvan, Sindhudurg. Three families comprising of two men and one women having background of brackishwater fishing in creeks were selected from villages of Tondavali, Talashil and Pan-Khol Juva, Taluka-Malvan, District-Maharahstra for IMTA culture of seabass and green mussels in cages installed in creeks. For culture, 700 seabass fingerlings (8-10 cm and 06-12 g), 300 pearlspot (1-2 inch and 01-02 g) and 10000 tiger shrimp (PL 20) were stocked in each pre-fabricated GI Pipe frame cages (8 x 4 x 1.2 m) The seabass were fed with CIBA seabass slow sinking grow-out feed of size 2-6 mm @ 10% body weight two times a day whereas pearlspot were fed with CIBA Polyplus feed @ 8-10% body weight and tiger shrimp were fed with shrimp feed @ 10% body weight two times a day. To achieve good growth, survival and to avoid cannibalism, regular grading of fish at an interval of 15 days was carried out at each

Two commercially important brackishwater species: *Chanos chanos* (Milk fish) and *Crassostrea cuttackensis* (edible oyster) was cultured along with Gracilaria

Integrated multi-trophic aquaculture system in Malvan, Sindhudurg

IMTA cage site. The IMTA cage culture is under progress. The seabass fishes attained a growth of 100-200 g with a survival ranging from 60- 95%; pearlspot attained a growth of 15-20 g with 70-95% survival and tiger shrimp attained 3-5 g with survival ranging from 40-50%. The harvest is expected in mid-June 2020 with an estimated total revenue generation of Rs. 2.0 lakhs to each IMTA family within a span of 5-7 months culture.

DEVELOPMENT OF BRACKISHWATER INTEGRATED FISH FARMING SYSTEM AS A LIVELIHOOD MODEL FOR TRIBAL COMMUNITIES OF NAVSARI, GUJARAT

To provide employment and livelihood opportunities to tribal communities through different brackishwater aquaculture practices, an integrated brackishwater fish farming system (IFF) was developed at NGRC Matwad farm for tribals of Matwad Village, Navsari, Gujarat. The model comprises farming of Asian seabass, *Lates calcarifer* and Scat, *Scatophagus argus* nursery rearing in happas, polyculture of Milkfish, *Chanos chanos* and Pearl spot, *Etroplus suratensis* in pond and goat/poultry farming on dyke. The pond of around 2000 sq. m with a depth of around 1.5 m has been developed for IFF system with a goat shed of 16 x 12 ft on the rear end of pond dyke.

The selected tribal group of Matwad village successfully completed nursery rearing of seabass, milkfish, etroplus and scat seed in happas installed in the IFF pond. After a period of 75-90 days culture, SHGs sold about 6100 seabass fingerlings (3-5") and 8500 milkfish (3-5") to the local fishermen. Along with nursery, polyculture of milkfish, *Chanos chanos* and pearl spot, *Etroplus suratensis* was carried out in pond. The fishes were fed with CIBA Polypus feed twice

INTEGRATED FARMING SYSTEM AT MATWAD, NAVASARI

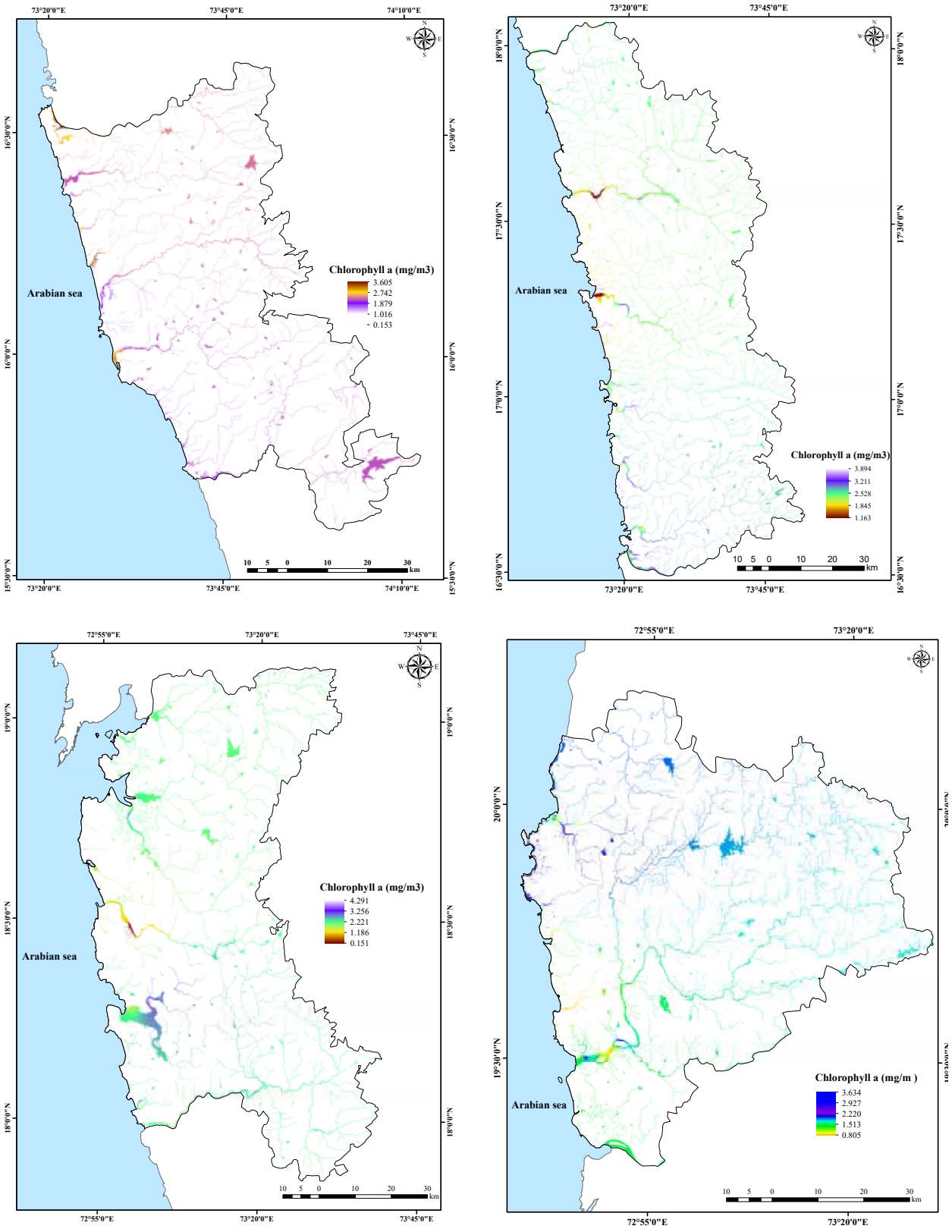
a day @ 3-8% body weight during the culture period. The goat shed was fabricated with bamboo and the droppings were allowed to fall into the pond water which in turn acted as a fertilizer for polycultured fishes. The goats were fed with grass grown on pond dyke and artificial feed in morning and evening respectively. Integration of livestock with fishes resulted in good growth and survival of fish. The pearlspot and milkfish attained 250-300 g and 300-500 g respectively with a survival of 90-95%. The Successful demonstration of nursery rearing, polyculture and livestock culture in IFF pond resulted in a revenue generation of Rs. 5.0 Lakhs to SHGs of Matwad village with the help of CIBA NGRC, Navsari.

ASSESSMENT OF RESOURCE CHARACTERISTICS AND ENVIRONMENTAL CONDITIONS IN THE WATERBODIES OF MAHARASHTRA

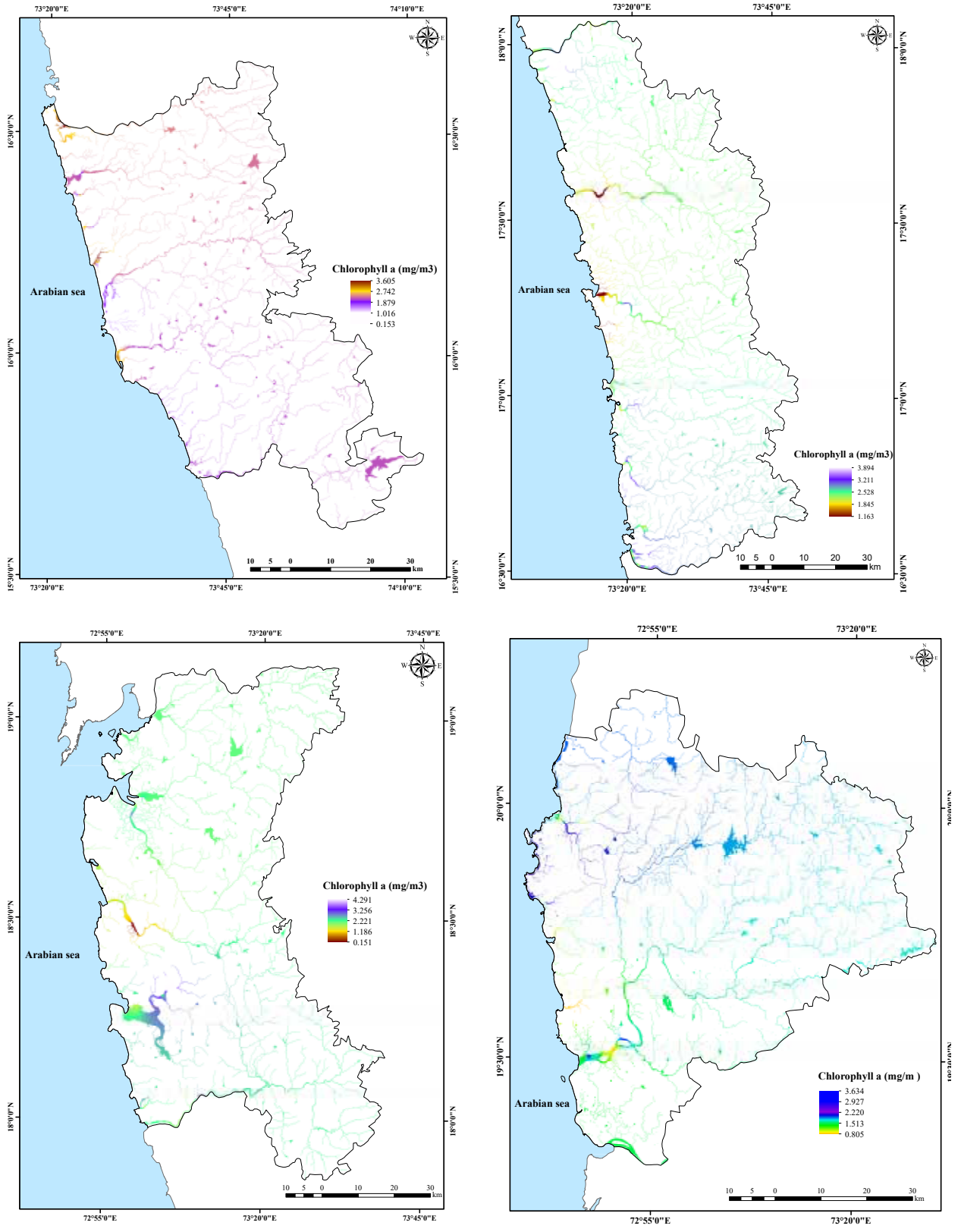
The waterbodies and different land-use classes (for example: agriculture, aquaculture, abandoned aquaculture, mudflat, reserved/ scrub forest, salt pan, abandoned salt pan, sand, scrub/hill, built up, mining/ industries and waterlogged) have been mapped for five coastal districts of Maharashtra. The physicochemical and biological parameters: water temperature, turbidity, pH, salinity, dissolved Oxygen, Ammoniacal Nitrogen, Nitrate, Nitrite, Phosphate and Chlorophyll 'a' in source water bodies. The physicochemical characteristics were more or less found to be within the range for aquaculture, however, turbidity and depth of water in the lowest tide period are the major limiting factors in deciding the sites for cages. The suitable range of turbidity for the successful cage culture will vary from 10-35 NTU. However, the mapped turbidity and Chlorophyll a in the source water bodies of the coastal districts indicated that the values ranged from 1 to 352 NTU ; 0.017 to 3.606 mg/m^3 respectively. In addition to the selection criteria of water bodies with the depth of above 3 m during the lowest tide, it is very important to select the waterbodies having optimum turbidity for the culture operations.

Water bodies studied for evaluating the potential

District	River/waterbody
Palghar	Dahanu River, Ghivali creek, Banganaga River, Murba creek, Murpo sat-pathi creek, Mankunsar Creek, Vaitrana River
Raigad	Karanja creek, Patalganga River, Amba River, Kurul creek, Kundalika creek, Rajpuri creek, Kalinje creek,
Ratnagiri	Savitri River, Kelshi Creek, Wadi Creek, Murdi Creek, Vashishti River, Jaigad River, Voraiyudi Creek, Kasarveli Creek, Kajali River, Muchkundi River, Agarwadi Creek. Pangeri Creek, Vahghotan River
Sindhudurg	Vahghotan River, Taramumbari Creek, Devgad River, Naringre River, Gad River, Kolamb Creek, Achara Creek, Karali River, Shriramwadi Creek, Mandavi River, Mochimad River, Tiroda Creek, Terekhol Creek



Chlorophyll-a in source waterbodies of Maharashtra a. Sindhudurg, b. Ratnagiri, c. Raigod and d. Palghar

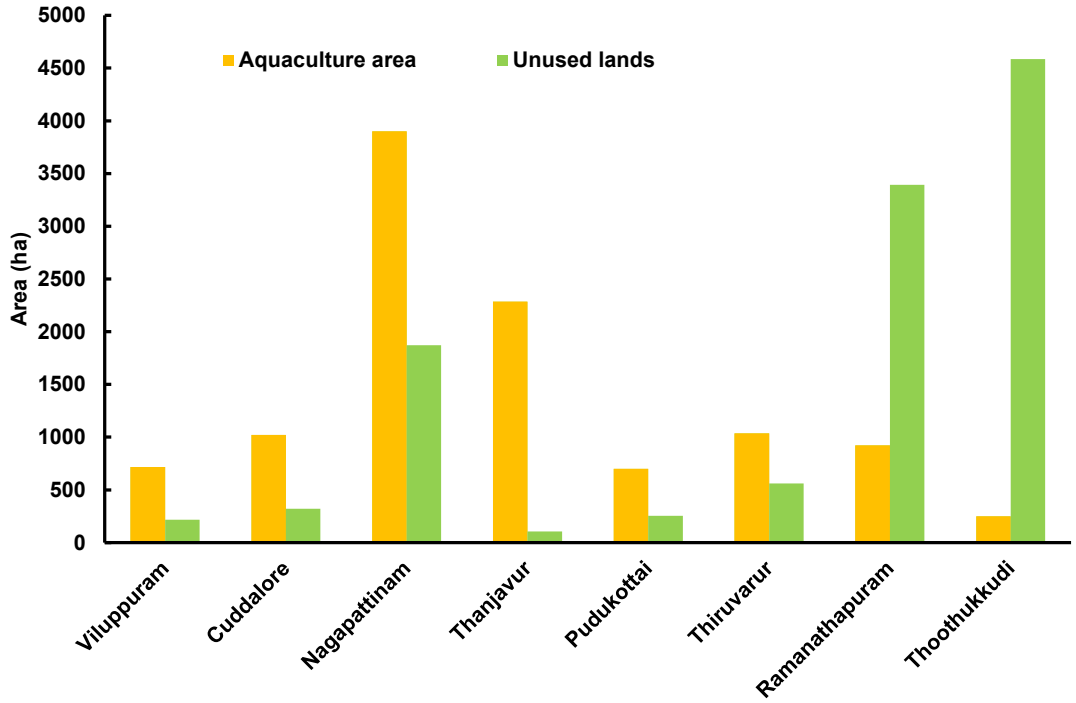


Turbidity in source waterbodies of Maharashtra a. Sindhudurg District b. Ratnagiri District C. Raigod District D. Palghar District

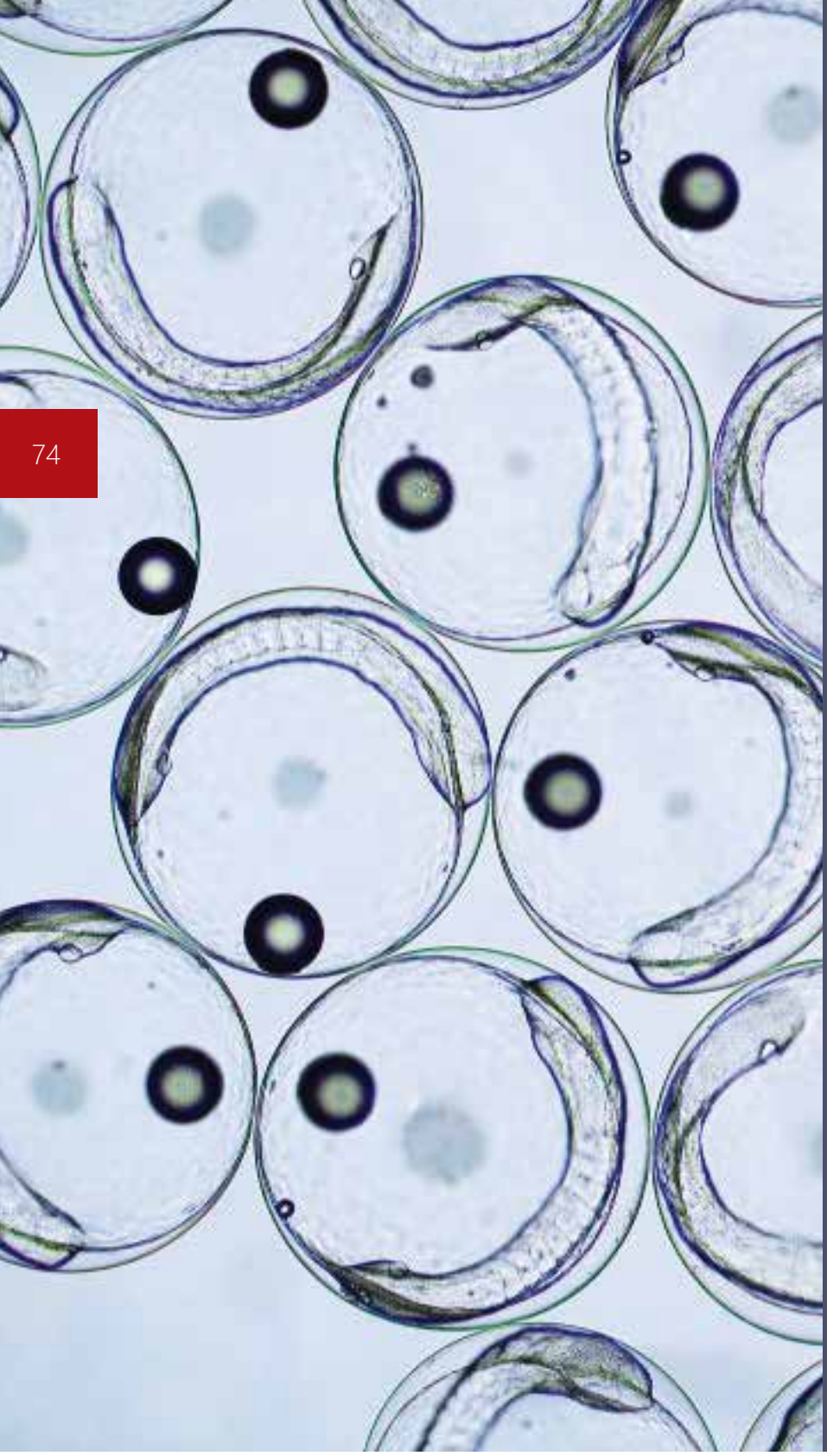
MAPPING OF UNUSED LAND RESOURCES FOR THE EXPANSION OF BRACKISHWATER AQUACULTURE IN TAMIL NADU

Tamil Nadu, has used hardly around 15% of brackishwater resources for aquaculture, and there is ample scope for further development. Even with this brackishwater area utilized for aquaculture, many environmental issues have been raised in coastal areas of Tamil Nadu due to improper planning and lack of proper site selection. In this context this study was carried out with the funding support from the Government of Tamil Nadu to map the unused wastelands that are not suitable for other production systems. The study was carried out in the six districts of Tamil Nadu: Villupuram, Cuddalore, Pudukottai, Toothukudi, Thiruvarur, and Thanjavur. The land and water resources were mapped, verified in the ground and then qualified. After removing the productive lands such as mangroves, agricultural lands, salt pans, settlements and the lands used for other purposes, suitable wastelands having source water bodies were selected and assessed. The nearest source water bodies characteristics namely pH, salinity, temperature, nitrate, total Ammoniacal nitrogen, Phosphate, water depth, water flow rate, were assessed for the aquaculture suitability. The soil samples have been collected from the unused lands and evaluated for pH, organic carbon and electrical conductivity and then mapped and interpolated using GIS. Based on the spatial analysis incorporating the environmental characteristics, the unused lands available in the districts were identified after providing 50m buffer from the nearest productive systems.

The land and water resources were mapped, verified in the ground and then qualified



Existing aquaculture area and unused lands for expansion in Coastal Tamil Nadu.



Reproduction, Breeding & Larval Rearing

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

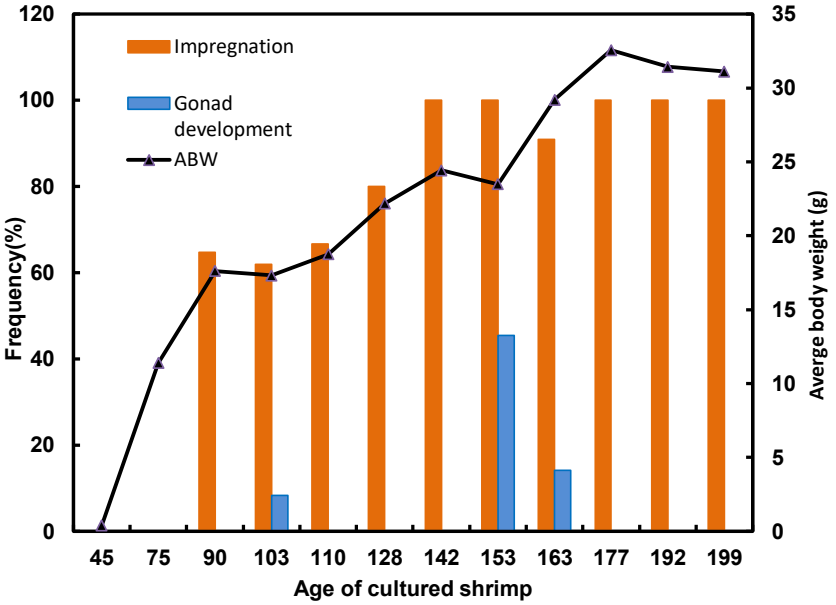
Reproduction, Breeding & Larval Rearing

PENAEUS INDICUS

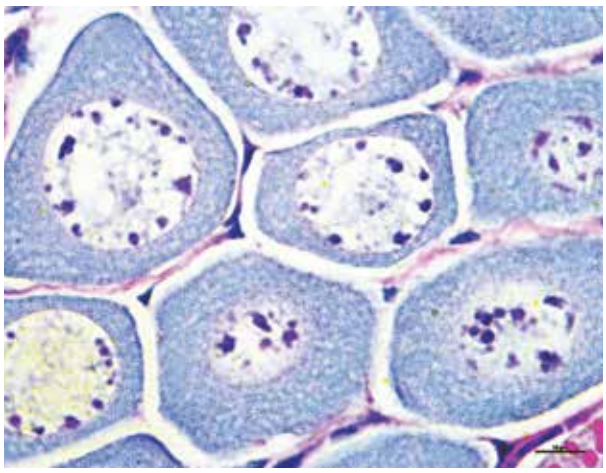
DOMESTICATION OF INDIAN WHITE SHRIMP, *PENAEUS INDICUS*

The current exclusive reliance of shrimp industry on exotic *Penaeus vannamei* is severely constrained by emerging diseases and declining production performances. As an initial phase of the large scale domestication and genetic improvement program of native *Penaeus indicus*, domesticated lines (G1 and G2) of this species were developed. In order to develop G1 lines, hatchery reared PL produced by wild brooders were reared in grow out ponds at low density 1 PL/m^2. Shrimps attained 30-45 g with 100% impregnation in female broodstocks within 10 to 11 months. Nearly 60% of the impregnated females were showed advanced gonad development from advanced second stages to 3 rd stage of ovary development. Mated females were unilaterally eyestalk ablated, and more than 70% animals reached final stage of maturation and 40% of animals spawned successfully. A total of seven, hatchery runs were carried out, and above 75% of the seed production cycle recorded successful spawning and hatching. Induced maturation revealed an average fecundity of 50- 90,000 egg per spawner with 50-70 percentages and above hatchability. In order to evaluate the role of sex steroids the ablated animals were administered with 17-β-Estradiol. Almost 70% of females at 2+ stage of ovary development responded with a fecundity of 75000 and above 80% hatchability. Growth and reproductive performance of these lines were studied; additionally these characteristics were compared with wild broodstock. Broodstock rearing was carried out in both earthen pond and indoor concrete tanks. The G2 lines grew faster than G1 lines, and within 135 days of culture (including 45 days of nursery), and 80% of animals attained impregnation. The current findings demonstrated that G2 line showed better reproductive performance than the G1 line corroborating the hypothesis that issues of reproduction becomes less problematic during the course of domestication. Reproductive performance of domesticated line is slightly lower than wild broodstock, and it is mainly due to the large body weight (possibly higher age) of wild caught animals. In order to circumvent the issues of biosecurity when broodstocks are grown in earthen ponds, indoor sand lined recirculation systems was developed, and animals (G1 lines) were reared. The reproductive performance of tank raised animals was lower than earthen pond system, and therefore, dietary and endocrine manipulations are being carried out to refine the system.

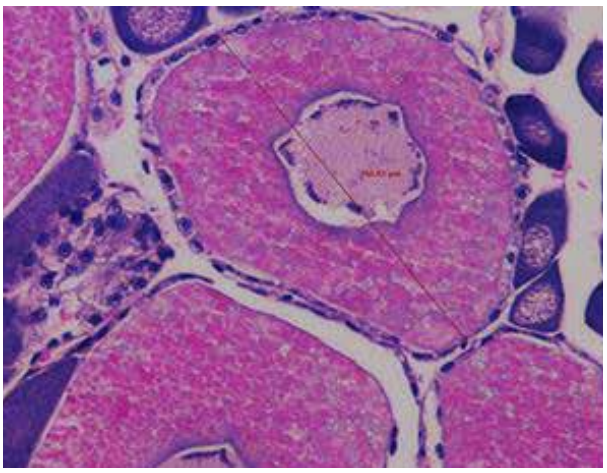
Although onset of gonad development started within 105 days of culture with nearly 46% of the population, the advanced gonad development was only found when animals attained 150 to 160 days of culture at 28 to 30 ppt salinity. Further, after the reduction of salinity below 25 ppt all the animals absorbed the gonad indicating salinity is a crucial factor for the gonad development. The study reveals the possibility of closing the life cycle of domesticated *P.indicus* within a period of 6-8 month. The findings from the present study would provide a further basis for the selection of broodstock to achieve best spawner performance.



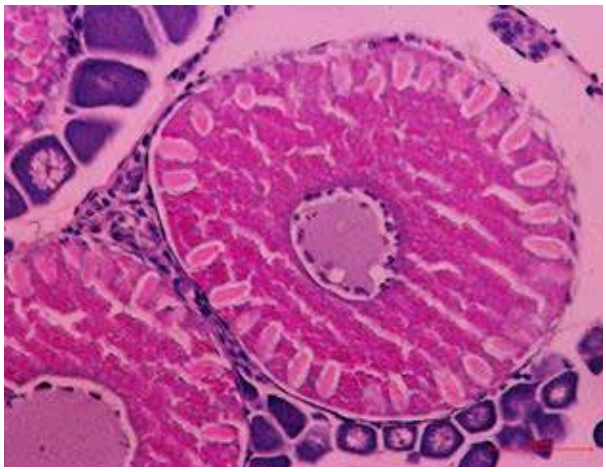
Percentage of impregnation, gonad development, and, Average body weight (g) of Domesticated G1 line of *P. indicus* with respect to culture duration



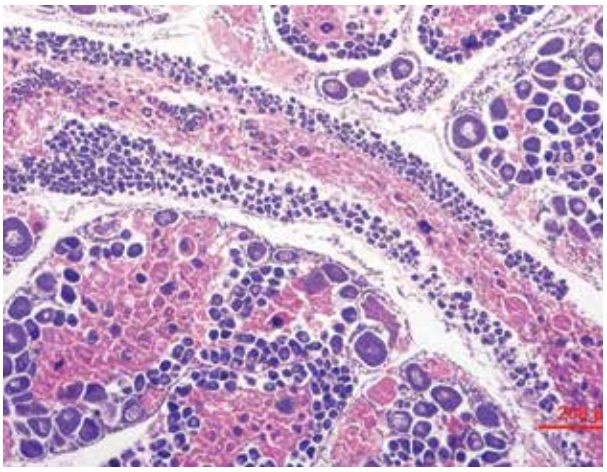
Pre vitellogenic oocyte of *Penaeus indicus*



Vitellogenic oocyte

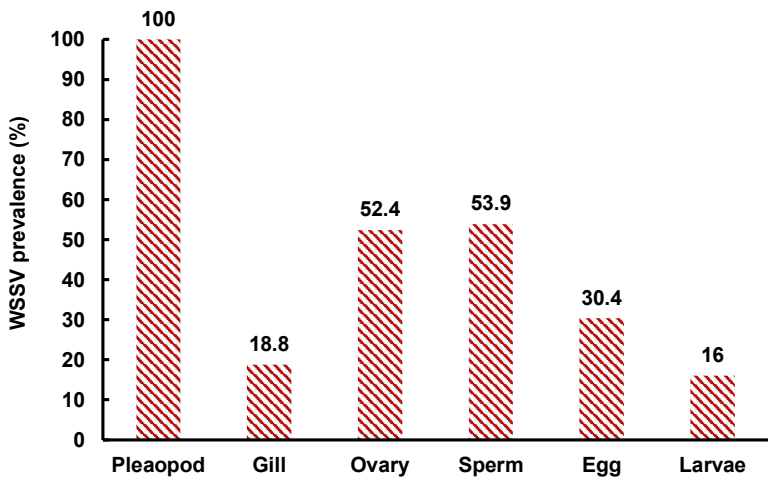


Oocyte with cortical rods

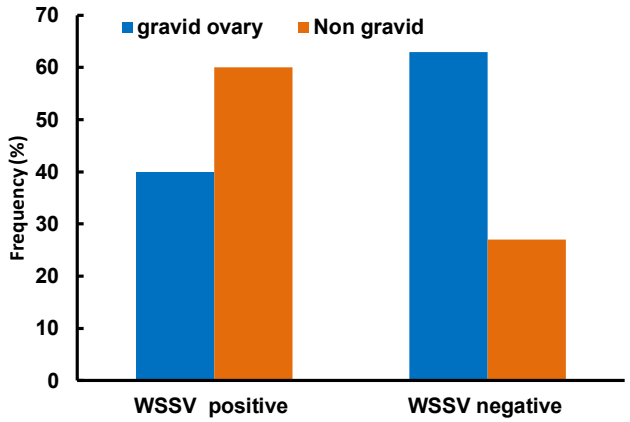


Oocytes with asynchronomous development

Ovarian development of captive reared broodstock of *Penaeus indicus*



Prevalence of WSSV in different organs of *Penaeus indicus*



Distribution of gravid and non gravid ovary in WSSV positive and WSSV negative brooders of *Penaeus indicus*

EFFECT OF WSSV INFECTION ON REPRODUCTIVE MATURATION OF INDIAN WHITE SHRIMP, *PENAEUS INDICUS*

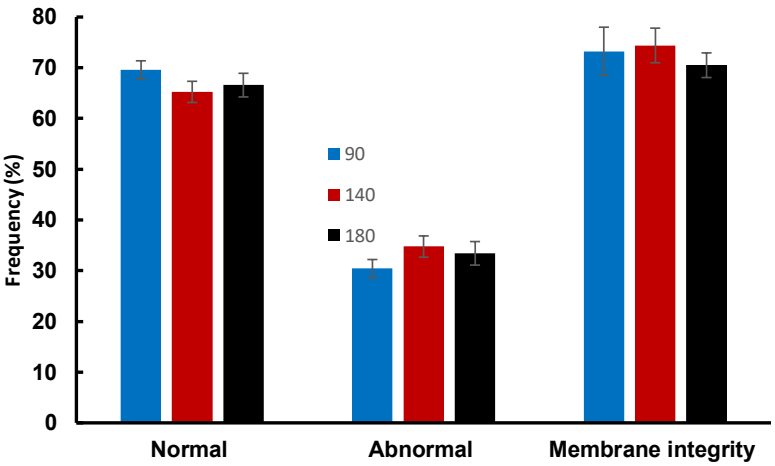
Screening of broodstock for white spot syndrome virus is the most critical step in the penaeid hatchery production cycle. The dynamics of this virus during the reproductive maturation/ gametogenesis is crucial for understanding the transmission of virus between generations, the vertical transmission. Reproductive tissues (ovaries and spermatophores), fertilized eggs and larval stages (protozoea and Mysis) of 120 second step positive brooders (based on pleopod samples) were diagnosed for WSSV, and revealed that more than 50% of reproductive tissues were infected with WSSV. However the level of infection was found to be extremely low particularly in the ovaries in the advanced stage of gametogenesis and fertilized eggs. On the contrary first step step PCR positive wild brooders had regressed ovary indicating that higher level of infection hinders final ovarian maturation. Further, study suggests that almost 60% of WSSV positive animals had undeveloped ovary whilst 63% of WSSV negative brooders had gravid ovary.

EFFECT OF AGE ON SPERMATOPHORE QUALITY OF MALE *PENAEUS INDICUS*

Evaluation of male reproductive quality is paramount in management of male broodstock. The understanding of sperm quality in relation to age is useful in selecting male broodstock. To evaluate the sperm quality of male *Penaeus indicus* in relation to age, advanced post larvae (~1g) were reared in 600 m^2 polythene lined pond. The shrimps were fed with formulated diet vannamei ^{plus} at 10% of the body weight/day. Sampling were done at the end of every month to assess the development

Table Spermatophore quality in different age groups of *Penaeus indicus*

Days of culture	Length (cm)	Weight (g)	Spermatophore weight (g) (*n=10*)	Spermatosomatic index (%) (*n=10*)	Sperm count (X10^6 cells) (*n=6*)
90	11.74 ± 0.29	10.98 ± 0.33	0.29 ± 0.004^a	0.267 ± 0.03^{ab}	13.83 ± 1.04
140	12.06 ± 0.12	13.21 ± 0.39	0.05 ± 0.008^b	0.414 ± 0.05ab	13.32 ± 0.83
180	12.77 ± 0.13	15.50 ± 0.38	0.09 ± 0.007^c	0.596 ± 0.03^c	14.93 ± 0.8



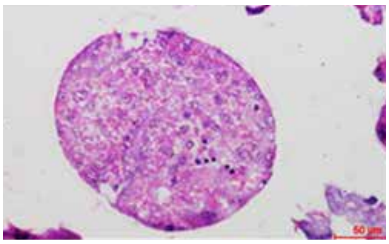
Comparison of sperm morphology and membrane integrity at different age groups of *Penaeus indicus.*

of the spermatophore. Spermatophore weight (g), Spermatosomatic index (%) and sperm count, abnormal cell morphology, membrane integrity and acrosome reaction were evaluated. Spermatophore was found to occur in the terminal ampulle during 90 th day onwards (11. 8 g ± 0.29 g). Spermatophore weight in higher age groups were significantly higher ($P<0.05$). Significantly higher spermatophore index were only observed at 180 days (0.596 ± 0.03; $P< 0.05$). The sperm count, abnormal and normal sperm morphology and membrane integrity was not significantly different ($P<0.05$) among the age groups. Compared to 90 days of age, significantly higher acrosome reaction was observed in 140 and 180 days of age. However significant difference was not observed in acrosome reaction between 140 and 180 days of age at $P<0.05$

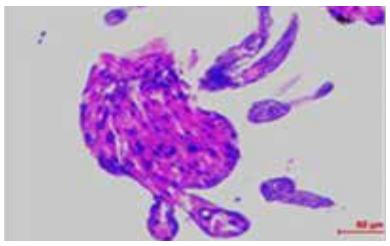
On the contrary first step step PCR positive wild brooders had regressed ovary indicating that higher level of infection hinders final ovarian maturation

ONTOGENY OF HEPATOPANCREAS

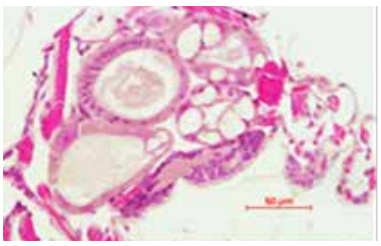
Ontogenic development of hepatopancreas at cellular level was studied using histological methdos (H&E) for zoea, mysis and post larvae. Embryonic cells,(E) and bliser cells (B) are dominated in the hepatopancrase of zoeal stage with 2-3 tublues



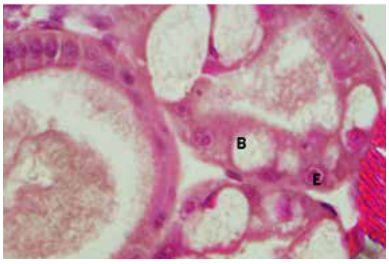
Fertilized Egg (40x)



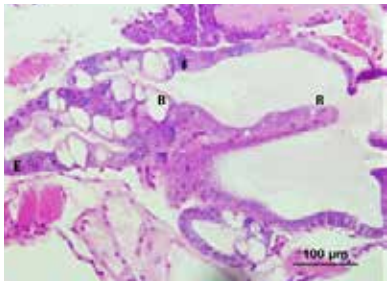
Nauplius Stage (40x)



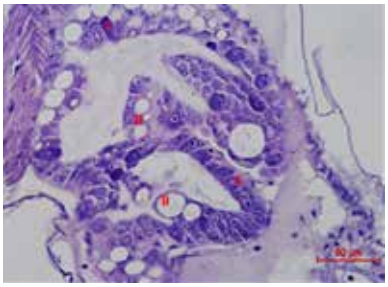
Zoea (40x)



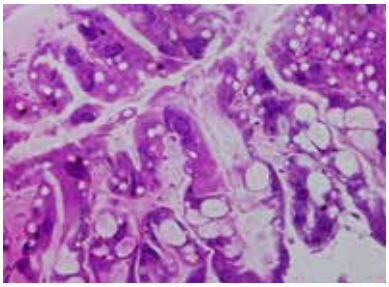
Zoea (100x) with B and E cells



Mysis 2 (40x) with four B,E,R and F cells



Post Larvae 2 (40x) with well developed and numerous R,B,F, and E cells



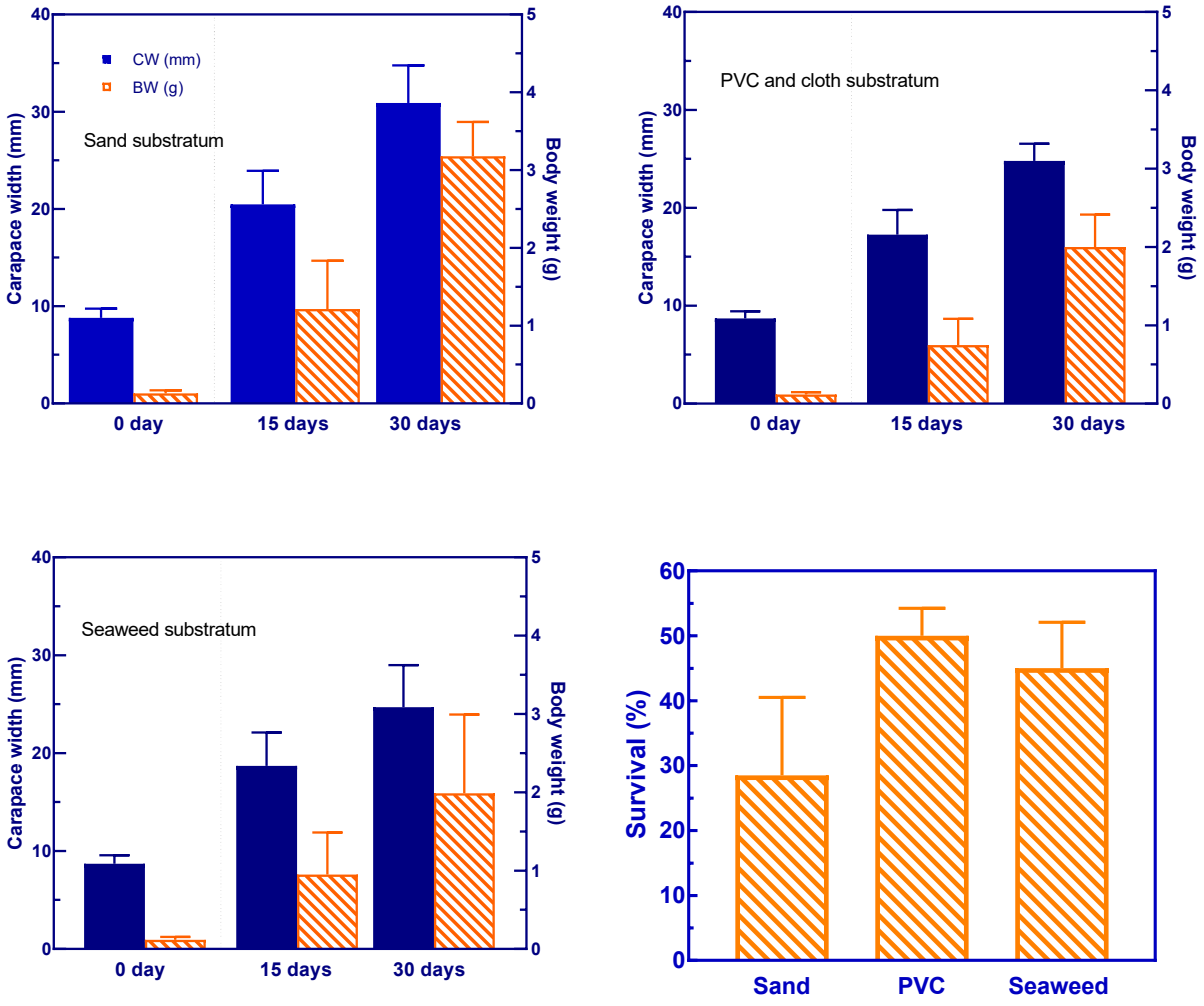
Post Larvae 12 (40x)

in hepatopancreas, which later increased to 4 tubules in Mysis 1 satge followed by 4-6 tubules in mysis 2 stages. Onset of fibrillar cells (F) and resorptive (R) cells were recorded in Mysis 3 with six hepatopancreatic tubules. B cells are known for secretory in function for digestive enzymes. R cells (absorptive lipid and glycogen) and F cells (protein and mineral storage) were found to be developed from mysis 3 stages onwards and its number and size found to increase as it enter post larvae stage. Post larve 12 was found to be with 12-15 number of hepatopancreatic tubules with well developed and differentiated E,B F and R cells. Further study is on progress.

MUD CRABS

MUD CRAB, SCYLLA SERRATA NURSERY CULTURE OF MUD CRAB IN THE INDOOR TANK SYSTEMS

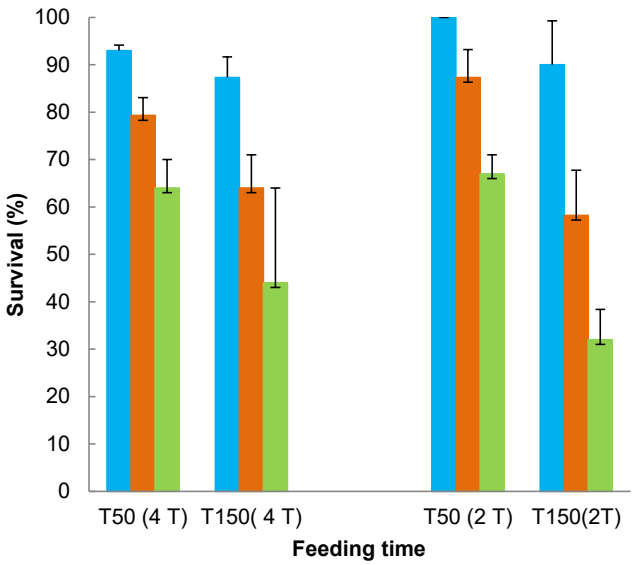
Juvenile production of mud crabs in the out door earthen pond provides relatively high success rate than indoor culture. However it remains to be a constrained for those hatcheries do not have an out door production unit. As mud crab farmers prefer advanced instars to stock their ponds, an indoor nursery rearing experiment was carried out. Three different substratum: sand, PVC and cloth and seaweed, were used and animals were stocked at the rate of 30 instars per 100 L tank. The experiment was carried out for 30 days and animals were fed with trash fish at satiation. The experimental units were refreshed with fresh seawater every day. After 30 days of experiment crab with PVC and cloth substratum had maximum survival, and conversely highest growth rate obtained in the tank with sand substratum. The study indicates



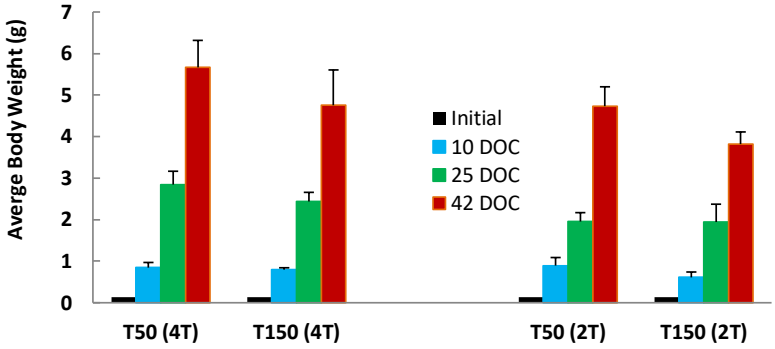
Growth and survival of mud crab *Scylla serrata* in the indoor nursery rearing tanks

the possibility of using indoor hatchery for nursery production.

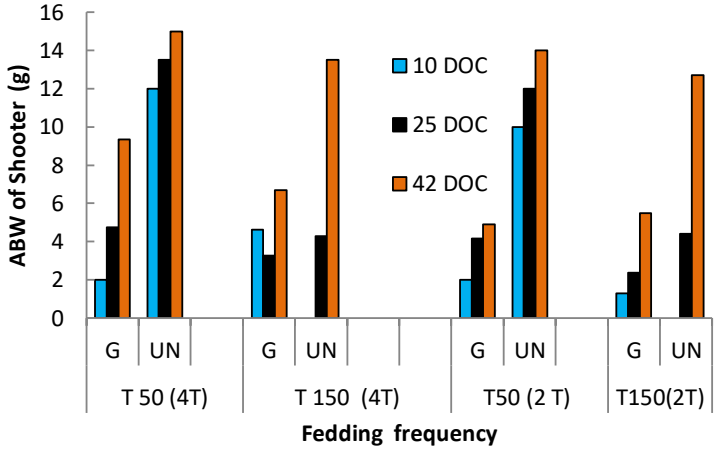
In another experiment, mud crab instars (2-day old; average body weight of 0.13 ± 0.03 g) were reared at two densities (50 and 150 crabs/m^2) with two levels of feeding (two and four times per day) for 45 days, and with segregation of shooter at 10 days interval. The study was aimed to determine the optimum survival of mud crabs during nursery culture when shooters are segregated periodically. In general, up to 10 th day survival was found to be insensitive to stocking density (88 -100%), and 93 to 100% in low density group and 87 to 93% in high density group. At the end of 45 days rearing survival reduced to 64-67 % in low density group and 32-44 % in high density groups. The highest body weight was attained in cages fed with four time feed (50 crabs/m^2 : 5.7 ± 0.65 and 150 crabs/m^2 : 4.7 ± 0.85), where as two time fed groups achieved 4.73 ± 0.46 (50 crabs/m^2) and 3.18 ± 0.29 (150 crabs/m^2). Shooters development in nursery were found to be irrespective of feeding interval. Segregation of shooters in each sampling helped to grow the remaining stock in each cage irrespective to feeding time. The average weight of shooters were very higher in un culled population in cages (bw 12-15 g) compared with culled crabs (8-9 g) although its percentage of shooter development were less. This indicate, shooter development is inherent in mud crabs even in the presence of ad libitum feed where as frequent segregation of shooters helps to grow the remaining stock at optimum rate.



Survival (mean ± SD) of nursery reared mud crab instar in hapa system under two different density and two feeding regime



The average body weight (mean ± SD) of nursery reared mudcrab instar in hapa system under two different density and two feeding regime



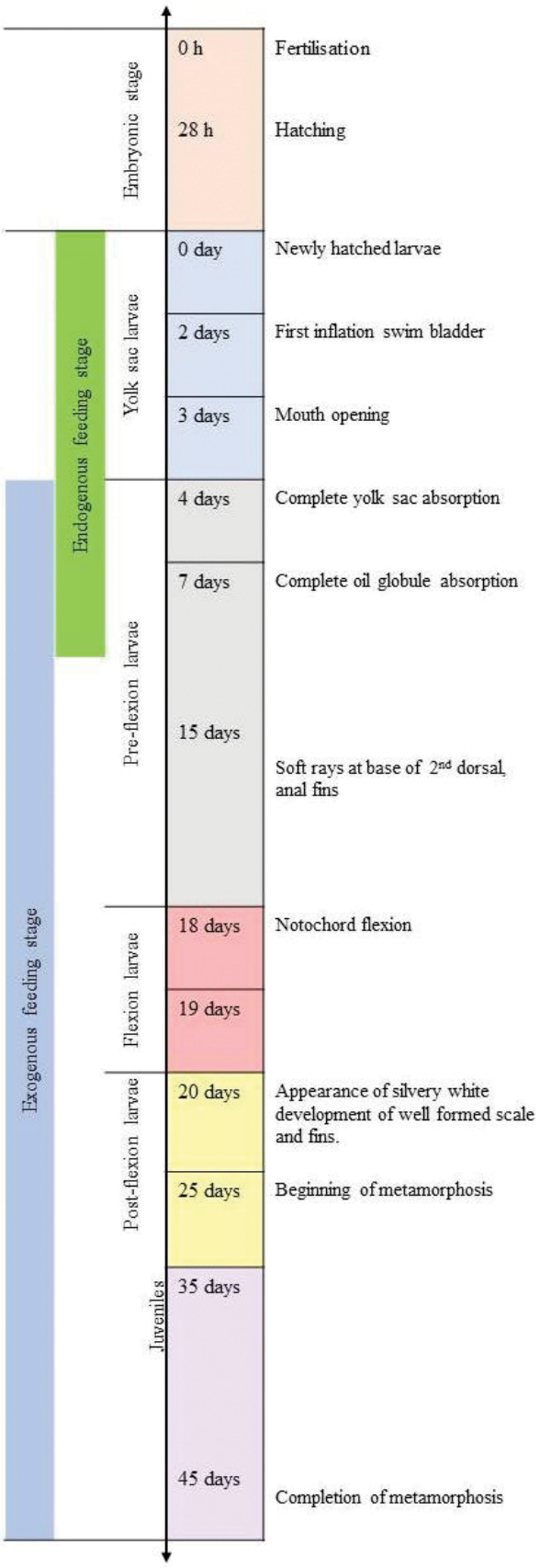
The average body weight of shooters during mudcrab nursery rearing in hapa system under two different density and two feeding regime

GREY MULLET

SUCCESSFUL PRODUCTION OF GREY MULLET SEEDS (FRY) IN CAPTIVITY USING STOCKS MATURED IN CAPTIVITY

In India, grey mullet is a high valued food fish and an important component of polyculture in traditional and contemporary farming systems. Availability of seeds of grey mullet is inconsistent and sharply declining from wild, affecting grey mullet aquaculture adversely. Consequent to the narrow annual reproductive period coupled with multiple reproductive dysfunctions of grey mullet in captivity, commercial hatchery-based seed production of the species still remains a challenge. More recently, greater impetus was given to captive reproduction of grey mullet in CIBA, and consistency in captive breeding and larval production was achieved since 2015-16 at both west and east coast using farm reared brood fish in low volume breeding system and at captive tank reared broodstock respectively. For first time, a success was achieved in captive fry production of grey mullet, inching closer towards commercial production of grey mullet seed. Grey mullet female, (body weight, 800 g; average oocyte size, 530 µm) was stocked with two milting males after giving hormonal treatment for spawning induction. Natural spawning was recorded 14 h after resolving dose administration. Newly hatched larvae, TL, 2.4 mm were observed after 28 h at 29^{0}C. Larvae were reared using microalgae and other conventional hatchery feeds. After 20 dph, 2000 numbers of metamorphosed larvae (SL, 3.57 ± 0.53 mm) were obtained. Fry attained a size of average body weight, 6.4 ±0.75 g, tl, 79.57 ± 0.75 mm after 80 days and 110 fingerlings are being maintained.

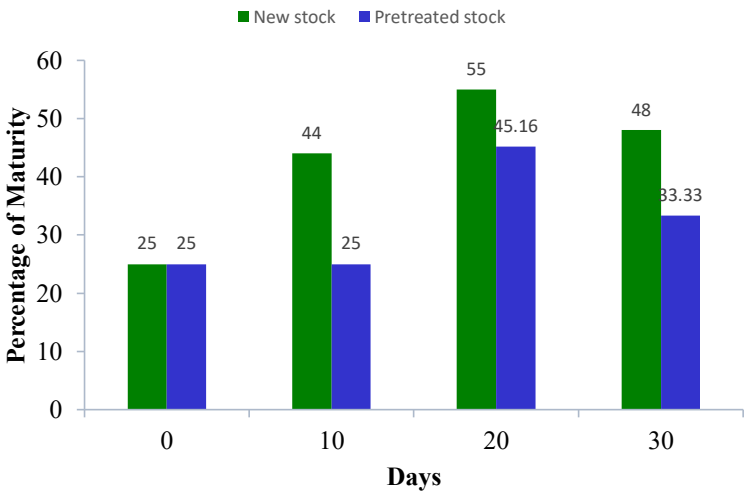
Grey mullet *Mugil cephalus* fingerlings produced at fish hatchery, MES, ICAR-CIBA



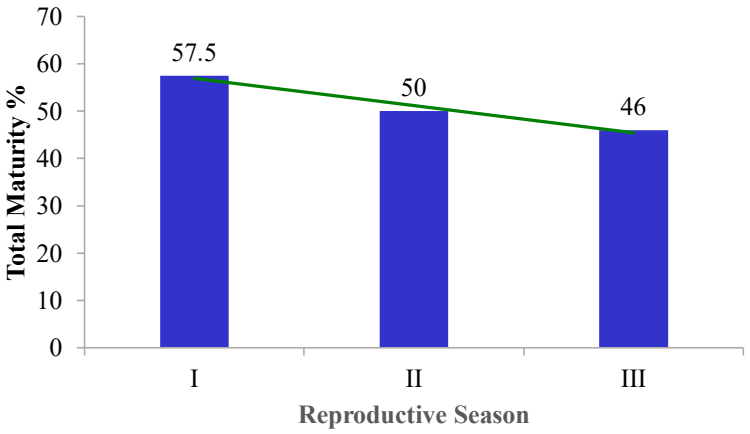
Time scale of the most important events during development of grey mullet *Mugil cephalus* larvae

REPRODUCTIVE MATURITY OF GREY MULLET *MUGIL CEPHALUS* TREATED WITH SLOW RELEASE EXOGENOUS HORMONES OVER REPRODUCTIVE SEASONS SHOWED PROGRESSIVE DECLINE IN MATURITY

Grey mullets on account of its importance in sustainable aquaculture have been considered a high priority species for captive seed production globally. Chronic release exogenous hormones were administered to captive grey mullets to overcome gonadal dysfunctions. Female grey mullet were administered LHRHa in cholesterol pellets and male were administered 17-α-methyl-testosterone to enhance the gonadal recrudescence. Fish broodstock treated in previous seasons to larger peptides like gonadotropic hormones have reported gradual immunity to the hormone treatment. It has been hypothesised that LHRHa is small decapeptide and hence the fish may not elicit a similar immune response. We compared reproductive maturity of grey mullet treated over two reproductive seasons with chronic LHRHa pellets (200 µg per fish) with domesticated grey mullets not given any previous hormone treatment in previous seasons. Grey mullets (n= 45; Tl- 390- 510 mm) were maintained in 100 t flow-through tanks and fed Mullet BroodI^{Plus} at 3-4% body weight twice daily. Before the reproductive period, the females were given intra-muscular treatments of LHRHa in cholesterol pellets and males were given 17-α-methyl- testosterone. After 15 days (1st November, 2020) female were observed for maturity through ovarian biopsy and assessing the presence of vitellogenic oocytes. Milting males were recorded. Although a similar trend was observed in the progression of maturity for the two treatment groups attaining peak gonadal maturity by third week of November, the grey mullet broodstock previously treated with hormones showed a lower maturation response (25, 25, 45, 33% as compared to newly recruited broodstock (25, 44, 55, 48%) after 0, 10, 20, 30 days post treatment. Further, grey mullet *Mugil cephalus* treated with chronic release exogenous hormones 57.5 % (year-1) showed progressive decline over next two reproductive seasons, 50% (year-2) and 46% (year-3).



Percentage of maturity of grey mullet *Mugil cephalus* treated over two reproductive seasons with chronic release LHRHa as compared to control group



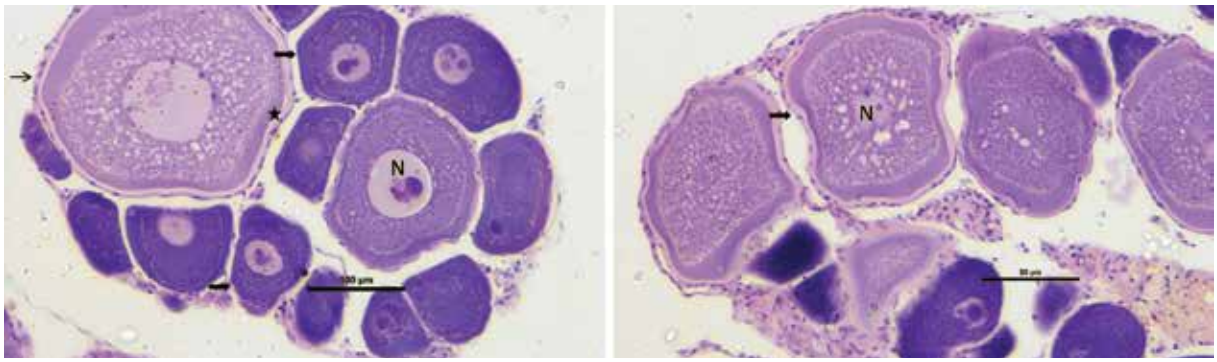
Percentage of maturity of grey mullet *Mugil cephalus* treated with chronic release LHRHa over three reproductive seasons (year-1, year-II, year-III)

CHARACTERIZATION OF ATRETIC STAGES AND IMMUNOLOCALIZATION OF VITELLOGENIN *MUGIL CEPHALUS* OOCYTES.

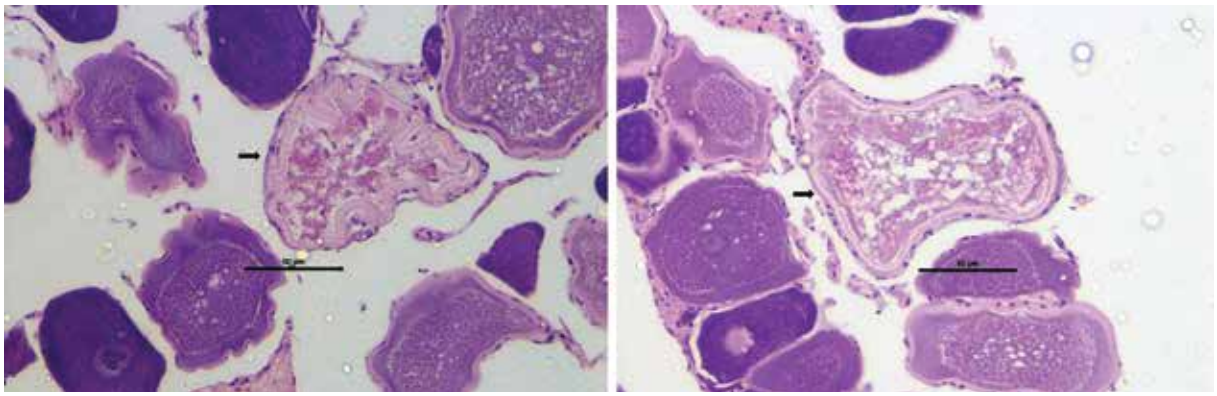
Follicular atresia is the breakdown of the ovarian follicles in the process of oocyte maturation. The atretic stages of the captive *Mugil cephalus* oocytes can be classified in to alpha, beta, gamma and delta stages. Alpha stage: The follicle was apparently

shrunken and the yolk granules increased in number and size. On advancement of atresia, the oocyte became flaccid, more vascular and irregular in outline and presented a granular and basophilic staining. The nucleus was irregular and usually with one nucleolus and with a homogeneous basophilic staining. The nuclear membrane disappears and the nuclear contents merge in to the ooplasm. The ZR loses its integrity become uneven in diameter. Most of the cytoplasm and yolk were resorbed and resulting structure was much smaller than the original one. Beta stage: The structure in this stage consists of numerous disorganized granulosa cells surrounded by thin thecal layer. The blood vascularity is greatly increased; zona radiate completely disappears. The ooplasm and its components are being resorbed. Gamma stage: During this stage, complete absorption of the ooplasm and its components is seen, due to the phagocytic activity of the hypertrophied follicle cells. The structure was much smaller than the beta stage and was characterised by the presence of flocculent yellow

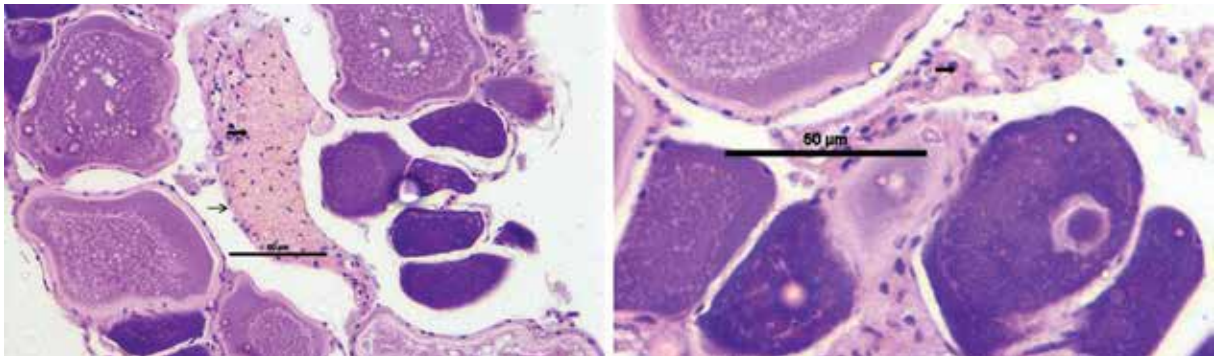
The atretic stages of the captive *Mugil cephalus* oocytes can be classified in to alpha, beta, gamma and delta stages.



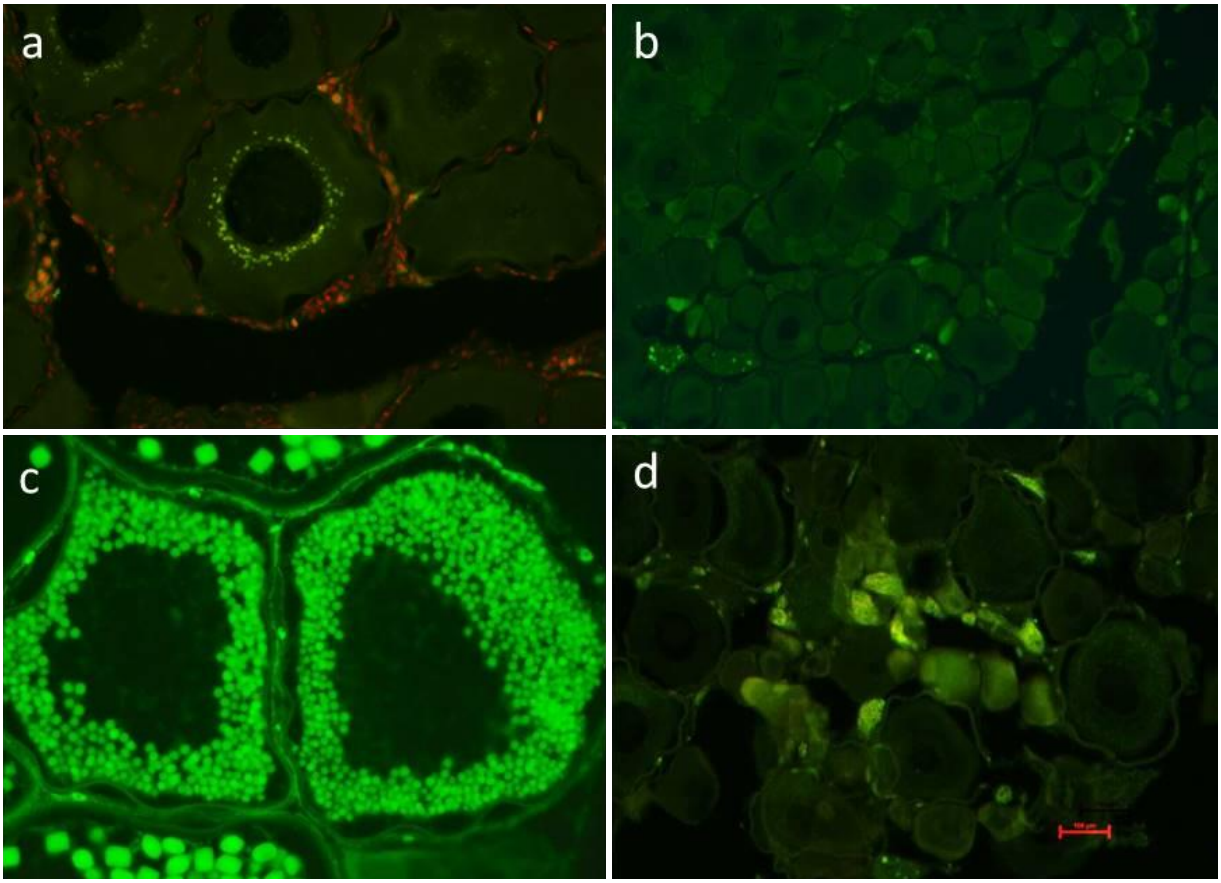
Alpha stage



Beta stage



Gamma stage Delta stage



Vitellogenin immunolocalization in a) maturing ovary b) in spent ovary c) mature ovary d) captive atretic ovary; red- granulosa cells, Green-vitellogenin granules

material surrounded by granulosa and thecal cells. Delta stage: The presence of dark yellow-brown pigments is the characteristic feature of this stage.

RED SNAPPER

MATURATION AND SPAWNING OF MANGROVE RED SNAPPER, *LUTJANUS ARGENTIMACULATUS* IN CAPTIVITY

Mangrove red snapper, *L. argentimaculatus* is an important food and sport fish throughout the Indo-Pacific region. Aquaculture importance of this species has been well documented due to high demand in the international market. Considering the commercial importance of this species, CIBA

has taken up research programme to standardize breeding and seed production. Captive maturation of this species has been observed under tank based rearing system in fish hatchery at Muttukkadu Experimental station of CIBA. A total of 110 fishes in the size varied from 2.4 to 4.4kg is being maintained in 100 ton capacity RCC tanks and 300 m2 earthen ponds separately. In the tank system , maximum maturity of 47.5% (19 fishes out of 40) could be observed during July 2019 with male and female maturity of 27.5% 20% respectively. The matured male and female fishes found in the size range of 2.6 to 3.4kg and 3.2 to 4.2kg respectively and thereby indicated that the females are larger in size than the males. The fishes were fed with low value fish such as tilapia, sardines and mackerel @ 3-4% body weight daily. A successful spawning instance was achieved for the first-time during July 2019. A total of 1.15 lakh larvae were obtained and they survived up to 10 days of post hatch.

Aquaculture importance of this species has been well documented due to high demand in the international market

Developing eggs

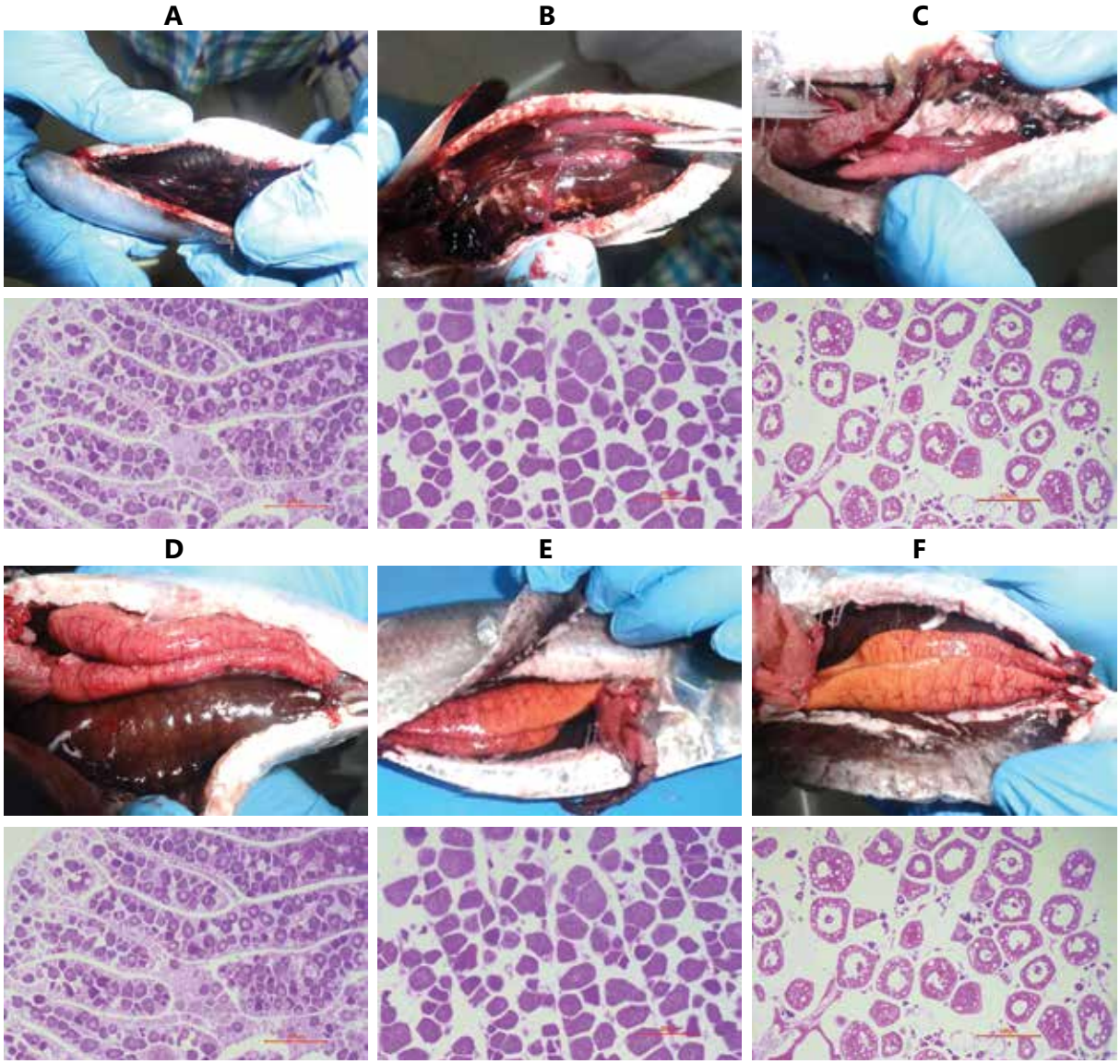
Newly hatched Larvae | 1 dph Larvae | 2 dph Larvae

4 dph Larvae | 5 dph Larvae | 7 dph Larvae

HILSA

MACROSCOPIC AND MICROSCOPIC OBSERVATION OF GONAD DEVELOPMENT OF WILD STOCK OF HILSA, *TENUALOSA ILISHA*

Histological observation of gonad development is an important indicator for spawning season and spawning pattern. In present study, hilsa, *T. ilisha* of different size were collected from wild (Hooghly river and Frezerganj, West Bengal) during breeding season (January- March and July-August). Fishes were dissected out to find the sex, maturation stages and gonadosomatic index (GSI) through macroscopic observation of gonad. Histological samples were fixed in neutral buffer formaline (10%NBF), dissected with the aid of microtome, stanied with H & E stain and observed under light microscope. Macroscopic observation showed the presence of immature (I), early maturing (II), late maturing (III), maturing (IV) mature and ripe (VI) ovary. Histological observation showed the presence of primitive oocytes, chromatin nucleolar oocytes, perinucleolar oocytes, vitellogenic oocytes, post-vitellogenic oocytes and hydrated oocytes, respectively at I, II, III, IV, V and VI maturation stages. Oozing female having the gonadosomatic index (GSI) of 14.51 ± 3.77 and oocytes diameter ranges from 670-700 µm. Present study will be useful comparing the gonad development of captive reared hilsa with wild stock maturation.

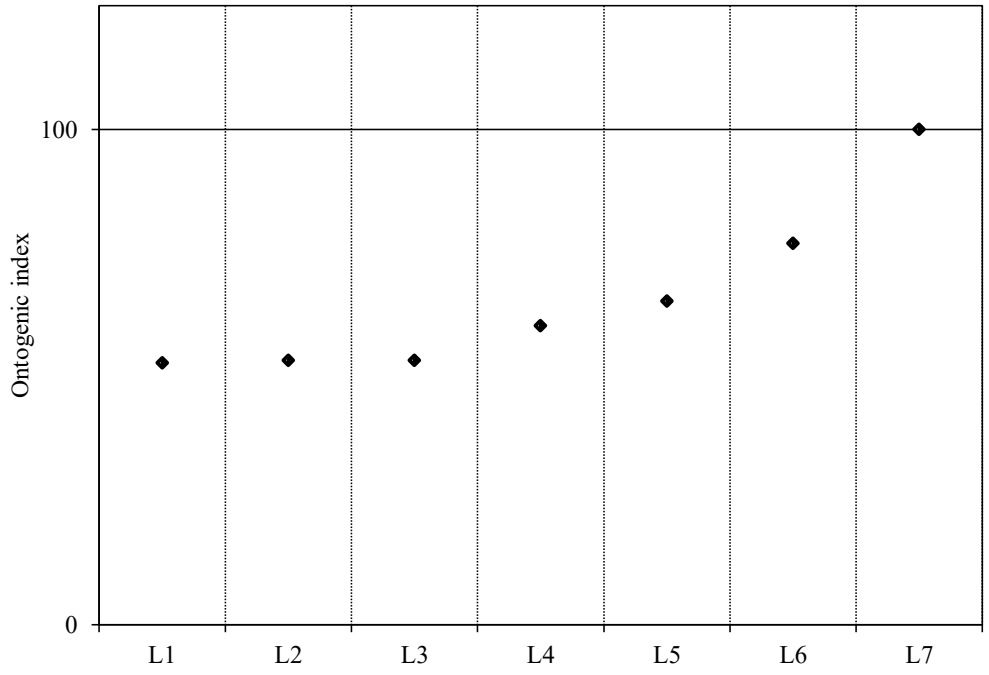


Hilsa, macroscopic and microscopic observationof gonad development collected from wild. Histological photography was carried out at 10X magnification (Scale 200 µm)

PEARL SPOT

Pearlspot in one of the important indigenous cichlids of India and its natural distribution confined to Southern Peninsula and Sri Lanka. Limited information is available on the early development pattern of pearlspot. For an aquaculture species, the patterns of early development features sets a model for comparison when the normal development patterns are altered. Growth and development of larval stages of pearlspot from 0 dph to 40 dph (n=150) was studied using pearlspot larvae produced in the hatchery. During the larval phase, growth with respect to larval length followed an exponential relation; $y=0.03+1.8$, $R^2=0.97$. Higher increase in growth was observed after 20 dph upto completion of metamorphosis, 38-40 dph. The major development events of pearlspot larval stage was identified and ontogenetic index estimated. The ontogenetic indices were estimated as L1- eye pigmentation-52.88%, L2- initial mouth opening, 53.42%, L3-notochord flexion and appearance of first caudal fin rays, 53.42%, L4- complete yolk sac absorption, 60.33%, L5- appearance of fin rays, 65.32 %, L6- complete fin differentiation, 77.03% L7- squamation, 100%. Based on the appearance of these ontogenetic stages pearlspot larvae were categorised into four stages; yolk sac larva; total length (t.l.)- 5.6±0.16 to 7.8±0.03 mm; post-larva- t.l.- 8.3±0.01 to 10.8±0.01 mm; prejuvenile, t.l.- 11.6±0.14 mm to 25.99±0.71 mm and the juvenile stage was reached in individuals exceeding t.l.>26 mm. The mouth sizes of the four respective stages were; yolk sac larva, 600- 800 µm; post-larva- 900- 1000 µm; prejuvenile, 1000- 3000 µm and the juvenile stage exceeds 3000 µm. The initial larval stage of pearlspot is characterised by the presence of adhesive glands on the dorsal head region. A time period of over 38 days is required for pearlspot to reach juvenile stage marked by completion of squamation and prominent appearance of blotch on posterior end of dorsal fin.

Pearlspot is one of the important indigenous cichlids of India and its natural distribution confined to Southern Peninsula and Sri Lanka



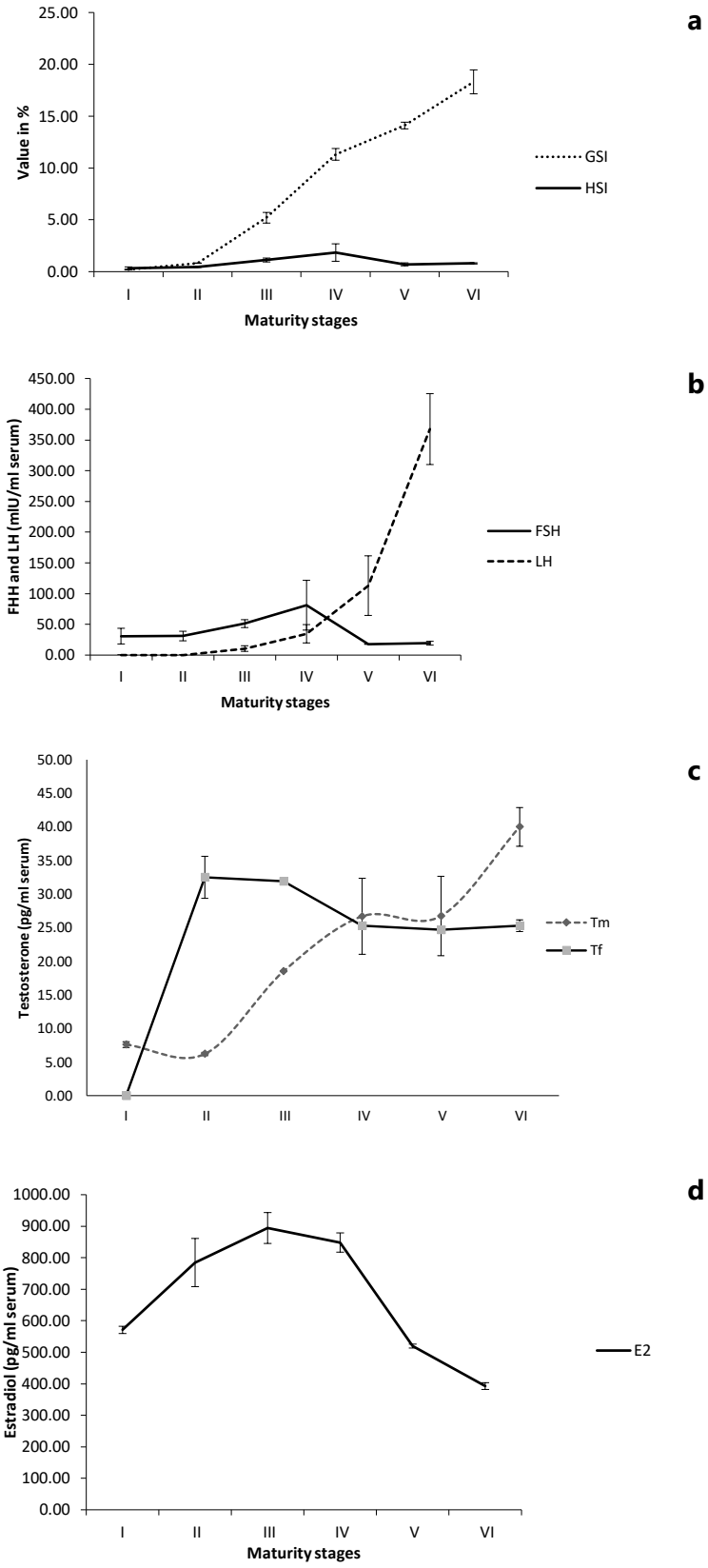
L_{1}-Eye pigmentation, L_{2}- Mouth open, L_{3}-Notochord flexion, First caudal fin rays, L_{4}- Complete yolk sac absorption, L_{5}- Appearance of fin rays, L_{6}- Complete fin differentiation, L_{7}- Squamation

Morphological development and growth pattern of hatchery reared pearl spot larvae

GOLD SPOT MULLET

SEX HORMONES LEVEL AND DOPAMINE ACTIVITY IN DIFFERENT PUBERTAL STAGES OF GOLDSPOT MULLET, *LIZA PARSIA* BROODSTOCK DEVELOPED IN BRACKISHWATER POND

In addition to the GnRH stimulatory system, neurons secreting dopamine (DA) have been identified as an inhibitory system over the reproductive axis. Role of DA in inhibitory control of reproduction of fish is major cause of reproductive dysfunction in many of the captive reared fish. Based on macroscopic observation and GSI values, fishes of different maturity stages were collected, anesthetized to collect the blood (serum). Different sex hormones such as follicle stimulating hormone (FSH), luteinizing hormone (LH), testosterone (T) and E2 were analysed using Enzyme Linked Immunosorbent Assay (ELISA). Expression of dopamine receptor (D2R) in whole brain tissue of different maturity stages, different size groups (fry, fingerlings and sub-adult), and different brain parts (forebrain, midbrain and hind brain) of *L. parsia* was carried out through SDS-PAGE and western blotting technique. The serum E2 level changed with ovarian developmental stages, and the significantly highest ($p<0.05$) level of E2 was observed at late-vitellogenic (III) (894.30±49.02 pg/ml), which does not vary with mid-vitellogenic (II) (784.70±76.47 pg/ml) and vitellogenic (IV) (848.20±30.57 pg/ml) stages of oocyte development. After IV stage, E2 level come down to basal level.



Showing (a) gonadosomatic index (GSI) hepatosomatic index (HSI) (b) follicle stimulating hormone (FSH) and luteinizing hormone (LH) (c) testosterone (T) and (d) estradiol (E2) in six different maturity stages of captive reared *Liza parsia*

FSH profile showed similar trend as E2, which has peak value at stage IV (81.14±40.48 mlU/ml). Concentration of LH increased gradually and peak value was found at stage VI (367.67±57.67 mlU/ml. In male, concentration of T increased gradually from stage I (7.60±0.43 pg/ml) to VI (40±2.89 pg/ml). In female, T was undetectable at stage I, however it reached its maximum value (32.5±3.13 pg/ml) at stage II. The SDS-PAGE and western blot analysis of D2R and β-actin in different brain parts (forebrain, midbrain and hindbrain) (Figure), whole brain tissue of different size groups (fry, fingerlings and sub-adult) (Figure), and of different maturity stages (Figure) of *L. parsia* showed single bands between 41 and 45 kDa (~ 44 kDa). Result showed that the D2R is distributed in all three parts of adult *L. parisia* brain and it express even in fry stage. The brain tissue of different maturity stages showed expression of D2R, however faint band noticed at more developed stages IV, V and VI (Figure).

protocol to achieve year round mass spawning and equal breeding response from two different east coast breeding populations of milkfish i.e. Chennai (C: Avg. body weight 5.47 kg) and Kakinada (K: Avg. body weight 4.36 kg) we have modified the implantation frequency and reduced to only two i.e. before breeding season (Jan) and after breeding season (July) compared to previous years (5 to 9 times) to minimize stress and inducing natural breeding behaviour during off seasons. In the previous years we reported mass scale breeding from newly introduced Kakinada population but their spawning frequency was significantly lesser than older population i.e. Chennai group ($p < 0.05$). Only two doses of combined hormone pellet (LHRH-A + 17α- MT: Each 50 µg/kg) were administered in both the stocks following similar breeding protocol and resulted in total spawning of 28 times out of which fifteen spawning was from Chennai population and thirteen was from Kakinada

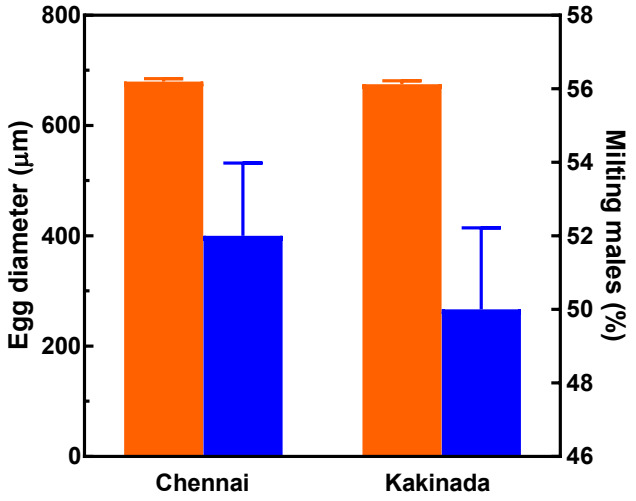
Role of DA in inhibitory control of reproduction of fish is major cause of reproductive dysfunction in many of the captive reared fish

population during eight months (March – October). This is the first time we have reported equal breeding response ($p > 0.05$) in both the population and breeding happened in off season months (July-October) consecutively for third year i.e. 2017-2019. Equal spawning response of milkfish from both the population gives possibility to overcome challenges of year round breeding by initiating trigger dependent natural spawning to pave pathway for satellite seed

MILK FISH

PROLONGED SPAWNING IN MILKFISH BY MODULATION OF GNRH ANALOGUE IMPLANTATION FREQUENCY IN TWO DIFFERENT POPULATION OF MILKFISH (*CHANOS CHANOS*)

Breeding strategies are required to maintain the breeding momentum of a performing stock over the years. It has been observed in other fish species that certain variation in regular implantation doses, timing or introduction of new stock boost the performance. In the aim towards establishing working



Comparison between different year breeding responses under treatment with combined GnRH-Analogue

rearing centres outside nucleus of CIBA hatchery.

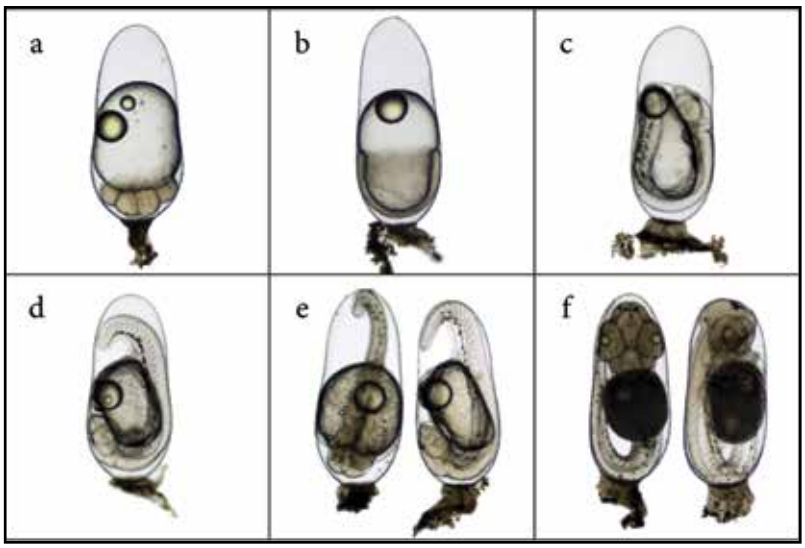
ORNAMENTAL FISHES

CAERULEAN DAMSEL, *Pomacentrus caeruleus*

BROODSTOCK DEVELOPMENT AND BREEDING OF MARINE ORNAMENTAL FISH, *POMACENTRUS CAERULEUS* IN BRACKISHWATER.

Caerulean damsel, *P. caeruleus* is a popular marine ornamental fish successfully bred in captivity. To explore the chances using this fish brackishwater aquarium, a study was conducted to ascertain the salinity tolerance and broodstock development. The fishes were acclimatized to lower salinities by gradually decreasing the salinity from 35 ppt to desired salinity by adding required quantities of freshwater. Observations made on the physiological and reproductive parameters indicated that the species can survive and acclimatize well in lower saline conditions and it can attain maturity and form functional breeding pairs. Spawnings were observed upto 20 ppt. Observations on spawning behaviour were made three times a day (at 08.00, 11.00 and 18.00 hrs) during the experimental period. Spawning took place after 30 to 45 days of rearing. Reproductive performance indices like number of eggs per spawning, spawning interval, egg length and width, incubation period were estimated in all the

Egg clutch of *Pomacentrus caeruleus* at 20 ppt salinity



Embryonic developmental stages of *Pomacentrus caeruleus* at 20 ppt salinity, a) 8 cell stage; b) germ ring formation; c) and d) body turnover stage e) eye formation stage; f) embryo before hatching.

treatments. The total number of eggs per clutch was estimated by counting all the eggs in 1 cm^2 area and then multiplied with the total area of deposition. Egg samples were collected immediately after fertilization and their embryonic development was

recorded. The length and width of the eggs were measured to the nearest 0.01 mm.

SILVER MOONY, *Monodactylus argenteus*

INFLUENCE OF SALINITY ON THE DEVELOPMENT OF EGGS AND GROWTH OF LARVAE OF SILVER MOONY, *MONODACTYLUS ARGENTEUS*

Fertilized eggs of the silver moony were incubated at different salinity levels (0, 5, 10, 15, 20, 25, 30, 35 and 40 ppt), and then the buoyancy, hatching performances, morphological parameters, survival and growth of larvae until total absorption of yolk sac were assayed. Eggs were buoyant at salinities above 25 ppt while eggs below this salinity sunk. Significantly highest hatch rates were observed for eggs maintained at 25, 30, 35 and 40 ppt. There were significant differences in survival rate after 12 h of larval hatching also. The data indicated that 25 to 35 ppt was suitable salinity ranges for the survival as well as for the mean length of the newly hatched larvae. On the other hand, the larvae that hatched at 5 and 10 ppt were deformed, died at hatch, and were not measured. In conclusion, the optimum ambient salinity level should be between 25–35 ppt during embryogenesis and early larval development for silver moony fish.

THE EFFECTS OF INITIATION FIRST FEEDING ON GROWTH AND SURVIVAL OF SILVER MOONY, *MONODACTYLUS ARGENTEUS*

The effects of the initiation first feeding on the point-of-no-return (PNR) and growth of silver moony, *Monodactylus argenteus* 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, 5th, 6th and 7th 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 obtain good growth, the silver moony larvae

Table Mean (± S.D.) hatching rate, survival rate, total length and pectoral fin length obtained in different salinities

Salinity (ppt)	Hatching rate (%)	Survival rate (%) after 12 h of Hatching	Total length (mm) after 12 h of hatching	Survival rate (%) after five days	Total length (mm) after five days	Pectoral fin length (mm) after five days
0	0	0	0	0	0	0
5	0	0	0	0	0	0
10	59.96 ± 6.63^{C}	13.34 ± 2.9^{D}	1.55 ± 0.05^{B}	21.86 ± 10.62^{D}	2.68 ± 0.03^{B}	0.44 ± 0.02^{C}
15	61.10 ± 8.42^{C}	28.82 ± 5.09^{C}	1.65 ± 0.07^{B}	44.83 ± 5.67^{C}	2.64 ± 0.09^{B}	0.51 ± 0.01^{B}
20	82.20 ± 6.95^{B}	67.74 ± 1.96^{B}	1.72 ± 0.04^{AB}	71.26 ± 6.15^{A}	2.75 ± 0.04^{AB}	0.56 ± 0.04^{A}
25	100 ± 0.00^{A}	98.87 ± 1.96^{A}	1.87 ± 0.05^{A}	76.66 ± 5.79^{A}	2.84 ± 0.17^{A}	0.58 ± 0.01^{A}
30	97.76 ± 3.86^{A}	97.71 ± 1.96^{A}	1.82 ± 0.08^{A}	79.00 ± 3.12^{A}	2.83 ± 0.10^{A}	0.60 ± 0.09^{A}
35	97.76 ± 3.82^{A}	94.46 ± 5.09^{A}	1.82 ± 0.08^{A}	77.50 ± 6.38^{A}	2.85 ± 0.06^{A}	0.50 ± 0.03^{B}
40	100 ± 0.00^{A}	78.72 ± 4.96^{B}	1.74 ± 0.07^{AB}	65.90 ± 9.03^{B}	2.75 ± 0.10^{AB}	0.53 ± 0.05^{AB}

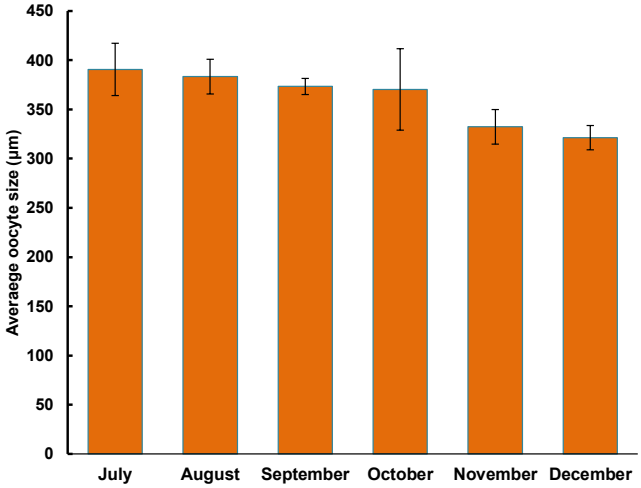
Effect of feeding on pigmentation pattern and pelvic fin formation. a) first feeding starts on 1st and 2nd dph; b) first feeding starts on 3rd dph; c) first feeding starts on 4th dph onwards.

must establish successful initial feeding within 48 hrs (2nd dph) after hatching.

SCAT, *Scatophagus argus*

SPAWNING PERFORMANCE OF SPOTTED SCAT IN LOW SALINE WATERS OF SUNDARBANS

Spotted scat (*Scatopahgus argus*) has been reported to sexually mature and breed in nearshore/coastal waters. ICAR-CIBA has already standardized seed production technology for coastal waters hatcheries (25 – 30 ppt salinity). Being a euryhaline fish, scat adapts to low salinities readily however gonadal maturation and induced spawning has not been reported from lower salinities of Sundarbans, India. To evaluate the maturation in existing adults in earthen pond of Kakdwip Research Station, Sundarbans, a pond based broodstock facility (Salinity: 10 – 20 ppt) for periodic assessment of gonadal maturation was standardized for 145 adult scats. Adult females (body weight: 269.36 ± 4.19 g) were found to be having oocytes (size: 390.67 – 321.33 µm) in vitellogenic stages with mature ovary from the months of June - October. Percentage of milting males (body weight: 181.34 ± 3.95 g) was highest (17%) during June-July. During mid-October a female (body weight: 347.28 g) with average oocyte size 479.13 µm was selected for induced spawning with 2 males (avg. body weight: 179.54 g) in a 500 L FRP tank (salinity: 15 ppt). Female was induced with the help of pre-standardized dose of synthetic hormones HCG followed by LHRHa. Female naturally spawned after 30.5 hours of induction time. Absolute fecundity was found 1.2 lakhs with 5 ± 0.38 % fertilization rate and after 22 hours hatching rate was 43 ± 4.64%. Larvae were reared in same salinity for 30 days and later shifted to earthen pond for outdoor nursery rearing. Successful induced spawning of scat in lower salinity promises hatchery based seed production technology for Sundarbans by entrepreneurs and SHG's.

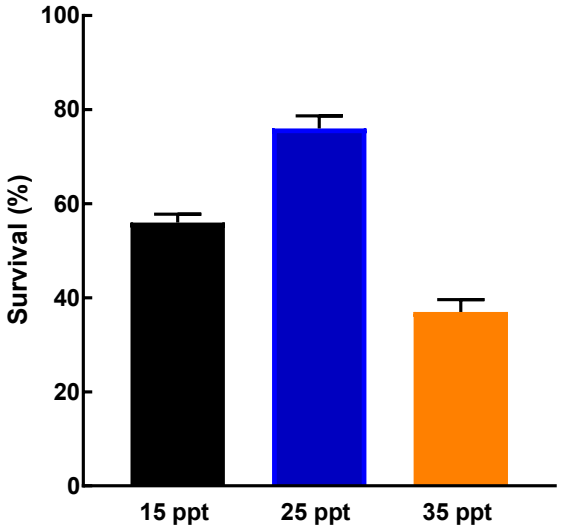


LIVE FEED

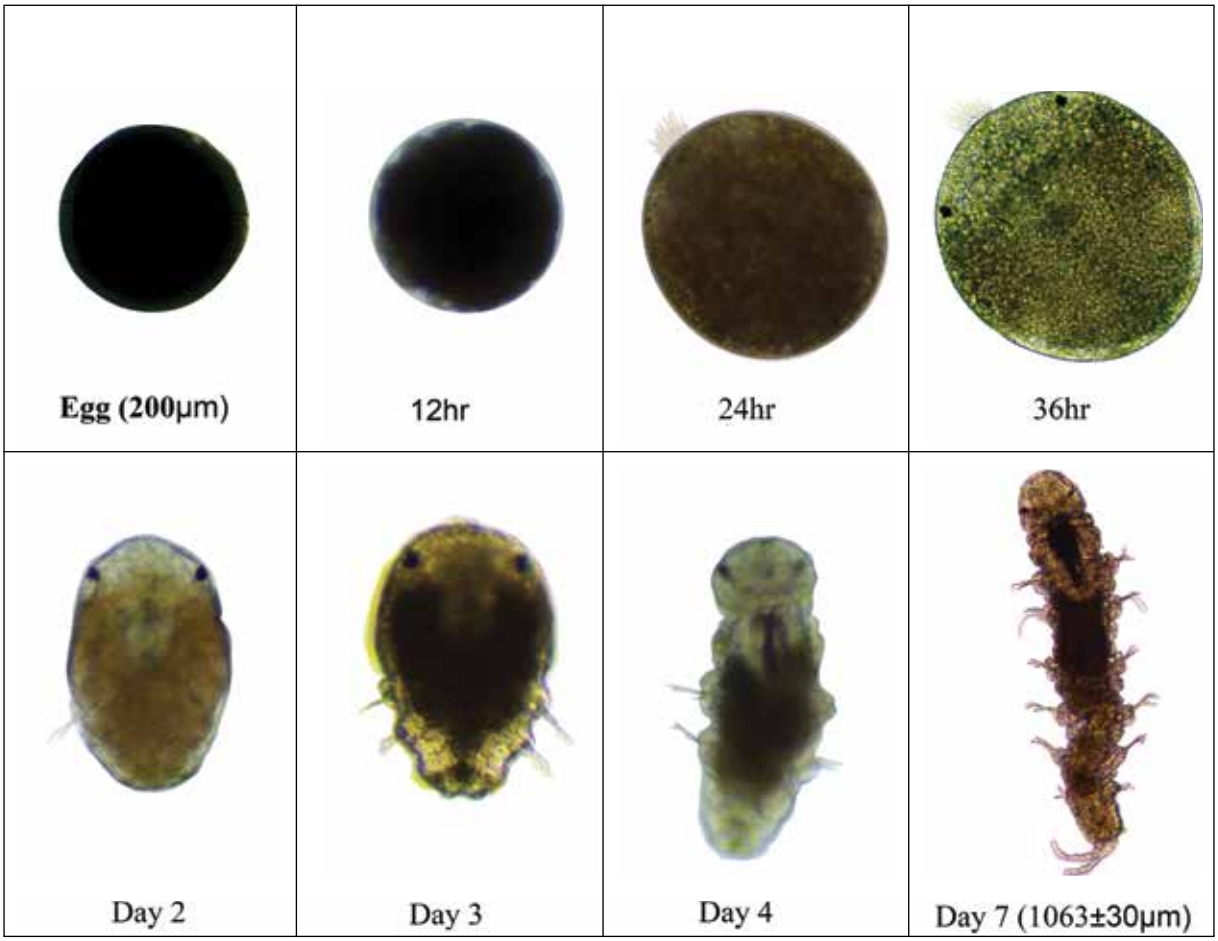
SURVIVAL OF POLYCHAETE LARVAE (MARPHYSA SP) IN DIFFERENT SALINITY RANGE

Polychaete egg mass were reared at different salinities: 0, 5, 15, 25 and 35 ppt for a period of one week in order to determine

survival rate of larvae. A total of 100 eggs were stocked in 1 L conical flask in triplicate. Eggs were hatched within 24-48 h and diatom *Chaetoceros* sp at the rate of 1-2 $\times 10^5$ cells/ml was added as diet once the larval yolk reserves were exhausted. The eggs mass stocked at 0 and 5ppt were not hatched and there is a significantly ($p<0.05$) higher survival rate was found at 25ppt (76±2.7%) compared to 15 and 35ppt (56±1.8 and 37±2.6% respectively).



Egg mass collected form earthen pond of CIBA stocked in 1 L glass beakers filled with cartridge filtered UV treated seawater with a salinity of 25 ppt. Number of eggs found in an egg mass (volume 50 to 500 ml) ranged between 7000 and 25000 eggs with an average of 11500 eggs. The eggs were hatched within 24-48 h and trochophore larvae started feeding diatom such as *Chaetoceros* sp/ *Thalassiosira* sp and reached juvenile stage within one week. One week old



Life stages of Polychaete worm (*Marphysa* sp.)

polychaete juveniles have an average length of 1063±30µm. the life stages of *Marphysa* sp is shown in figure.

POLYCHAETE WORM CULTURE WITH OR WITHOUT SAND BASED SYSTEM

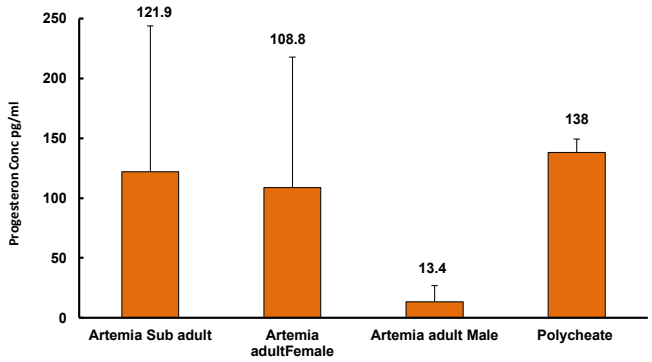
The juvenile polychaete were transferred into aquarium glass tank (30 X 30 X 30 cm) filled with or without soil (sandy and clayey) and organic manure at the bottom at different salinity range of 15, 25 and 35ppt with initial stocking density of 100nos with mild aeration. A 60 days culture trial was completed, and observed that highest survival was reported in sandy clay based tank system (62%). Highest growth was observed at 25 ppt salinity in sandy clay soil and attained a maximum length of 8.7 cm within 60 days with a mean of 7.5±1.6 (Table). The experiment is continuing for another 2 month period to complete the life cycle.

ARTEMIA

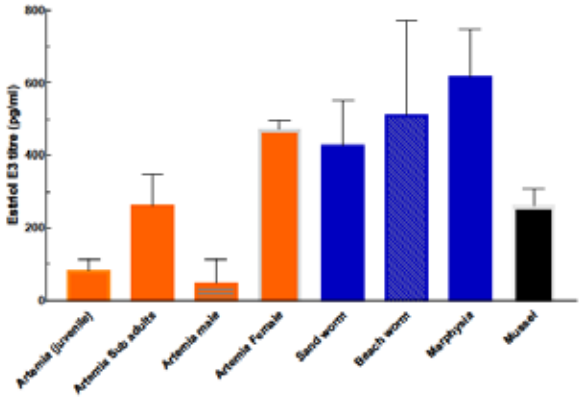
To understand the role of *Artemia* biomass as a quality broodstock diet for penaeid shrimps, presence of vertebrate like steroid hormones, progesterone, and estradiol in different stages of *Artemia* was studied and compared with important live feed polychaetes worm (sand worm: *Neries* sp., Blood worm: *Marphysia*, beach worm and mussel (*Perna viridis*). *Artemia* sub-adult, adult female, and the male had estriol, the major metabolite of estradiol, 262±87.64, 48.11±64.54, 471±24.60 pg/ml E3 estradiol respectively. Similarly, adult male and females had a progesterone level, 102.46 ± 15.92, 653.3 ± 45.27 pg/ml respectively. The

Table *Marphysa* sp culture with or without sand based system

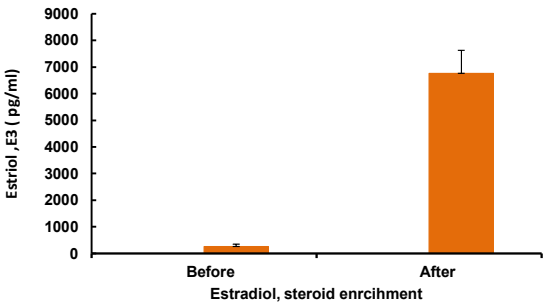
Marphysa sp (60 days culture) - Continuing						
	without sandy clay soil			with sandy clay soil		
Salinity	20ppt	25ppt	35ppt	20ppt	25ppt	35ppt
Mean length±SD (cm)	3.6±1.4	3.4±0.8	3.08±0.7	5.9±1.3	7.5±1.6	6.1±1.5
Length range (cm)	1.9- 6.1	2.1-4.5	1.6-4.2	3.7-8.5	4.5-10.1	3.9-8.7



Steroid 17 α hydroxyl progesterone (Man ±SD) level in different life stages of *Artemia*



Steroid estriol, E3 (Mean ±SD) level in different life stages of artemia biomass and commonly used polychaete worms and mussels, in shrimp hatcheries



Steroid estriol, E3 (Mean ±SD) level in *Artemia* biomass before and after enrichment of estradiol level

highest level of E3 was recorded in the polychaete, *Marphysia* (616 ± 131 pg/ml) followed by Beach worm (511.8±259) and *Artemia* female. To understand its role as a biovehicle for hormone delivery, 3 h enrichment of *Artemia* biomass carried out at 20 mg estradiol /3 ml alcohol. After enrichment 22 fold increase in estriol, bio encapsulation efficacy was noticed. 100% live feed acceptability was noticed by captive-reared brooders and 60-70% feed acceptability during frozen forms. *Artemia* biomass production in indoor system recorded highest biomass 3.29 ± 0.5 kg/m3 at 500 no/L followed by 1000 (2.69 ± 0.3 kg/m3) and 2000 no/L (2.59 ± 0.5 kg/m3). At a lower density, more than 90% of the population attained maturation. The study reveals that *Artemia* biomass is a suitable cost-effective alternative to costly polychaete worm due to multiple advantages like its short generation cycle, better control over biosecurity based system, ability to produce SPF generation and bio encapsulation ability of reproductive hormone and 100% acceptability as live form with zero wastage of live feed.

Economic analysis of batch mode artemia biomass production unit with different dietary supplements on operational expense based on 1000 L per tank rearing volume unit, recorded higher benefit-cost ratio,1.58 in mixed diet-fed groups followed by 1.53 in rice flour fed groups with the lowest BCR in groups reared only with rice bran. The cost of production found to be 190 in mixed diet-fed groups with 109/-profit per kg with a frozen biomass fetches 300 per Kg cost. Economic analysis of batch mode artemia biomass production unit on mixed feed regime with different stocking density based on operational expense in culture unit-1000 L per tank recorded the highest Benefit-cost ratio 2.7 recorded in lowest stocking density groups (500 nos/L) followed by 1.86 in 1000 nos/L density group when fed with mixed feed regime. As stocking density increases BCR and profit per kg found to decrease and, the cost of production found to increase from Rs. 109 to 300 per kg. As total culture cycle including preparatory the stage takes only 18-20 days duration, minimum, 16-18 cycles can be operated in a year with a net income of 7000-11000 per single unit.

Economic analysis of batch mode

	T_{500}	T_{1000}	T_{2000}
Total cost (cyst, aeration, labor (2h/day for 15 days, fertilizers, etc)	392.1	482.4	376.24
Total production (kg)	3.29	2.69	2.59
Total gross profit (Rs)	987	433.67	571.52
Net profit (Rs)	626.19	373.32	205.47
Profit/kg (Rs)	190.34	138.78	79.33
Cost of production per Kg (Rs)	109.66	161.21	220.67
Benefit cost ratio	2.73	1.86	1.36

	$T_{Mixed\ Diet}$	$T_{Rice\ Flour}$	$T_{Rice\ Bran}$
Total cost (cyst, aeration, labor (2h/day for 15 days, fertilizers, etc)	392.1	482.4	376.24
Total production (kg)	3.29	2.69	2.59
Total gross profit (Rs)	987	433.67	571.52
Net profit (Rs)	626.19	373.32	205.47
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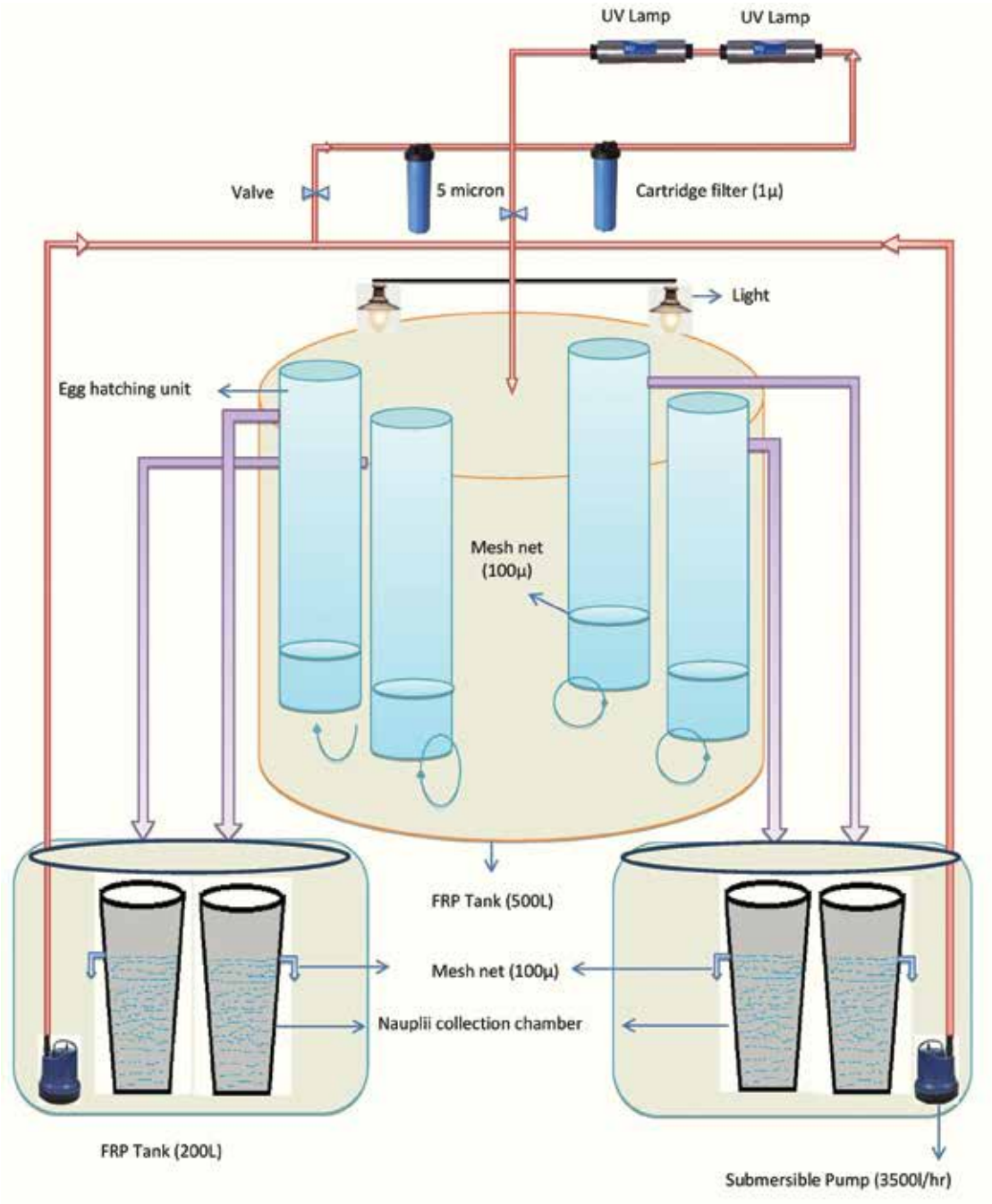
Benefit cost ratio	2.73	1.86	1.36

artemia biomass production unit's different dietary supplements on operational expense (rearing volume of culture unit-1000 L per tank).

PERFORMANCE OF THREE STRAINS OF GREEN MICROALGAE FOR MASS CULTURE

The performance of three strains of green microalgae were evaluated in the indoor algal culture and outdoor mass culture. Three algal strains (*Nannochloropsis occulata*, *Chlorella* sp. muttukad and *Chlorella marina*) were cultured in 1 L , 3 L flask and 20 L cans in triplicate. Continuous aeration, temperature (24°C) and light intensity 1000 lux were maintained. Cell density was measured at third day of the culture in each of the culture flask. Contents of the smaller flask were used for inoculating the higher volume culture. Outdoor mass culture were carried out in 500 litre tanks in triplicate. Cell



density was significantly higher in the *C. marina* and *Chlorella* sp. Muttukad in the indoor 1litre flask culture at $P<0.05$. However, this trend was not observed in the higher volume cultures. *C. marina* reported significantly higher cell density in the indoor higher volume culture and outdoor mass culture. *Chlorella* sp muttukad can be recommended for indoor small volume culture and *C. marina* for outdoor mass culture.

DEVELOPMENT OF NOVEL EGG WASHING SYSTEM

A novel RAS based egg washing system for penaeid eggs was developed. The system comprises of four cylindrical unit with a capacity of 5 L each fitted inside 500 L FRP tank, which is connected to RAS unit comprises of two sets of cartridge filter connected in series with 5 and 1 µm filter respectively followed by two units of UV sterilizers in series (36 W each). The water flow is regulated using two unit of submersible pump with flow rate of 3500 L/h each. *Penaeus monodon* eggs were then transferred into hatching unit stocked at the rate of 1000 eggs/L (5000 eggs stocked in each unit). Significant difference ($p<0.05$) in hatching percentage was observed in the RAS unit (91.3%) compare to control unit (74.8%). Percentage survival of *P. monodon* assessed during each life stages: Nauplius, Zoea, Mysis and Post larvae, and the highest final survival was found (41.5%) in the RAS hatching unit when compared to the control unit (30.2%).

RE-CIRCULATING AQUACULTURE SYSTEM (RAS) FOR REPRODUCTIVE MATURATION OF *PENAEUS INDICUS*

Re-circulatory Aquaculture System (RAS) is basically a technology for farming aquatic animals by recycling the water in the production system with less than 10% of total water volume replaced per day. A closed, recirculating water system offers an opportunity to improve water quality, subsidise water usage, preservation of pheromones and ensure biosecurity. Additionally it provides controlled environmental conditions to support maturation and spawning. In order to understand the efficacy of RAS for maturation and spawning of Indian white shrimp (*Penaeus indicus*), a RAS unit was developed and compared with flow through system (FTS). The system had six maturation tanks in which four tanks were connected to the filtration unit (RAS) and two tanks as control (flow through system). Each tank had a size of 4 m × 2 m × 1 m volume with tank water depth maintained at 0.5 m. The broodstock RAS is designed based on the biomass and carrying capacity, with respect to solids removal rate of mechanical filter, TAN removal rate of biofilter, Oxygen addition rate of aerator etc. The water flow rate, which is required to maintain the desirable concentration of TAN (Total Ammoniacal Nitrogen), TSS (Total suspended solids) and DO (Dissolved Oxygen) in RAS and sizing of biofilter, was calculated using the spread sheet. The estimated capacity was to stock two shrimps/m^2. The water flow rate in RAS is maintained at 8 m^3/h, i.e. The water in the tanks was completely filtered in every two hours. Brooders of *P. indicus* (mean 40 g) were stocked at the rate of two shrimps/m^2 with 3:1 female and male sex ratio. Standard maturation diet for penaeid broodstock was provided daily. Water quality analysis of shrimp maturation in control tanks revealed that the TAN was 0.5±0.03 ppm with 100% water exchange per day at a stocking density of two shrimps/m^2 whereas TAN was less than 0.02±0.001 ppm in RAS tanks. Nearly 30% of shrimps were matured in RAS compared to 15 % maturation observed in FTS. About 85% of moulting happened in RAS, but 70% in FTS. Mortality was only 20% in RAS whereas 50% mortality was occurred in FTS. Microbial count was more in FTS compared to negligible count in RAS due to the presence of disinfection unit within RAS. Only 50 tons of water was used in RAS for the whole 5 months experiment, whereas 1150 tons of water was used in FTS for the study.

Nutrition & Feed Technology

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

Nutrition & Feed Technology

BLACK SOLDIER FLY (BSF) MEAL AS A NOVEL SOURCE OF PROTEIN IN AQUA FEED

Insect meals are being recognised as novel alternative protein resources for animal feed. With a short life cycle, efficient food conversion rate, and high protein content, *Hermetiaillucens,* commonly known as black soldier fly (BSF), is getting significant importance. The larvae, prepupae, pupae and adults are suitable for use as a source of protein. Hence an attempt was made to find out the nutrient composition of BSF during these different stages. BSF biomass from different life stages hasbeen collected from 6 different culture units located in Tamil Nadu, Karnataka and Andhra Pradesh. A detailed analysis was carried out with standard methods. The average protein content of BSF larval meal was 43.27± 6.17%, with a minimum and maximum up to 32.92% and 51.01% respectively. The lipid content varied between 18.65 % and 35.25%. The total ash content also varied between 6.63% to 15.45% and showed a direct correlation with the lipid

Nutrient (g/100g)	Life stages of BSF			
	Larvae	Prepupae	Pupae	Adult fly
Crude Protein	29.01	39.26	47.67	44.35
Crude Lipid	43.28	28.43	27.65	25.77
Total Ash	6.41	14.81	11.7	14.1
Acid insoluble ash	1.28	2.05	6.84	2.36
Fibre	5.78	8.6	9.8	9.46
NFE	15.52	8.9	3.18	6.32

BSF - Larvae

BSF - Pre Pupae

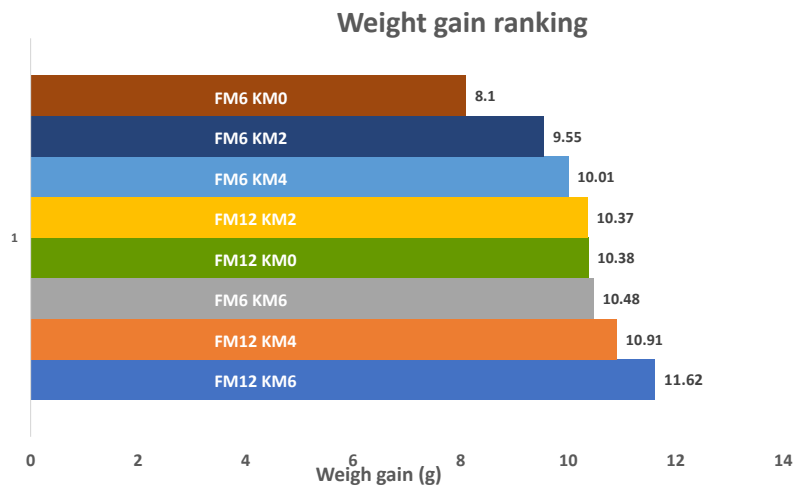
BSF- Pupae

BSF -Adult

content. From this, it is evident that BSF larval meal may be a good source of protein and lipid in aqua feeds, and there is a lot of variation in nutrient content in relation to the sources and the life stage of the larvae.

ANTARCTIC KRILL MEAL AS SPECIALITY FEED INGREDIENT:

Antarctic krill meal is regarded as an important animal protein source of marine origin in aquafeed. Krill Meal has consistently proven to be a highly effective attractant in shrimp feed, and also rich source of dietary pigment and essential fatty acids. Considering this nutritional richness, this study aimed to evaluate the potential of krill meal as a compensatory ingredient in practical feeds of shrimp, *Penaeus vannamei*. This study reports the nutritional composition of Antarctic krill meal and its value as a compensatory feed ingredient for the reduction of fishmeal in feeds for shrimp *Penaeus vannamei*. Based on the nutritional composition krill meal at graded levels was included in the practical shrimp diets which were formulated to contain two fishmeal inclusion levels (6% and 12%). An 8 week long experiment with white leg shrimp in indoor conditions in a flow-through rearing system tested the influence of krill meal inclusion (0, 2, 4 and 6%) against two levels of fishmeal inclusion (6 and 12%). Totally eight feeds were formulated and processed adopting the standard protocols. The growth performance and survival of shrimps with an initial weight of 0.6 g were assessed with four replications per treatment. There was a



Ranking of the weight gain with *Penaeus vannamei* fed practical diets containing two levels of fishmeal and varying levels of krill meal

Antarctic Krill meal

significant difference in all the growth performance parameters among treatments. Shrimp fed the 12% fishmeal + 6 % krill meal had the highest weight gain of 11.61 g. The present study proved the beneficial effects of krill meal in shrimp diets, and established that the inclusion level of 4% is minimum to express the difference in the performance of shrimp irrespective of fishmeal level.

PERFORMANCE OF *P. VANNAMEI* FED DIFFERENT LEVEL OF MUSTARD OIL CAKE

Parameter	0% MOC	5% MOC	10% MOC	15% MOC
Initial body wt. (g)	0.57±0.01	0.57±0.01	0.57±0.01	0.57±0.01
Final body wt. (g)	4.51±0.06	4.10±0.11	4.11±0.34	4.23±0.29
Total wt. gain (g)	3.58±0.07	3.53±0.11	3.55±0.35	3.66±0.29
FCR	1.38±0.03	1.41±0.04	1.42±0.13	1.36±0.11
Survival %	95.00±2.89	96.67±3.33	98.33±1.67	93.33±3.33
PER	2.17±0.04	2.12±0.06	2.16±0.21	2.22±0.17

EVALUATION OF MUSTARD OIL CAKE INCLUSION IN PENAEUS VANNAMIE DIET

A 63 day's feeding experiment was conducted to evaluate the dietary inclusion of mustard oil cake (MOC) in *P.vannamei*. Four practical diets were formulated containing three graded levels of MOC (0%, 5%, 10%, and 15%) and were fed to *P.vannamie* juveniles. The experiment was conducted in 1000 l FRP tank with four treatments and three replicates containing twenty shrimp in each with an average body weight of 0.57 g. There was no significant (P>0.05) effect on weight gain, FCR, survival and gut enzyme (protease, amylase) activity when the mustard cake was incorporated at 15 % level in the diet. It was concluded that mustard oil cake could be incorporated up to 15 % level in *P. vannamei* diet.

CHEMICAL CHARACTERIZATION OF MANGROVE LEAVES

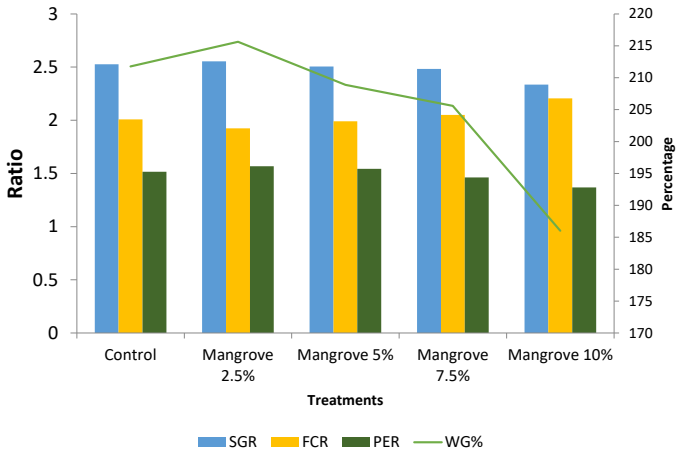
Mangroves ecosystems present shrubs or small trees that grow along coastal regions, and are capable of withstanding adverse conditions such as high salinity, high temperature, strong winds and extreme tides. Their leaves and woody matter form a vitalpart of the marine food chains that support fisheries. The leaves form a food for many larval and juvenile fishes which thrives in the mangrove regions. With theaim of adding novel ingredients to the aquafeed basket, we studied the chances of considering mangrove leaves as one of the ingredients in the aquafeeds. A detailed proximate analysis of the mangrove leaves from different mangrove regions was done. Visioning that, if found promising, it may provide livelihood to the local communities who depend on these ecosystems. Proximate content of the washed leaves are presented in the table.

The higher fibre content may be an issue for digestibility in shrimp and carnivorous fishes.

THE RESULTS OF THE PROXIMATE COMPOSITION OF THE MANGROVE LEAVES

	Sindhudurg, Maharashtra					Sorlagondi, Andhrapradesh			Pullicat, Tamil Nadu	
Nutrients (g/100g)	*Avicennia marina*	*Rhizophoramucronataahe*	*Sonneratia alba*	*Sesuvium portulocastrum*	*Acanthus ilicofolus*	*A. marina*	*A. officinalis*	*R. apiculata*	*A. marina*	*R. apiculata*
Moisturie	66.85	67.08	67.58	65.35	66.19	66.73	67.05	66.94	66.18	65.23
CP	3.01	2.98	2.46	2.89	2.77	3.16	3.04	3.25	2.94	2.67
EE	1.18	1.23	1.29	1.16	1.12	1.15	1.25	1.34	1.28	1.09
Total Ash	3.79	3.84	3.91	3.87	3.46	3.57	3.89	3.96	3.45	3.99
CF	5.96	5.89	5.76	5.83	5.47	4.95	5.33	5.18	5.22	5.46
NFE	19.21	18.98	19	20.9	20.99	20.44	19.44	19.33	20.93	21.56
AIA	0.48	0.52	0.51	0.48	0.49	0.56	0.57	0.52	0.56	0.55

Mangrove leaves contain biological active antiviral, antibacterial and antifungal compounds. Phytochemical screening of mature leaf revealed that secondary metabolites like alkaloids, phenolics, steroids and terpenoids have been characterized from mangrove leaves and have toxicological, pharmacological and ecological importance. Further studies are required for improvement of its nutritional quality, and nutraceutical properties and also optimization in the practical inclusion levels in diets for aquatic species before advocating as an feed ingredient.



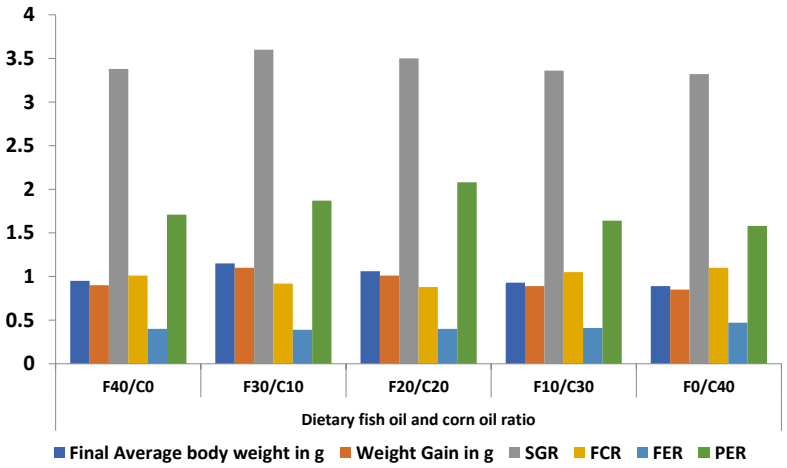
Effect of mangrove leaves inclusion in the diet of milkfish on growth and nutrient utilization

UTILIZATION OF DRIED AVICENNIA MARINA LEAVES AS A FEED INGREDIENT IN THE DIET OF MILKFISH, *CHANOS CHANOS* JUVENILES

In order to test the utility of mangrove leaves in the diet of milkfish five experimental diets were formulated with varying levels of dried mangrove leaves (*Avicennia marina*) at 0 (control), 2.5, 5.0, 7.5 and 10%. All the diet contained 33 and 5.5% of crude protein and ether extract. These diets are tested in the juveniles of hatchery produced milkfish, *Chanos chanos*. Twenty milkfish juveniles weighing 2.90 ±0.03 g are stocked in each experimental tank with three replications for each experimental diet. Feeding trial was conducted for 45 days. At the end of the experiment, gut tissues were collected to analyze the digestive enzymes. The experimental results have indicated that mangrove leaves can be incorporated up to 7.5% without compromising the growth and nutrient utilization. The pepsin activity drastically reduced at 10% inclusion level in pyloric caeca, cardiac and pyloric stomach.

EFFECTS OF DIETARY BLEND OF FISH OIL WITH CORN OIL ON GROWTH, DIGESTIVE ENZYME ACTIVITY AND FATTY ACID COMPOSITION OF MILKFISH (*CHANOS CHANOS*) LARVAE

A growth trial was conducted to investigate the effects of fish oil and corn oil on the growth, digestive enzymes activity and fatty acid composition of milkfish,

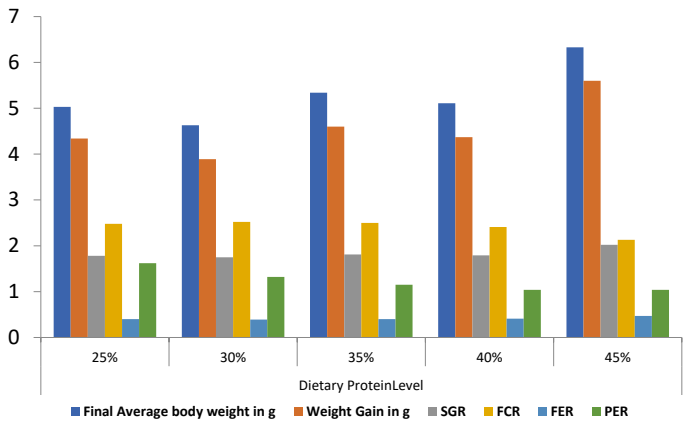


Effects of dietary protein levels on growth performances, Body indices, serum profile, and body composition of fry mono angel, *Monodactylus argenteus*

Chanos chanos larvae. Five micro extruded and marumerized (MeM) diets supplemented with 40 g kg^{-1} of either fish oil (F4), corn oil (C4) or blend of the both at a ratio of 3:1 (F3C1); 1:1 (F2C2) and 1:3 (F1C3) respectively. Each diet was fed to triplicate groups of milkfish larvae (45 ± 0.08 mg) in a flow through rearing system for 6 weeks. Final weight, weight gain and specific growth rate of fish fed the F3C1, F2C2 and F4 diets were highest ($P < 0.05$) followed by fish fed diet F1C3, and the lowest in fish fed diet C4. Larvae fed the F2C2 and F3C1 dietary groups were significantly better ($P < 0.05$) in terms of food conversion ratio (FCR), feed efficiency ratio (FER) and protein efficiency ratio (PER) followed by larvae fed the F1C3 diet, and the lowest in fish fed diet C4. Fish fed diet C4 had a lowest survival (%) among the five dietary treatments. Fatty acid composition of larvae fed experimental diets reflected the composition of the corresponding diet. These results suggest that milkfish larvae fed diets with 3:1 or 1:1 of fish oil to corn oil ratio had significantly ($P < 0.05$) higher growth to the fish fed diet which only had fish oil. Diet which had blended fish oil and corn oil shown significantly higher growth and survival of milkfish larvae than the larvae fed diet which contained either fish oil or corn oil as the dietary lipid source.

EFFECTS OF DIETARY PROTEIN LEVELS ON GROWTH PERFORMANCES, BODY INDICES, SERUM PROFILE, AND BODY COMPOSITION OF FRY MONO ANGEL, *MONODACTYLUS ARGENTEUS*

This study was conducted to evaluate the effects of dietary protein levels on growth, body indices, serum profile, skin carotenoid content and body composition in fry mono angel, *Monodactylus argenteus*. Fish averaging 0.73 ± 0.08 g (mean ± SE) was randomly distributed into 18 glass tanks (90 L water each) of recirculatory aquaculture system (RAS) @ 10 fry per tank and the feeding trial was carried out in triplicate for 90 days. Five isocaloric diets (16.7 kJ/g energy) were formulated to contain dietary crude protein levels (CP) as 25, 30, 35, 40 and 45 %. Fish were fed one of the experimental diets at apparent satiation twice a day in triplicate groups. At the end of 90 days feeding trial, weight gain (WG) of fish fed with CP_{30} and CP_{45} diets were higher than those of fish fed with CP_{25}, CP_{35} and CP45 diets. Fish fed with CP_{40} and CP_{45} diets had higher feed efficiency (FE) and specific growth rate (SGR) than those of fish fed with CP_{25}, CP_{30}, and CP_{35} diets. Protein retention efficiency (PRE) decreased with increase of dietary protein levels among fish fed with the experimental diets. Whole-body crude protein and lipid contents increased with the dietary protein level up to CP_{40} diet. In conclusion, analysis of variance (ANOVA) revealed that the optimum dietary protein level could be 30 % for maximum growth of juvenile parrot fish, while the broken-line analysis of WG suggested that the level could be 30.2 %, in a diet containing 16.7 kJ/g energy.



INDIGENOUS MICRO EXTRUDED FLOATING ORNAMENTAL FISH FEED KALOR FISH PLUS

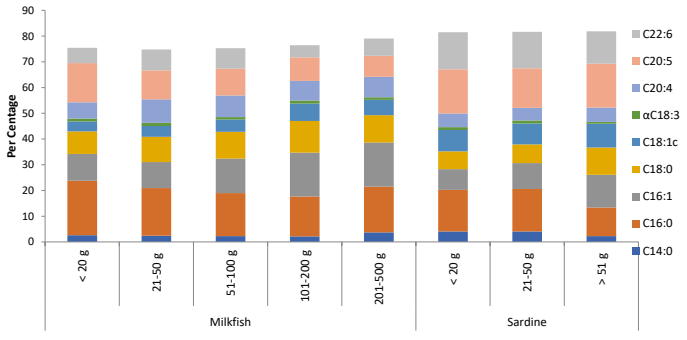
A formulated feed was developed for ornamental fish by optimising the processing conditions such as moisture content, starch sources, temperature, screw speed etc. Feed has been evaluated for its physical features such as colour, bulk density, texture, etc. The results indicated that pellets made using maize have the lowest bulk density followed by maida, wheat and rice. It was observed that additional moisture at 20.0% resulted in floating pellets and moisture upto 22.5% also resulted in good floating extruded pellets. Further it was found that proper conditioning of the starch source and feed mix with additional water is essential for producing desired pellet properties. The effect of speed of the extruder shaft on product out put was studied by subjecting the feed mix at shaft speed of 30, 35, 40 and 45 Hz and found that at 35-40Hz speed

Indigenous cost-effective ornamental fish feed developed and branded as Kalor fish Plus has been commercialised on a nonexclusive basis

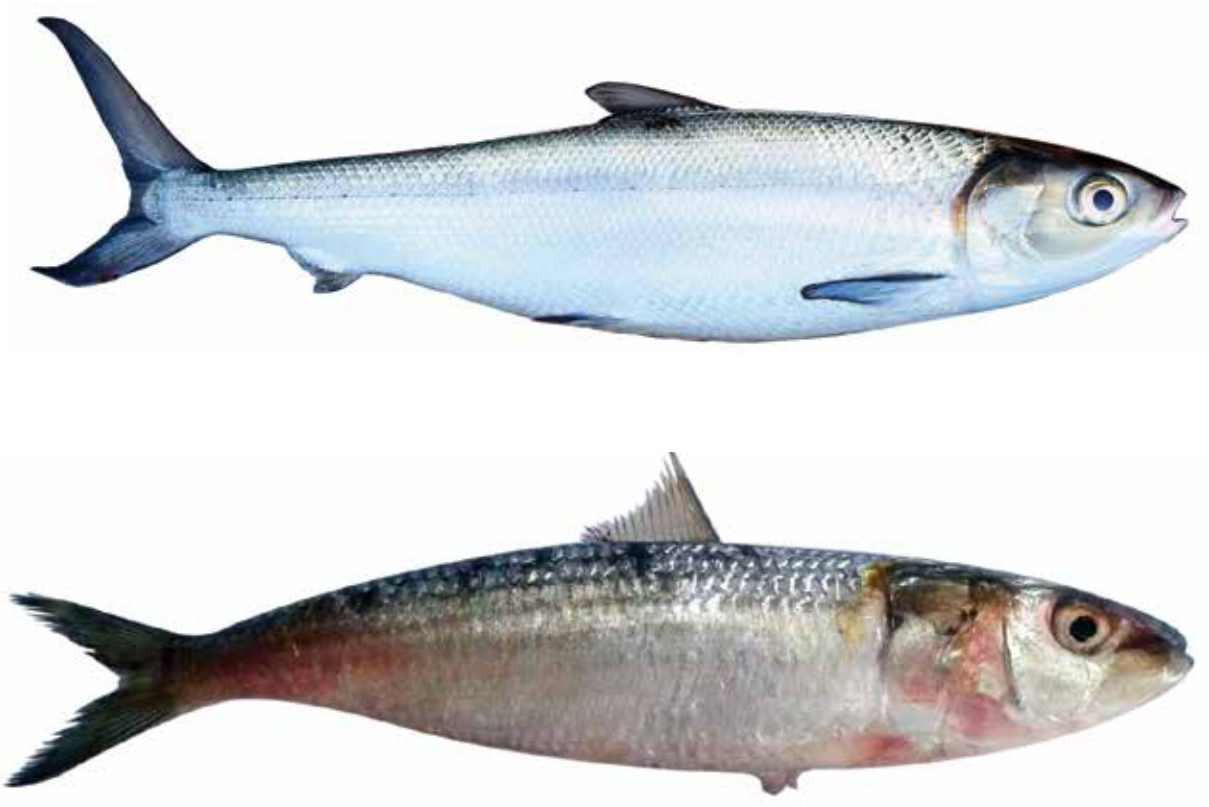
is optimal for floating pellets. At the temperature of 90 and 100°C the product started better extrusion resulting in floating pellets. Temperature up to 90°C had no effect on extrusion and the product comes out as sinking pellets. Effects of varying chemical dies by including at 0.01, 0.02, 0.03, 0.04, 0.05, 0.06 and 0.07% and the results revealed that 0.02 to 0.03% of chemical dyes results in the required colour.

COMPARATIVE NUTRIENT PROFILING OF MILKFISH AND OIL SARDINE FISHES

Oil sardine is highly known for the higher oil content which his proportionately rich in omega-3 fatty acids. Though the chances of farming oil sardine is not feasible due to several techno economic reasons, the fast growing milkfish with which fine-tuned farming technology is there for sustainable production can be promoted as substitute for oil sardine, if it matches with the nutritional profile of sardine. With this objective, the nutrient profiling of wild milkfish and oil sardine fishes were analysed by collecting different size groups of fishes. Five size groups of milkfish viz., <20g, 21-50g, 51-100g, 101-200g and 201-500g and three size groups of oil sardine <20g, 21-50g and >51g. Irrespective of size groups oil sardine fishes

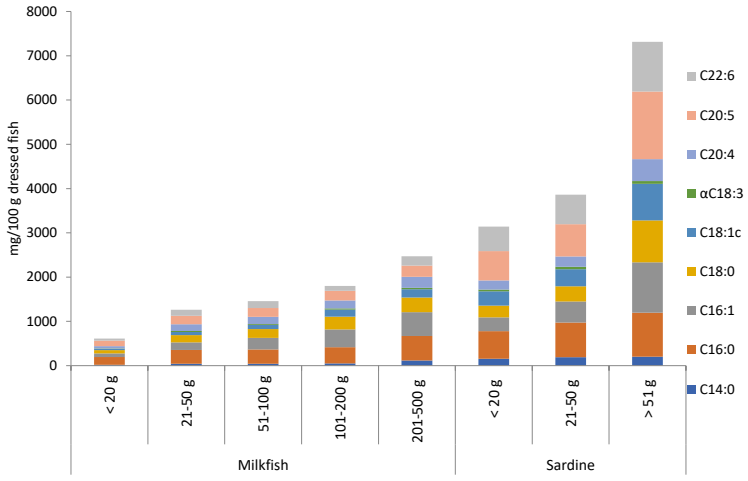


Proportion of fatty acids (%) in different size groups of milkfish and oil sardine



Fishes of similar appearance and feeding behaviour nutritionally could complement each other? Top- Farmed milkfish; Bottom – Wild caught oil sardine

contain higher proportion of eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) whereas the proportion of arachidonic and palmitic acids were higher in milkfish. The quantification of fatty acids indicated that as size of the fish increases, the fatty acid content increased in both the fishes but the fatty acid values are higher in oil sardine. A serving of 50 to 150 g for milkfish and 20g of oil sardine is required to meet the daily needs of 250 mg of EPA+DHA for adult human being. Higher Ca and Mg minerals were recorded in milkfish whereas all other minerals are almost similar in both the fishes.



Quantification of fatty acids (mg/100g dressed fish) in different size groups of milkfish and oil Sardine

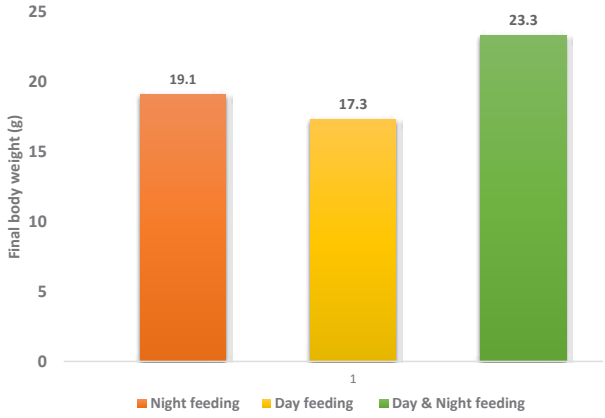
EFFECT OF FISH TRIMMINGS HYDROLYSATE ON FEED REPLACEMENT IN *ETROPLUS SURATENSIS*

ICAR-CIBA already optimized the production of hydrolyzed products from fish trimmings. Fish trimmings hydrolysate is one such product found rich in all essential nutrient as in fishmeal. An outdoor experiment of 45 days long was conducted to study the potential of application of fish trimmings protein hydrolysate on replacement of feed quantity in pearlspot (*Etroplus suratensis*) culture. Pearlspot fry (ABW 0.09±0.01 g) randomly distributed in triplicates 27 tanks with 20 fry per tank (80 l) The experiment was conducted in 3*3 factorial design where, variable 1 was level of FWH supplementation (0, 20 and 40 ppm) and variable 2 was level of feed supplementation (0, 50 and 100 %). Feed requirement was assumed to be 10 % of biomass. It was found that FWH supplementation@40 ppm significantly ($P<0.01$) influenced average daily gain (ADG), total biomass gain and survival (%) of *Etroplus suratensis*. At 40 ppm FWH level, 50% feed reduction resulted similar ADG, biomass gain, specific growth rate (SGR) as compared to control with 100% feed supplementation. Therefore, it can be concluded that FWH supplementation @ 40 ppm can save 50 % of required feed without any compromise in growth and survival of *Etroplus suratensis*.

CONCLUSION TO THE DEBATE ON DAY AND NIGHT FEEDING IN WHITE LEG SHRIMP

There is active debate among the stakeholders on choice of feeding time day or night. To bring a piece of scientific evidence, and end the debate among the stakeholders on the choice of feeding time, day or night, a planned experiment was conducted with 4 g shrimps. Results of the experiment showed better performance with shrimps fed continuously covering both day and night, performance almost similar in the treatment fed either in day or night. At the end of 8 weeks shrimps attained a final weight of 19.1, 17.3 and 23.3 g in treatments like night feeding alone, day feeding alone, and day and night feeding, respectively. With a significantly higher weekly gain of 2.4g continuous feeding yielded better results than either day feeding or night feeding alone.

Fish hydrolysate produced from fish trimmings



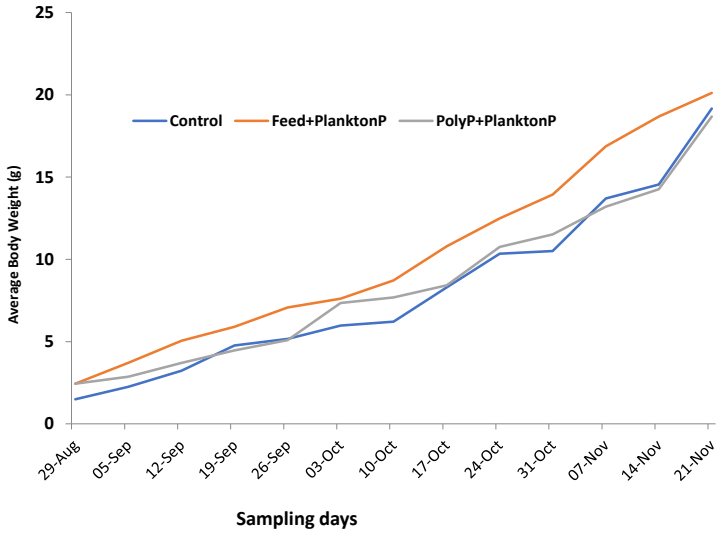
Final weight of the shrimps at the end of eight week feeding trial

Indoor shrimp rearing system where shrimps reared for day and night feeding experiment

CIBA-PLANKTON *PLUS* PERFORMANCES IN FARMERS PONDS AND TANK BASED PRODUCTION SYSTEMS

IN SHRIMP FARM AT WEST BENGAL

Effectiveness of Plankton *plus* (PPlus) was demonstrated in farmer's ponds at Lalpool, Namkhana, West Bengal. Three ponds were used for demonstration with three different treatments, i.e., control (Commercial shrimp feed) without PPlus application, T1, supplemented with PPlus (Feed used: Commercial shrimp feed) and T2, Poly *plus* feed supplemented with PPlus. Plankton *plus* was used at 30 ppm. A significant increase of phytoplankton count was noticed in T1 and T2. Highest phytoplankton cell count (2.1 X 10^6 cells/ml) and zooplankton cell



count (12991 no/ml) was achieved in treatment with Poly ^{plus} + Plankton ^{plus}. Highest production of 7.24 t/ha was achieved when Plankton ^{plus} supplemented with commercial feed followed by Poly plus feed with plankton plus 6.30 t/ha and control 6.04 t/ha.

IN SHRIMP FARM AT KERALA

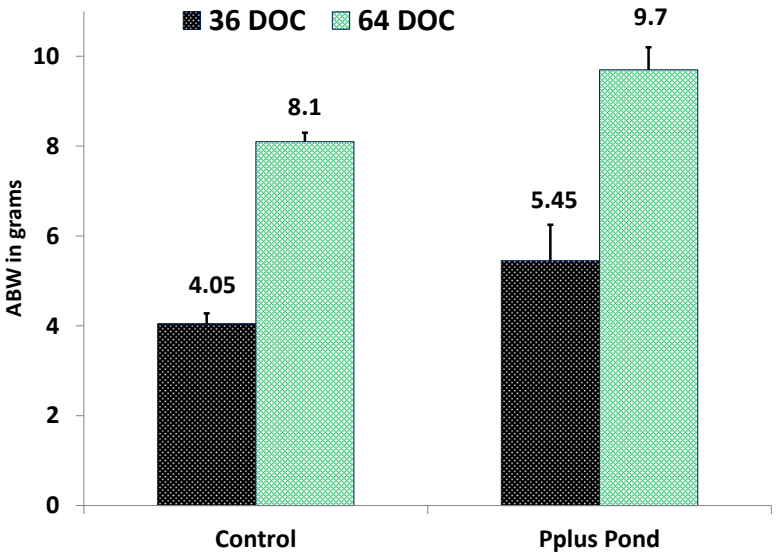
The pond culture demonstration of shrimp with Plankton ^{plus} was conducted at Payyannur, Kerala. The species cultured was *Penaeus monodon*. The demonstration culture was conducted in a progressive shrimp farmer in Keral. Two ponds were used, wherein one was used as control without the supplementation of Plankton ^{plus} and other was supplemented with Plankton ^{plus} at 30 ppm (90 kg Initial dose, 12 kg weekly dose). The ponds used were of 1-hectare area and the salinity was 18-22 ppt.

P. monodon was stocked at 4 numbers/m^2 in both the ponds. The growth of the shrimps where monitored weekly and all the water quality parameters were analysed in regular intervals. On 75th day of culture, due to heavy flood in northern Kerala the farmer lost the entire crop. Even though, there was a significant difference ($p<0.05$) in growth of *P.monodon* in Plankton ^{plus} supplemented pond compared to that in control pond (Fig).

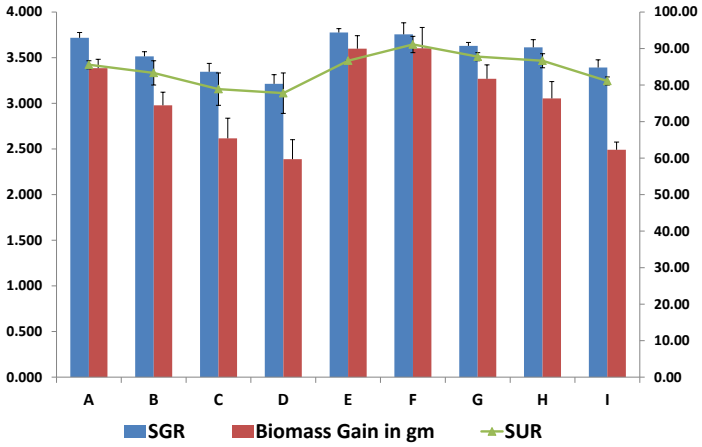
The phytoplankton and zooplankton diversity as well as abundance were estimated monthly during the culture. There was a significant increase in total number of phytoplankton cells in plankton plus supplemented pond compared to the control pond. There was an increase in beneficial microalgae like *Nitzschia, Chlorella* etc and presence of less number of blue green algal cells in plankton ^{plus} supplemented ponds.

EFFECT OF PLANKTON ^{PLUS} IN POLYCULTURE TANK SYSTEM

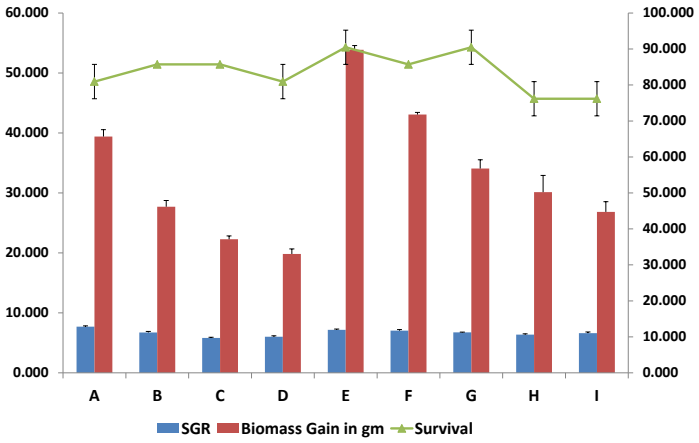
A 70 days trial was conducted in 500 L outdoor FRP tanks to study the effect of Plankton ^{plus} in polyculture system of *Penaeus monodon* and *Chanos chanos*. Thirty juvenile *Penaeus monodon* (0.273 ± 0.016 g) and seven *Chanos chanos* fry (0.303± 0.027 g) were stocked in the tanks at 30 ppt. The experiment was conducted in zero water exchange system. The feed (40% CP) was two times a day, morning and evening. The plankton ^{plus} was applied in the experiment at 40 ppm, in that 40% was applied before stocking and remaining 60% was applied in equal weekly doses. The treatments were following;



Growth of *P monodon* in culture demonstration using Plankton ^{plus} at Payyannur, Kerala



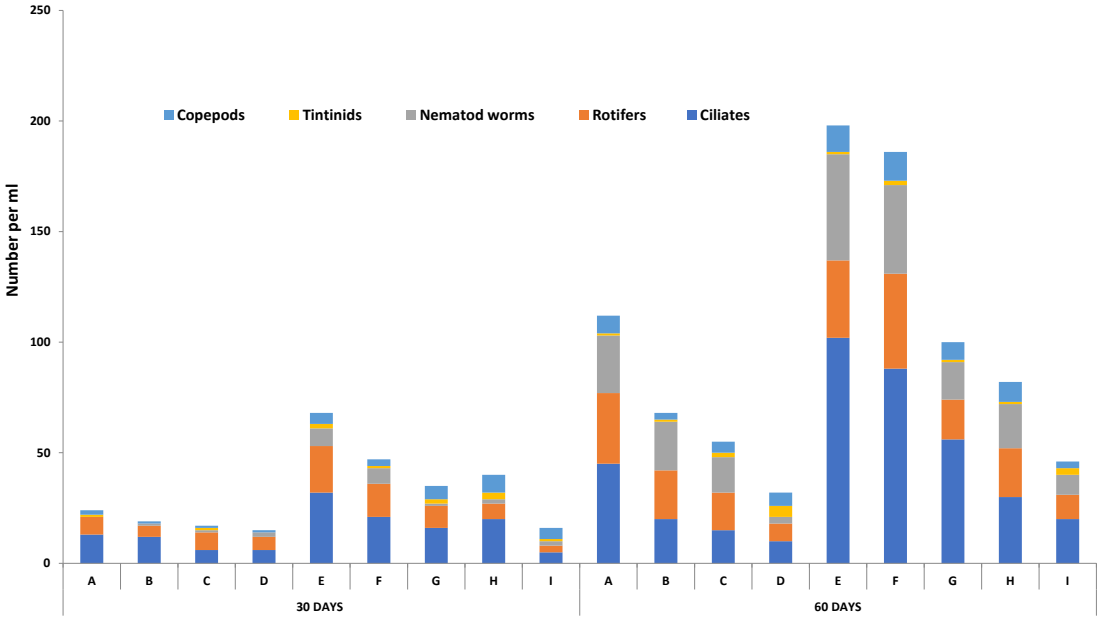
Growth parameters and survival of *Penaeus monodon* in polyculture system supplemented with Plankton ^{plus}



Growth parameters and survival of *Chanos chanos* in polyculture system supplemented with Plankton ^{plus}

Healthy milk fish and tiger shrimp supplemented with plankton ^{plus}

A:Feed; B: 10% reduction in feed, C: 20% reduction in feed, D: 30 Percent reduction in feed; E: Feed + Plankton ^{plus}; F:10% reduction in feed + Plankton ^{plus}; G:20% reduction in feed + Plankton ^{plus}; H: 30%reduction in feed + Plankton ^{plus}; I: 40% reduction in feed + Plankton ^{plus}. The phytoplankton and zooplankton diversity and abundance were estimated monthly. Significant increase ($P<0.01$) was observed in growth parameters (ADG, SGR and Biomass gain) of *Penaeus monodon* treated with Plankton ^{plus} and feed (Fig).



Diversity and abundance of zooplankton in polyculture system supplemented with Plankton^{plus}

EFFECT OF PLANKTON ^{PLUS} ON *PENAEUS MONODON* CULTURED IN INDOOR SYSTEM

A 45 days indoor trial was conducted in 350 L FRP tanks to study the effect of Plankton ^{plus} on shrimp in indoor systems. The Plankton ^{plus} was applied @ 40 ppm. The treatments of the experiment were as following; Feed without Plankton ^{plus} (A), Feed + Plankton ^{plus} (B), 75% of the required feed + Plankton ^{plus} (C); 50% of the required feed (D) + Plankton ^{plus}; 25% of the required feed + Plankton ^{plus} (E). The experiment Plankton ^{plus} has no growth promoting effect in indoor conditions in *Penaeus monodon*. So that it can be inferred that Plankton ^{plus} act as an indirect feed to shrimps and fishes by boosting the phytoplankton, zooplankton and other natural food organisms in the presence of sunlight.

	IBW (g)	FBW (g)	Survival	SGR	ADG	Weight Gain (g)
A	2.590 ± 0.085^{a}	4.423 ± 0.272^{b}	77.780 ± 7.35^{a}	0.012 ± 0.001^{c}	40.801 ± 4.74^{c}	1.833 ± 0.213^{c}
B	2.740 ± 0.032^{a}	4.130 ± 0.16^{b}	88.890 ± 2.78^{a}	0.009 ± 0.001b^{c}	30.880 ± 4.19b^{c}	1.390 ± 0.19b^{c}
C	2.660 ± 0.106^{a}	3.350 ± 0.193^{a}	69.443 ± 7.35^{a}	0.005 ± 0.002^{ab}	15.322 ± 6.59^{ab}	0.690 ± 0.29^{ab}
D	2.797 ± 0.018^{a}	3.413 ± 0.258^{a}	69.447 ± 12.1^{a}	0.004 ± 0.002^{ab}	13.662 ± 5.7^{a}	0.617 ± 0.258^{a}
E	2.767 ± 0.019^{a}	3.273 ± 0.137^{a}	77.777 ± 5.56^{a}	0.004 ± 0.001^{a}	11.148 ± 3.4^{a}	0.507 ± 0.153^{a}

Growth parameters and survival of *Penaeus monodon* supplanted with Plankton ^{plus} in indoor system.

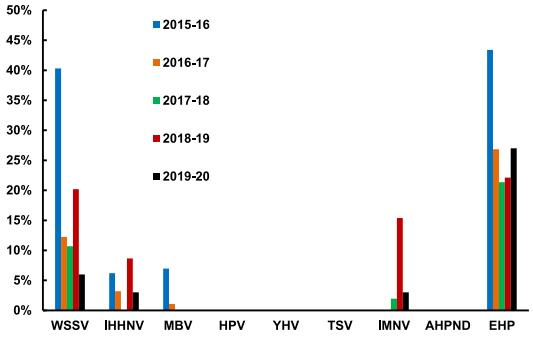
Aquatic Animal Health

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

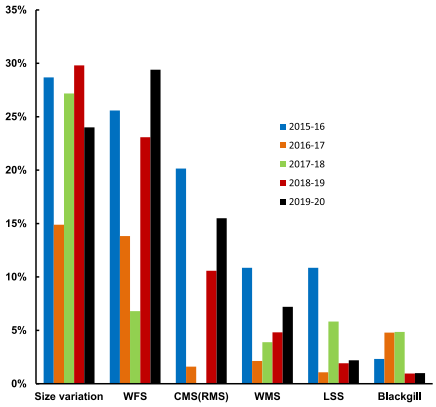
Aquatic Animal Health

WSSV AND EHP CONTINUE TO BE MAJOR THREATS TO THE INDIAN SHRIMP FARMING

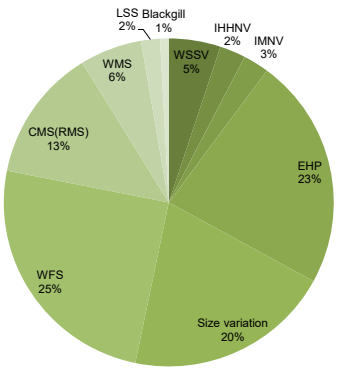
Diseases are the biggest threat in growth and sustainability of shrimp farming sector. As a part of the ongoing disease surveillance program, 703 *Penaeus vannamei* farms were screened during 2015-2020 for OIE listed and other viral, bacterial and parasitic pathogens in coastal states of Tamil Nadu, Andhra Pradesh and West Bengal. The analysis indicates that *Enterocytozoon hepatopenaei* (EHP) and white spot syndrome virus (WSSV) continue to pose the highest threats. Among the infectious diseases, the incidence of microsporidiosis (due to EHP) was maximum (27% of the farms), followed by white spot disease (in 6% of the farms), and infectious hypodermal haematopoietic necrosis virus (IHHNV) and infectious myonecrosis virus (IMNV) in 3% of the farms each. Similarly, among the 180 surveyed vannamei farms during 2019-20, the highest prevalence was recorded for EHP (27%), followed by WSSV (6%), IHHNV (3%) and IMNV (3%). The incidence of management associated diseases such as running mortality syndrome (RMS), white faeces syndrome (WFS), white muscle syndrome (WMS), size variation etc., in



Prevalence of viral, bacterial and parasitic diseases in Andhra Pradesh, Tamil Nadu and West Bengal during 2015 – 2020 (n= 703 farms)



Prevalence of disease syndromes of shrimp in Andhra Pradesh, Tamil Nadu and West Bengal during 2015 – 2020 (n= 703 farms)



Overall prevalence of major diseases and syndromes in shrimp aquaculture farms on the east coast of India since 2015 (703 farms) contributing to reduced productivity in shrimp farms

Shrimps showing size variation in inland saline areas of Haryana

Indian shrimp farming were the major factors for the reduced productivity in the shrimp farms.

The Indian brackishwater aquaculture sector during the last five years were free from other OIE listed diseases such as taura syndrome virus (TSV), yellow head virus (YHV), acute hepatopancreatic necrosis disease (AHPND) and necrotising hepatopancreatitis (NHP).

ECONOMIC LOSS EVALUATION FROM WSSV AND EHP IN INDIAN SHRIMP FARMING

In an effort to analyse the economic loss due to disease, a survey was conducted (n=909) in Andhra Pradesh, Tamil Nadu, Gujarat, West Bengal, Odisha, and Maharashtra using multistage stratified sampling at district level with simple random sampling without replacement at village level. The probability of occurrence factor index was computed using the proportion of disease occurrence at the farms from the total culture area of the concerned state. WSSV and EHP were the major disease affecting shrimp farms in Andhra Pradesh, Tamil Nadu and Gujarat. The study also found that the severity of EHP, WSSV, and their mixed infections was very high followed by RMS. The study estimated total economic loss due to WFS and EHP to be Rs. 1904 crores with production loss of 41,994 metric tonne; followed by WSD to the tune of Rs. 1681 crores during 2017-18. Further, employment loss of 11 lakhs man days was estimated.

ENTEROCYTOZOON HEPATOPENAEI (EHP) INFECTIONS DETECTED IN SHRIMP FARMS IN INLAND SALINE AREAS

Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) continue to be a major disease, limiting the production in Indian shrimp farming sector. To investigate the impact of EHP in low saline inland regions, the disease investigation was carried out during August 2019 in three North Indian states, viz., Haryana, Punjab and Rajasthan. Shrimp samples (n=16) collected from these three states revealed the presence of EHP by second step

PCR in two farms of Haryana. No other infectious disease agents were detected. The presence of mild infection of EHP suggests the seed-borne transmission in inland saline areas.

EHP INCIDENCES IN SHRIMP FARMS IN GUJARAT, WEST COAST OF INDIA

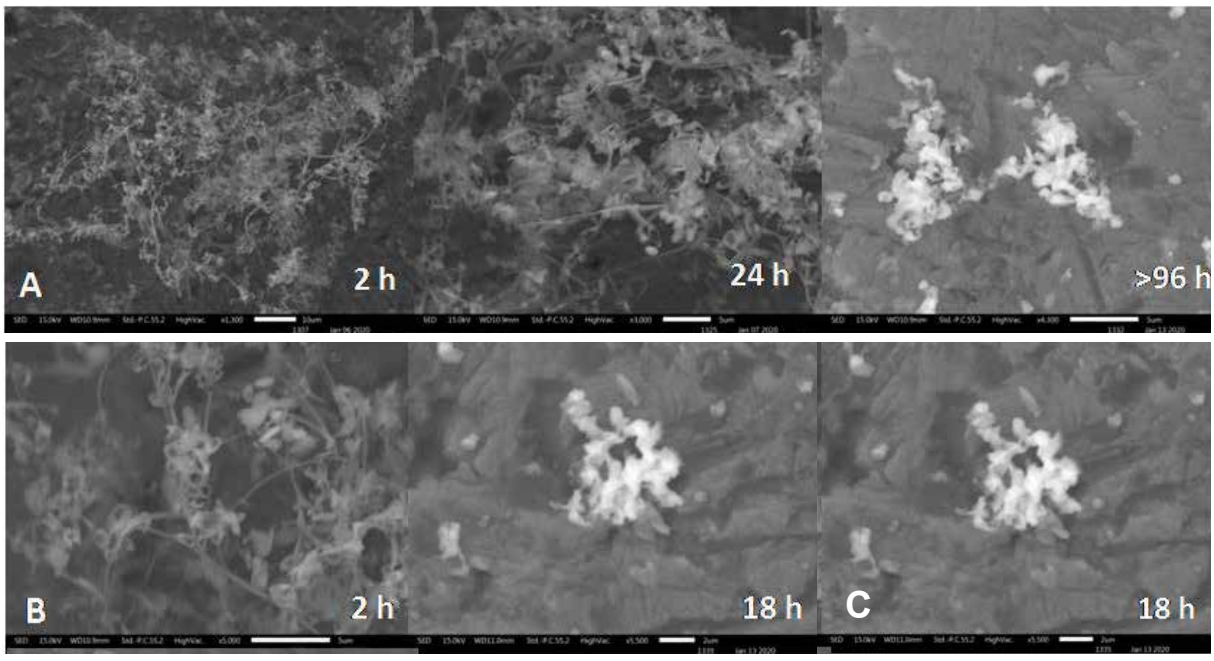
Enterocytozoon hepatopenaei (EHP) has been widely reported in shrimp farming countries and often associated with reduced feed consumption, growth retardation and white faeces syndrome (WFS). The prevalence of EHP is well recorded in eastern coast of India, which has been as high as 27%. To investigate the prevalence in west coast, eighteen shrimp farms from different regions of Gujarat such as Matwad, Sambapur, Onjal, Panar, Mendharbaat and Maroli of Navsari were analysed. All the eighteen farms were affected with WFS, seven with size variation, three with loose shell whereas one was affected with black gill. Moreover, five of these disease affected farms also had the past experience of WFS. Investigation revealed that all the eighteen samples were positive for EHP and negative for WSSV, AHPND and IHHNV. Testing of feed inputs revealed negative for EHP. Notably, all 18 farms received post-larvae either directly from east coast hatcheries (14 farms) or postlarvae reared in west coast hatcheries after procuring nauplii from east coast hatcheries (4 farms). As testing of EHP is not routinely practiced in commercial hatcheries, it could be concluded that seed could be the major source of transmission for EHP in the west coast of India, particularly in Gujarat.

FREEZING AND BOILING PREVENTS THE GERMINATION AND VIABILITY OF EHP SPORES

The germination and viability EHP spores at different temperatures 100ºC, 4ºC, -20ºC, and -80ºC was assessed at different time intervals by studying extrusion of polar tubule of EHP spores. Fifty percent of the EHP spores remained viable at room temperature and at -4ºC upto 6 months as revealed by polar tubule extrusion. However, polar tubule extrusion was completely inhibited in 4 days at -20ºC, at -80ºC in 18 h and within an hr at 100ºC indicating loss of viability of EHP spores. Thus, in conclusion, polychaete worms and feed inputs contaminated with EHP may be stored at -20ºC for more than 4 days and at -80ºC for more than 18 hrs to inactivate the EHP spores before using as inputs in hatchery/farm.

WHITE FAECES SYNDROME (WFS): COLOURLESS FAECAL THREADS AND AGGREGATED TRANSFORMED MICROVILLI (ATM) STRUCTURES COULD BE PRODUCED BY EXPERIMENTAL CHALLENGE

White faeces syndrome (WFS) has emerged as serious concern for global shrimp aquaculture.



EHP spores stored at different temperatures for different time interval A (-20◦C), B (-80◦C), C (100◦C)

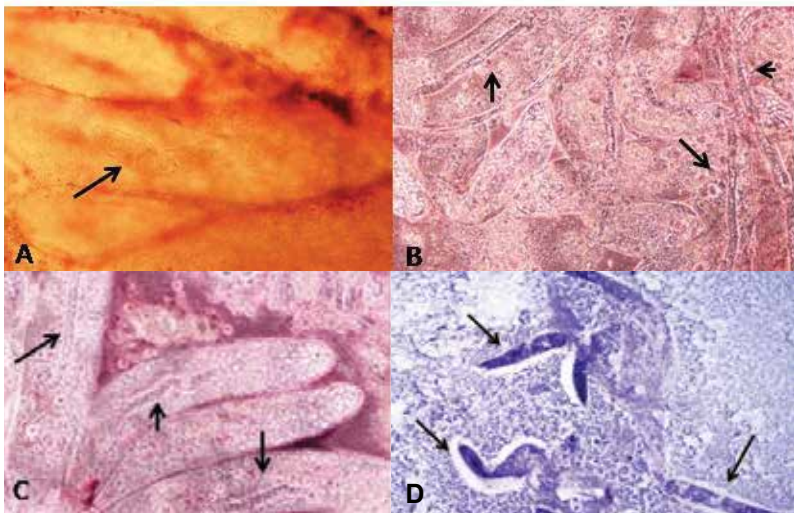
Their occurrence is suspected to be associated with incidences of the emerging microsporidian *Enterocytozoon hepatopenaei* (EHP) in *P. vannamei* grow-out system. To reproduce the WFS in laboratory conditions shrimps were fed with WFS affected hepatopancreas (HP) tissue, white faecal threads and purified EHP spores. After 3 days post infection, shrimps fed with white faecal threads and WFS affected minced HP tissue revealed ATM structures in the HP tubule lumen and started producing transparent and non-floating faecal threads. Animals fed with purified spores and pellet feed produced normal faecal threads. All faecal threads of three groups except control animals were tested positive for EHP by Spore Wall Protein-PCR after 7 days of post infection. ATM structures reproduced in the HP lumen are reportedly involved in producing the white faecal threads. Although the faecal threads excreted by challenged animals were non-floating and transparent, the ATM structures and EHP could be detected in these shrimp by light microscopy, Scanning Electron Microscope and SWP-PCR. We assume that the lack of buoyancy and lack of white colour in the faecal thread of challenged animals may be due to a type and quality of feed, the non-availability of natural feed in the experimental conditions and lipid content in the artificial feed. Thus, white faecal threads and WFS affected minced HP tissue containing EHP spores reproduced the ATM structures but EHP spores alone failed to reproduce the ATM structures in the challenged shrimp. Further studies are needed to confirm the aetiology of WFS and its association with EHP.

We assume that the lack of buoyancy and lack of white colour in the faecal thread of challenged animals may be due to a type and quality of feed

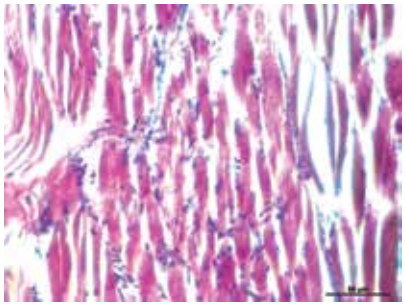
WHITE MUSCLE SYNDROME (WMS) IN FARMED SHRIMP

Shrimps showing symptoms of white muscle syndrome (WMS) were collected from Kalpakkam and Nellore. Majority of the affected shrimps had gross pathological whitish musculature in 3rd and 4th muscular segment, while a few showed such abnormalities in the 1st and 2nd segments. The affected shrimps had muscular degeneration with heavy infiltration of haemocytes. In almost all of the WMS affected shrimp, gills and hepatopancreas appeared normal. These shrimp were tested for the presence of viral, bacterial and parasitic agents. All the shrimp samples tested negative for OIE listed DNA and RNA shrimp viruses such as WSSV, IHHNV, IMNV, YHV and TSV. These shrimp were also negative for EHP. However, several *Vibrio* species such as *Vibrio metschnikovii, V. fluvialis and V. furnisii* were

White muscle disease affected shrimp



Light Microscopy of hepatopancreas shows aggregated transformed microvilli structures, A,B,C- Hepatopancreas smear unstained, D- HP smear stained with Haematoxylin.



Muscle tissue heavily infiltrated by haemocytes – H& E-40x

isolated from the haemolymph of WMS affected shrimp. While *V. campbellii,* a luminescent bacterium, was isolated from one of the farms. Majority of the farms affected with WMS utilized bore well water for farming. The exact cause of WMS could not be ascertained.

TILAPIA LAKE VIRUS DETECTED IN CULTURED NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FROM WEST BENGAL

Tilapia lake virus (TiLV) has emerged as serious pathogen for cultured tilapia worldwide with some reports in brackishwater fishes. The present work was initiated to assess the epidemiological pattern of TiLV in cultured brackishwater and freshwater fishes in Sundarban area of West Bengal. A total eight farms of cultured Nile tilapia from South 24 Parganas, West Bengal were screened for TiLV infection by RT-PCR using ME1/ME2 primers. The study revealed that the incidence of TiLV infection was recorded in 25% of the farms with mortality ranging from 10-30% in the affected farms.

DISEASE PATHOGENESIS

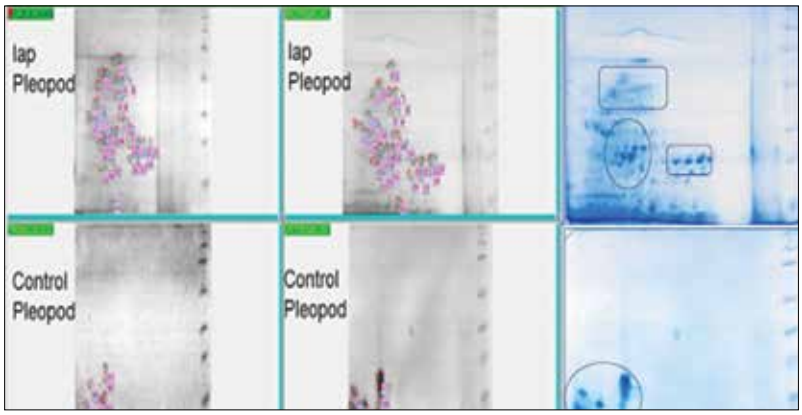
CHARACTERIZATION OF INHIBITOR OF APOPTOSIS (IAP) GENE IN *PENAEUS MONODON* BY 2-D GEL

Eye lesion in TiLV affected Nile Tilapia

ELECTROPHORESIS BASED PROTEOMIC ANALYSIS

Inhibitor of Apoptosis (IAP) gene play important role in apoptosis and innate immunity of crustaceans. It has been reported that knockdown of this gene by specific dsRNA brings mortality within 48 hours in tiger shrimp, *Penaeus monodon*. Here we tried to characterize this protein by doing proteomics analysis. After 48 hours of IAP knockdown by dsRNA, pleopod samples were collected and protein was extracted. The 2-D gel electrophoresis was carried out over the pH range of 4-7. Gels were stained with coomassie brilliant blue. Differentially expressed proteins were identified based on PDQuest software analysis.

A total of 45 protein spots were identified which were found to be differentially expressed. Out of these, 37 differential spots were expressed in IAP knockdown sample and 8 in control sample. One of the most important differentially expressed proteins in IAP knockdown sample was Catechol O-methyltransferase domain-containing protein 1 which is involved in signal transduction pathways, metabolism, defense, DNA repair and synthesis, apoptosis and cell cycle regulation. Similarly another protein identified was

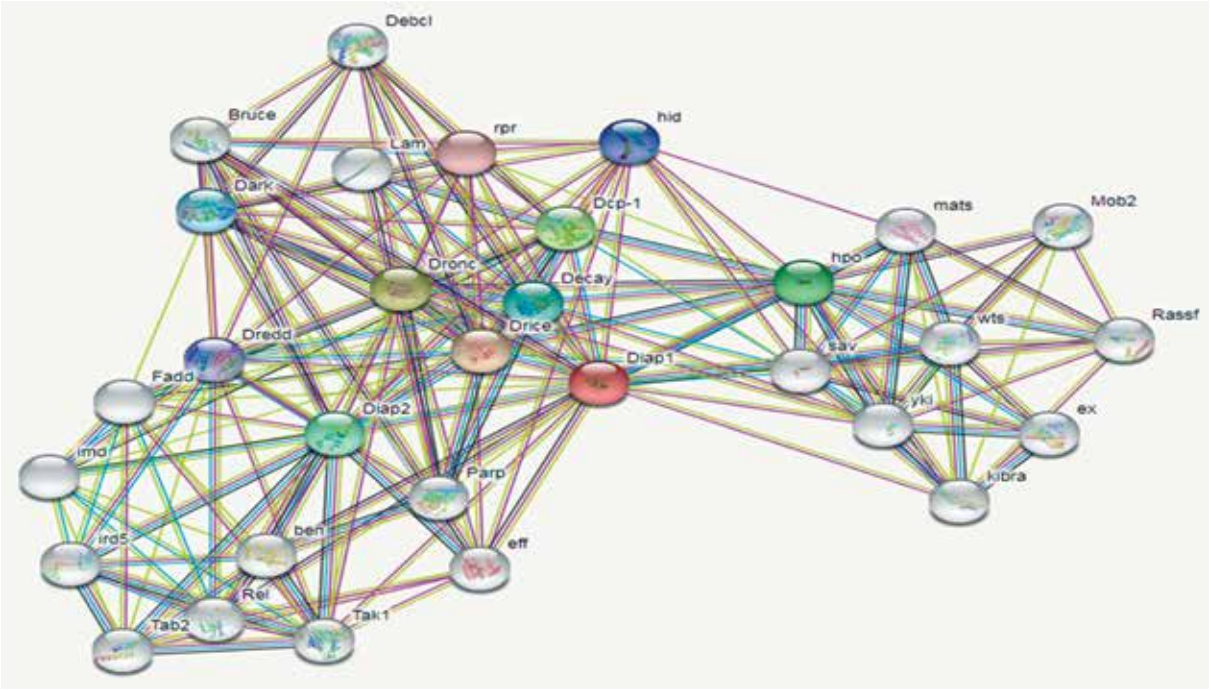


DE profiles from IAP dsRNA injected and control pleopod from *P. monodon*

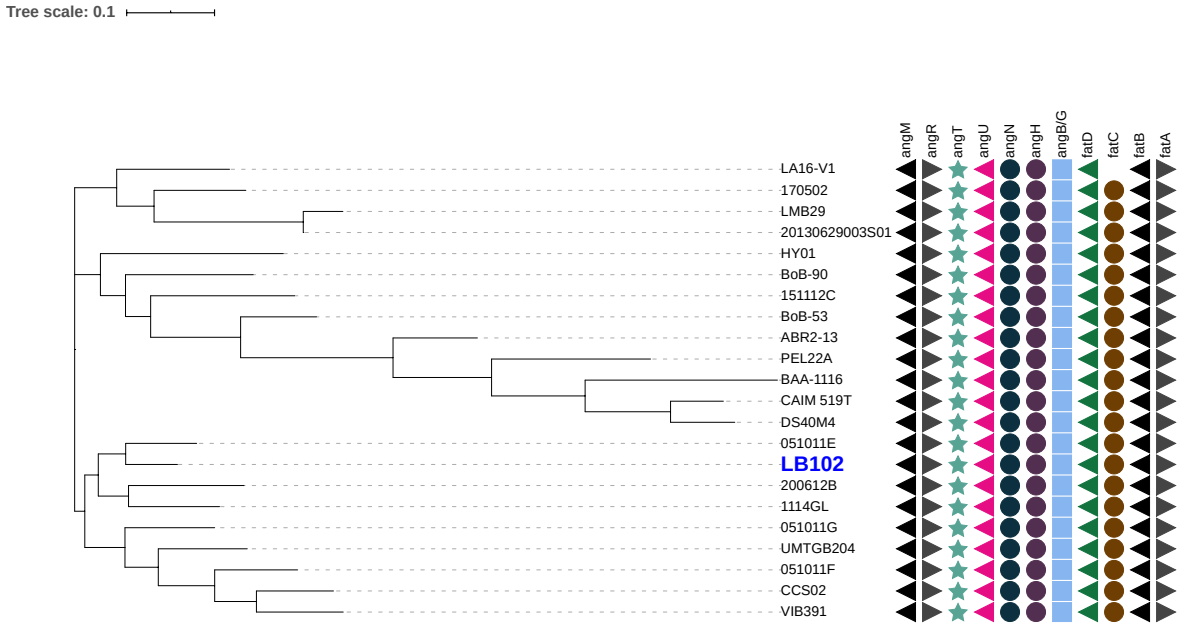
Inhibitor of Apoptosis (IAP) gene play important role in apoptosis and innate immunity of crustaceans

triosephosphateisomerase which is a glycolytic enzyme. Differentially expressed proteins in control were ubiquitin carboxyl terminal hydrolase thiol protease that recognizes and hydrolyzes a peptide bond at the C-terminal glycine of ubiquitin and enolase which is a phosphopyruvatehydratase, a metalloenzyme.

In order to predict the outcome of this differential expression, we tried to establish the network of IAP protein interaction. Since, shrimp IAP protein interaction network is not available, we covered the *Drosophilla* IAP protein. From this complex interaction, it is predicted that the entire system will be disturbed by knockdown of IAP protein. So new proteins may get expressed by breakup of the network or proteins which are under the control of IAP may lose the control signal and therefore are expressed differentially.



String analysis of Drosophilla IAP protein – protein network interactions



Distribution of anguibactin based siderophore system in *Vibrio campbellii* isolates

ANGUIBACTIN BASED SIDEROPHORE VIRULENCE SYSTEM DETECTED IN *VIBRIO CAMPBELLII*

Iron is one of the most limited nutrients available for microbial growth and often considered as critical requirement for growth and virulence of bacterial pathogens. Bacteria solve this problem by secreting an iron chelator called siderophore which transports iron inside bacterial cell. Anguibactin is one of the most characterized siderophore system and has been considered as the most important virulence factor in *V. anguillarum*. To screen their presence, 91 genomes of *V. harveyi* clade; comprising 21 isolates of *V. campbellii*; 33 isolates of *V. harveyi*; 12 isolates of *V. owensii*; 15 isolates of *V. jasicida*; 10 isolates of *V. rotiferianus* were genetically analysed. The analysis indicated that all isolates of *V. campbellii* possess genes required for anguibactin synthesis (*angR, angT, angU* and *angH*) and their translocation (*fatA, fatB, fatC* and *fatD*). However, such genes were not observed in other species of *Vibrio harveyi* clade. This suggests their diagnostic potential and possible role in virulence and growth of *V. campbellii*.

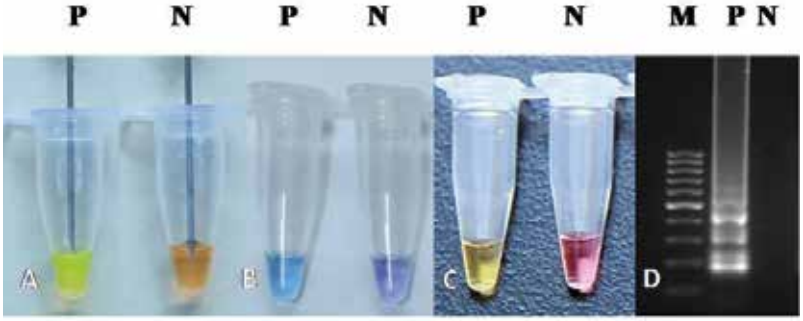
DIAGNOSTICS

VISUAL LAMP ASSAY DEVELOPED FOR THE DIAGNOSIS OF WHITE SPOT SYNDROME VIRUS (WSSV)

White spot syndrome virus (WSSV) is causing severe economic losses in shrimp farms globally. As therapeutics to control the disease is lacking, early detection and biosecurity measures are the only means to manage this disease in aquaculture. Majority of diagnostic procedures such as histopathological techniques, DNA probe, immunological methods and PCR assays demand

Primers used in this study

Primers	Sequence
WSSV 1 F3	CGGAGGACCCAAATCGAAAT
WSSV 1 B3	CCTCTGCAACATCCTTTCCT
WSSV 1 FIP	GGTCGTCGAATGTTGCCCAAGATTTTGCCTACGCACCAATCTGTG

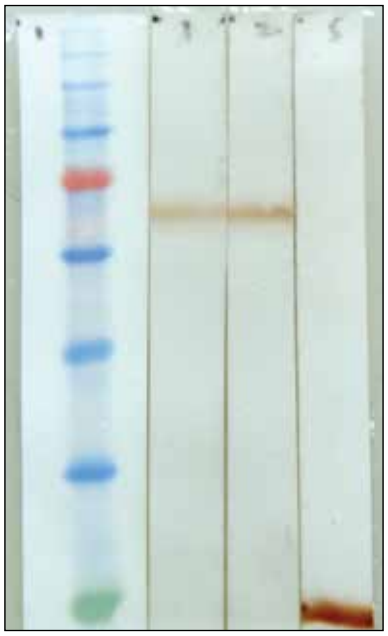


Visual loop mediated isothermal amplification (LAMP) for detection of WSSV. A- Syber green, B- Hydroxynapthol blue (HNB), C- Phenol red, D- Agarose gel electrophoresis. M – Marker, P- Postive, N – Negative

well equipped laboratory. In contrary, loop mediated isothermal amplification (LAMP) based diagnostic technique is simple, reliable and provides high degree of sensitivity and specificity in detection of WSSV. Hence, in this study, a LAMP protocol was developed using ORF 121 gene. The target sequence of WSSV was amplified at constant temperature of 65°C for 45 min and amplified LAMP products were visually detected in a closed tube system. This simple, closed tube, visual LAMP assay has great potential for diagnosing WSSV at the farm level, particularly under low resource circumstances.

INDIRECT ELISA TO ASSESS IMMUNE RESPONSE IN ASIAN SEABASS AGAINST VIRAL NERVOUS NECROSIS

Assessing immune response is critical for developing an effective vaccine and non-lethal diagnostics against viral nervous necrosis. With this objective, IgM of Asian seabass was purified, using Protein A agarose column, and used to immunize BALB/c mice. The hybridoma clones were generated by fusing sensitized B lymphocytes and mouse myeloma cells. Positive clones were identified by ELISA and the monoclonal antibodies (MAbs) specific to heavy chain and light chain of seabass IgM were obtained. Based on the



Western blot of anti-seabass IgM MAb against seabass IgM. Lane 1: Protein marker; Lane 2: MAb 2B6; Lane 3: MAb 1E12; Lane 4: MAb 10B8

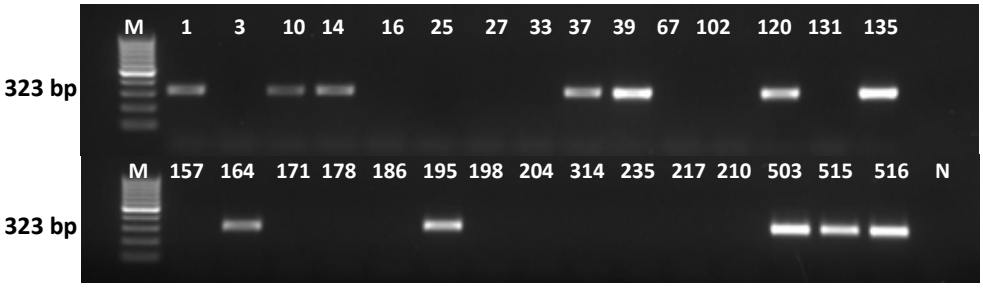
reactivity, MAb 1E12 was selected for developing indirect ELISA for assessing immune response in seabass. The heavy chain isotype of the MAb 1E12 was IgG2b and that of the light chain was kappa. The MAb 1E12 was found specific to the heavy chain of Asian seabass IgM. An indirect ELISA was optimized by checker board titration. The optimum concentration of the ELISA reagents were, coating antigen: 10 µg/ml; blocking buffer: 3% skim milk powder in PBS; MAb: 5 µg/ml and conjugate: 1:2000 dilution. The assay could detect

The target sequence of WSSV was amplified at constant temperature of 65°C for 45 min and amplified LAMP products were visually detected in a closed tube system

the immune response of Asian seabass to vaccination against VNN.

PCR BASED DIAGNOSTIC DEVELOPED FOR DETECTION OF FILAMENTOUS PHAGES ENCODING VIRULENCE FACTORS IN *VIBRIO CAMPBELLII*

Lysogenic filamentous phages play a crucial role in virulence of several *Vibrio* species such as *V. cholerae* and *V. parahaemolyticus*. Our earlier studies using mitomycin induction, transmission electron microscopy and pangenome analysis had suggested the presence of filamentous phages in several strains of *V. harveyi* clade. Such phages were found to carry zona occludans toxin (zot) and accessory cholera enterotoxin

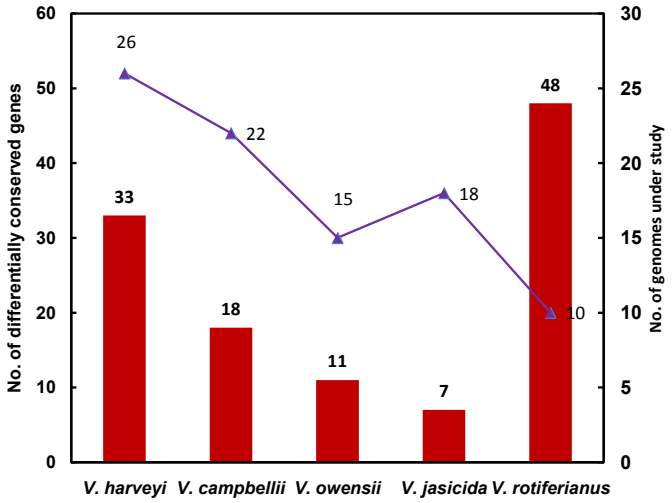


Gel picture showing presence of filamentous phages in *Vibrio campbellii* isolates

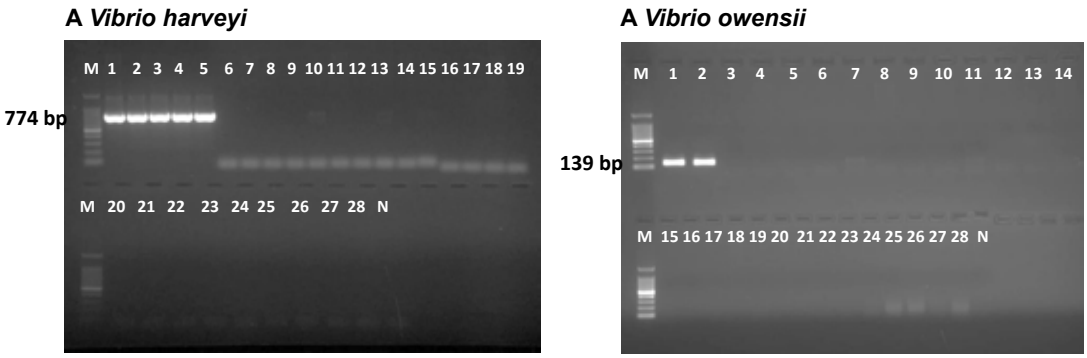
(ace) in their genetic loci. The present study suggested that during routine bacterial growth *V. campbellii* excreted filamentous phages in the supernatant which had limited lytic activity against several bacterial strains. This also poses challenge to phage therapy, as during isolation procedure therapeutic lytic phages can get contaminated with pathogenic filamentous phages. Therefore to sort out this problem, all the sequences available filamentous phages at NCBI database were downloaded, aligned and clustered. Using Hyden software a set of degenerate primers was designed for individual and group of clusters. A primer set using zot gene taking 22 sequences, encompassing three out of total four clusters produced specific 323 bp product. The level of degeneracy was limited to two for forward primer and 12 for reverse primer. The PCR detected presence of filamentous phages in twelve out of screened 30 isolates of *V. campbellii*.

NOVEL DIAGNOSTIC MARKERS IDENTIFIED FOR DIFFERENTIATION AND QUANTIFICATION OF *VIBRIO HARVEYI CLADE*

V. harveyi and *V. campbellii* are associated with luminescent vibriosis in shrimp hatchery and often causing 100% mortality in mysis and early postlarval stages. Despite their great



Differentially conserved gene present in *Vibrio harveyi* clade species namely *V. harveyi, V. campbellii, V. owensii, V. jasicida* and *V. rotiferianus*. Bar reflects no. of differentially conserved gene and line reflects no. of genome analysed



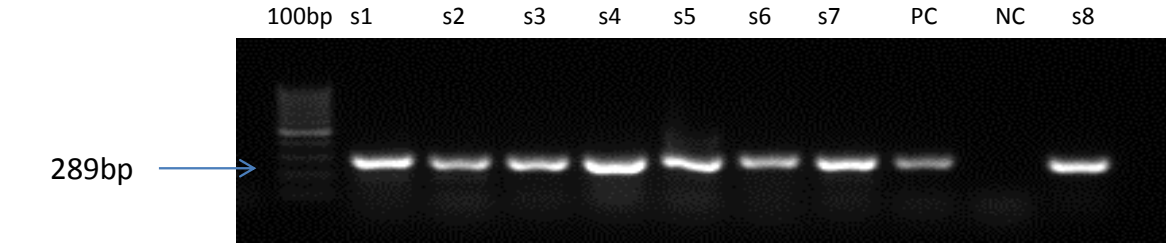
Gel picture showing sensitivity and specificity of *V. harveyi* and *V. owensii* primers. Fig A; Lane 1-5, *V. harveyi* howing positive band, Lane 6-20, Eight other *Vibrio* species; Lane 21-24, Four isolates of Gram negative bacteria other than *Vibrio*; Lane 25-28, Four isolates of Gram positive bacteria Fig B. Lane 1-2 *Vibrio owensii* showing positive band; Lane 3-28, 16 other bacterial species

economic importance no specific quantification method is available. The culture based method providing detail of total *Vibrio* count and luminescent bacterial count represent large diverse group of bacteria, both pathogenic and commensal in nature. This can't be accurate for estimation of pathogenic *Vibrio* species. Therefore, for developing quantitative PCR for *V. harveyi* and *V. campbellii,* and differentiation of other species of harveyi clade, a pangenome wide search of novel diagnostic markers was carried out. A total of 117 differentially conserved genes and 11 novel target genes were identified. Based on these genes primer specifically identifying *V. harveyi, V. campbellii* and *V. owensii* were developed.

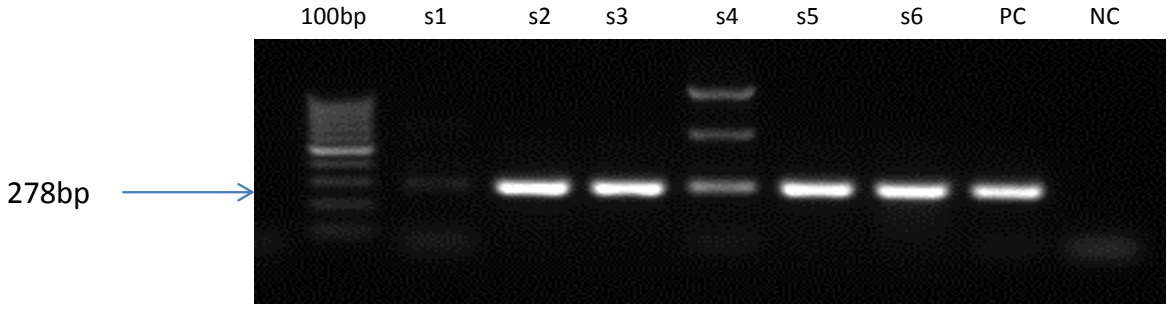
DETECTION OF ANTIMICROBIAL RESISTANCE (AMR) IN BACTERIAL PATHOGENS FROM CULTURED SHRIMPS

About 40 shrimp samples were collected from 6 different districts of Andhra Pradesh and Tamil Nadu. The samples were processed for the isolation of *Escherichia coli, Staphylococcus aureus* and

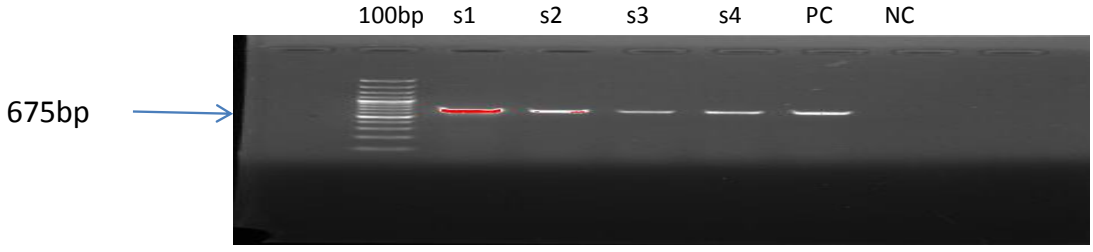
The culture based method providing detail of total *Vibrio* count and luminescent bacterial count represent large diverse group of bacteria, both pathogenic and commensal in nature



E. coli specific *lacY gene amplification.*



S. aureus specific *nuc gene amplification*



V. parahaemolyticus specific *VPM gene amplification*

PCR amplification of specific genes for the respective bacterial pathogens

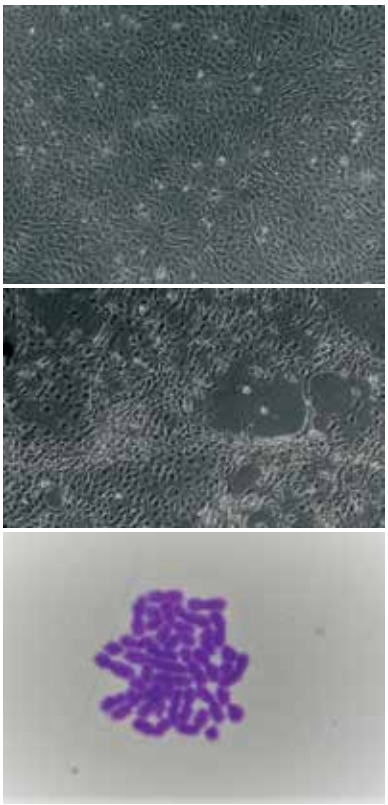
Isolates	Total no. of isolates	Resistant	
		Antibiotic	**No of isolates (%)**
E. coli	17	Amikacin (30 µg)	2 (11.76)
		Amoxicillin (10 µg)	11 (64.70)
		Ampicillin (10 µg)	5 (29.41)
		Cefoxitin (30 µg)	1 (5.88)
		Chloramphenicol (30 µg)	1 (5.88)
		Ciprofloxacin (5 µg)	2 (11.76)
		Gentamicin (10 µg)	1 (5.88)
		Imipenem (10 µg)	1 (5.88)
		Nalidixic acid (30 µg)	2 (11.76)
		Tetracycline (30 µg)	4 (23.52)
		Trimpethoprim (1.25 µg)	3 (17.64)
		Erythromycin (15 µg)	11 (64.70)
S. aureus	9	Pencillin (10 µg)	9 (100)
		Ciprofloxacin (5 µg)	1 (11.11)
		Chloramphenicol (30 µg)	1 (11.11)
		Linezolid (30 µg)	1 (11.11)
V. parahaemolyticus	26	Ampicillin (10 µg)	26 (100)
		Amoxycillin (10 µg)	26 (100)
		Cefepime (30 µg)	1 (3.84)
		Cefotaxime (30 µg)	1 (3.84)
		Cefoxitin (30 µg)	2 (7.69)
		Ceftazidime (30 µg)	1 (3.84)
		Tetracycline (30 µg)	1 (3.84)

Vibrio parahaemolyticus. Biochemical analysis was carried out for the preliminary identification of typical colonies from the selective plates. Subsequently, PCR was carried out for species specific identification of pathogens. From this, 17 isolates of *E. coli,* 9 isolates of *S. aureus* and 26 isolates of *V. parahaemolyticus* were taken for AMR study through disc diffusion test. All 9 isolates of *S. aureus* against penicillin, all 26 isolates of *V. parahaemolyticus* against both ampicillin and amoxicillin and majority of *E. coli* (11 each out of 17 isolates) were found resistant for amoxicillin and erythromycin. However, majority of *V. parahaemolyticus* (25 out of 26 isolates) were susceptible for tetracycline.

CELL CULTURE

MILK FISH BRAIN CELL LINE MFB-1 DEVELOPED FOR PROPAGATION OF BETA NODAVIRUS

The development of cell line is essential for several purposes such as mass production of viruses for vaccine development, understanding the process of virus infection *in vitro*, evaluating prophylactics and therapeutants *in vitro*. So far, no cell lines are available from milk fish, which is a hardy fish and often resistant to diseases. Hence, the present study was aimed at developing a new cell line MFB-1 from the brain of milk fish. The primary cell culture of brain tissues of milkfish formed a monolayer of fibroblast like cells with 100% confluence after 12 days incubation at 27°C using L-15 medium and 20% FBS. On subsequent subculture, the cell attachment and confluence attained in 120 h in initial five sub-passages, and 72-96 hrs in seven to ten passages. At 10th passage, cells were confirmed for mitochondrial cytochrome oxidase subunit 1 (cox1) marker gene. The milkfish brain was immortalized through continuous passages. Total 55 sub-passages have been completed successfully with the split ratio achieved of 1:2. The cell line has been standardized for continuous propagation in L-15 medium with 10% FBS at 27 °C.



Phase-contrast photomicrograph of the MFB-1 cell line developed from milkfish brain at (A) confluent epithelial-like cells at passage 45 (100x) (B) Susceptibility of MFB-1 cells at passage 15 to noda virus (RGNNV) at 72-96 hours post infection with CPE of multiple vacuolation and cell death (100x) (C) Light microscopy of chromosome count of MFB-1 cell line at passage 45 using metaphase spreads stained with Giemsa (X100)

The noda virus RGNNV strain was inoculated in 15th passage level of MFB-1 and virus was adapted for five passages. The cytopathic effect (CPE) of RGNNV infection was characterized by multiple vacuolation at 72-96 hours post infection in the new MFB-1 cell line. At fifth passage of viral adaptation in MFB-1 cells the $TCID_{50}$ of RGNNV was found to be 1×10^{9} ml $^{-1}$ and the viral presence was confirmed by nested RT-PCR. The cell line MFB-1 cells can be used for noda viral infectivity studies, large scale virus propagation for vaccine production and to adapt and isolate unknown viral pathogens infecting milkfish.

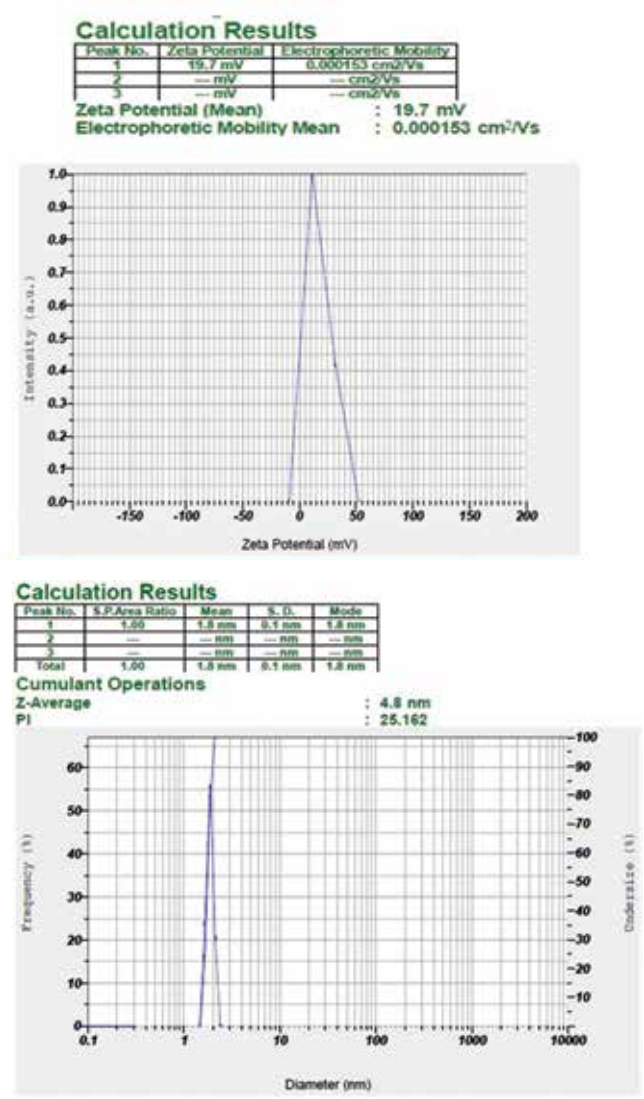
The primary cell culture of brain tissues of milkfish formed a monolayer of fibroblast like cells with 100% confluence after 12 days incubation at 27°C using L-15 medium and 20% FBS

PROPHYLAXIS AND VACCINES

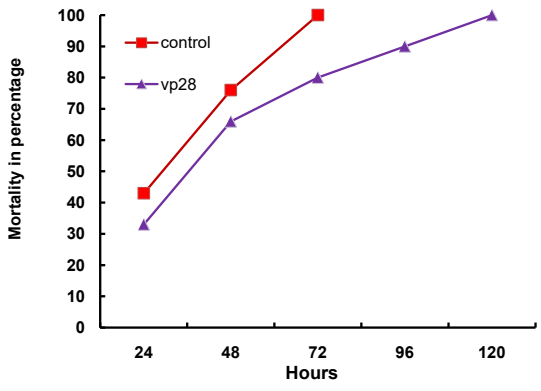
EFFICACY OF PEPTIDE NUCLEIC ACID BOUND VP28 shRNA AS A POSSIBILITY FOR CONTROL OF WSSV INFECTION IN FIELD APPLICATION

VP28 shRNA against the VP28 gene of WSSV was synthesised and this was tried to conjugate with biotin labelled cell penetrating peptide (Biotin - LC - RRRRRRRRR - NH2). The peptide conjugation was tried with 3 different PH (4, 7 and 10) and the conjugation efficiency was estimated through the measurement of Zeta potential and particle size.

Only at pH 4, suitable zeta potential and particle size were obtained indicating effective binding of CPP with VP28 shRNA. This conjugate was coated to feed and supplied to juvenile *Penaeus vannamei* at 1 µg shRNA/gm of shrimp. The CPP conjugated VP28 shRNA only provided 48 hours extended protection against white spot syndrome virus (WSSV) through oral infection after 48 hours of shRNA feeding. The result indicates that CPP conjugated VP28 shRNA is not an effective product for field application in controlling the shrimp WSSV.



Zeta potential and particle size of CPP and VP28shRNA at pH 4

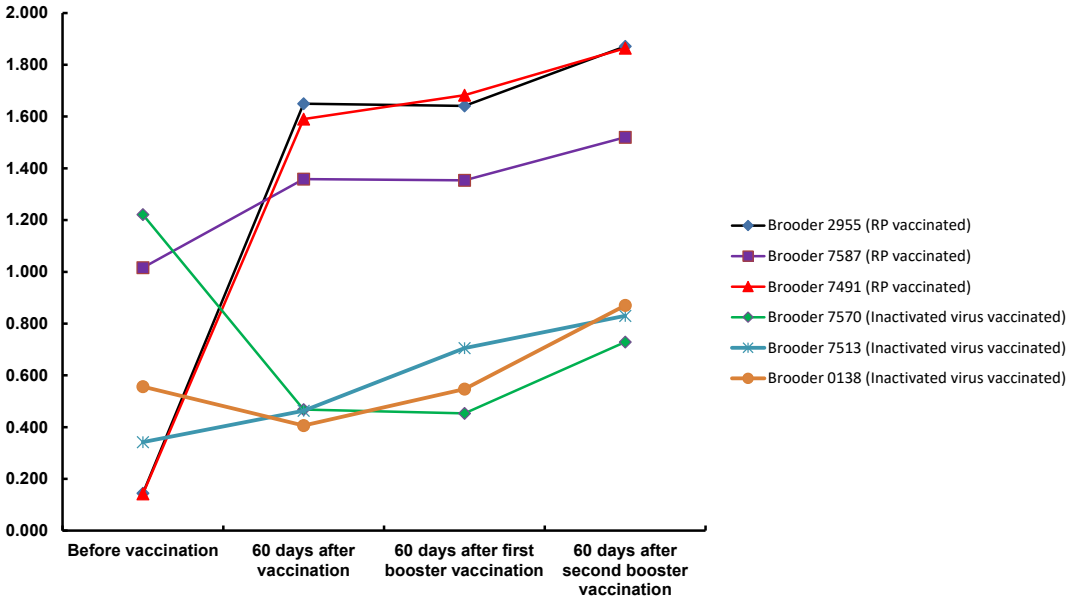


Cumulative mortality of shrimps orally fed with shRNA and challenged after 48 with WSSV

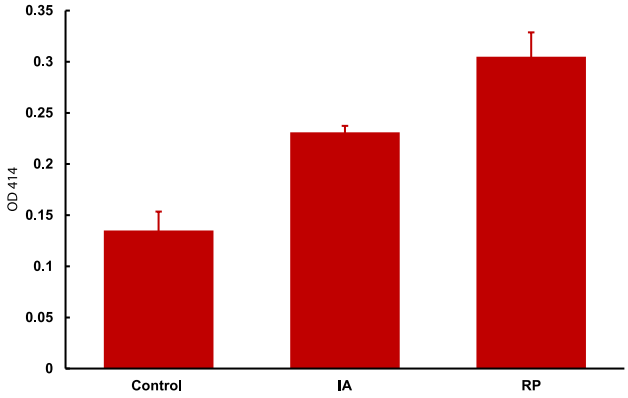
RECOMBINANT PROTEIN BASED VIRAL NERVOUS NECROSIS VACCINE PROVIDES BETTER IMMUNITY AND MATERNAL ANTIBODY TRANSFER IN ASIAN SEABASS

Viral nervous necrosis (VNN) is an acute viral disease affecting more than 120 species of marine, brackishwater and freshwater fish causing up to 100% mortality in seabass larvae. The disease is transmitted vertically through egg and milt from the infected carrier broodstock to the larvae. Vaccination of broodstock is the practical way to prevent the vertical transmission of the virus. The capsid protein gene of nervous necrosis virus, the causative agent of VNN, was cloned into prokaryotic expression vector and the recombinant protein was expressed in *Escherichia coli*. The recombinant protein was purified using Ni2+ affinity chromatography columns. The purified protein was emulsified with adjuvants and administered to Asian seabass broodstock by intra-peritoneal injection at a dose rate of 1 µg/g body weight.

An inactivated NNV vaccine was prepared by propagating the virus in SSN-1 cells, followed by inactivation of the virus using BEI and emulsifying with an adjuvant. The vaccine was administered to seabass broodstock at a dose rate of 1 µg of viral ag g^{-1} body weight. Two boosters with similar dose were administered to both the recombinant protein vaccinated and the inactivated virus vaccinated groups. Anti-NNV serum antibodies were estimated using the indirect ELISA. The recombinant protein vaccinated group gave a better



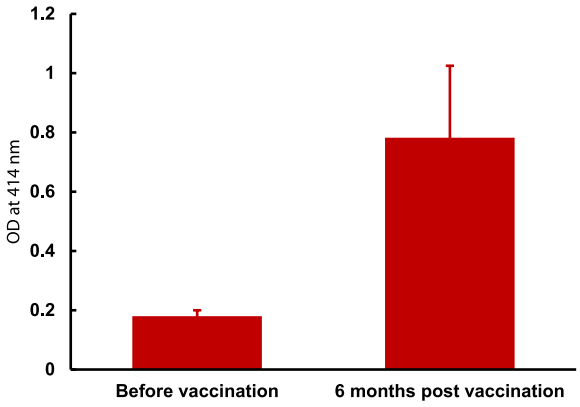
Indirect ELISA for serum anti-NNV antibodies in Asian seabass brooders vaccinated with recombinant protein vaccine and inactivated virus vaccine



Anti-NNV maternal antibodies in one day post hatch Asian seabass larvae hatched from vaccinated and unvaccinated brooders. IA: Inactivated virus vaccinated group; RP: recombinant protein vaccinated group

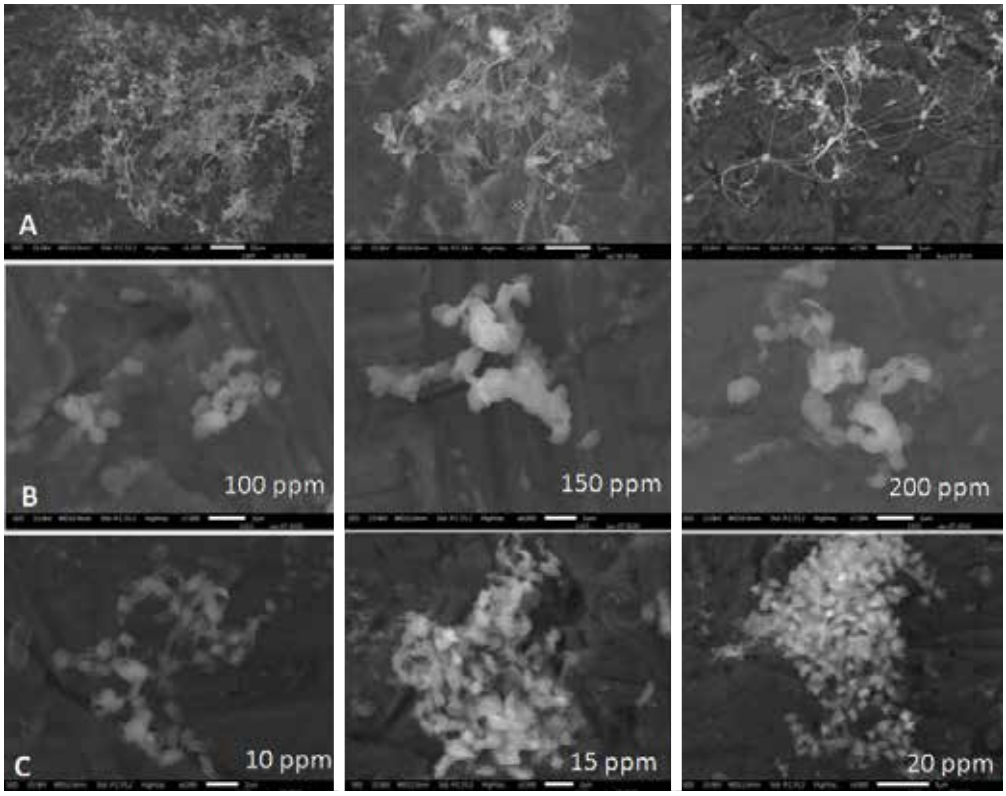
VACCINATION OF ASIAN SEABASS FOR GROWING NNV FREE BROODSTOCK

Nervous necrosis virus causes viral nervous necrosis, also called as viral encephalopathy and retinopathy in Asian seabass and several other marine, brackishwater and freshwater fishes. Adult fish when infected with the virus becomes carriers of the virus and transmits the virus vertically through eggs and milt. Hence it is important to use disease free broodstock for breeding. Vaccination of the broodstock is the only immune response to the vaccine. The maternal antibodies in the larvae hatched from the unvaccinated and vaccinated groups were estimated by ELISA. The larvae hatched from the recombinant protein and inactivated vaccinated groups had higher maternal antibody compared to larvae from control groups.

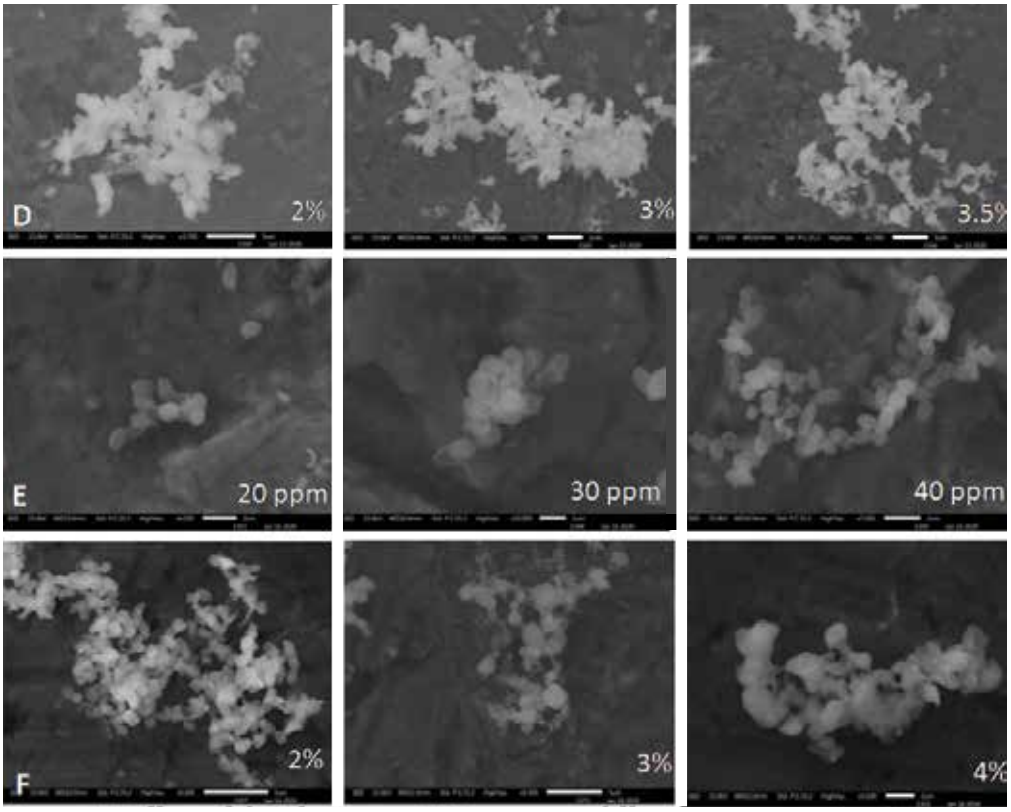


Immune response of seabass fingerlings to VNN vaccine

Indirect ELISA OD_{414} values detecting IgM of seabass fingerlings before and after vaccination against VNN



Effect of disinfectant on EHP spores at different concentration A- Control, Germinated EHP spores, B- Formalin treated spores, C- Pottassium permanganate treated spores.



Effect of disinfectant on EHP spores at different concentration D- Sodium hydroxide treated spores, E- Calcium hypochlorite treated spores, F- Hydrogen peroxide treated spores

practical measure to prevent vertical transmission of the virus. An injectable recombinant protein vaccine against NNV was developed at CIBA under the consortium research platform on vaccines and diagnostics.

Asian seabass fingerlings weighing 92 g average body weight were vaccinated against NNV using the recombinant protein vaccine by administering the vaccine at a dose rate of 1 µg g^{-1} body weight of fish intraperitoneally. Six months post vaccination, the fishes weighed on an average 548 g and they were administered a booster dose of the vaccine. The fish are being maintained in a lined pond and fed with formulated feed developed by CIBA at a rate of 7% of the body weight. Blood samples were collected before primary and booster vaccination. The immune response was assessed by indirect ELISA quantifying IgM in seabass fingerling. The fishes vaccinated had a significant immune response 6 months post vaccination.

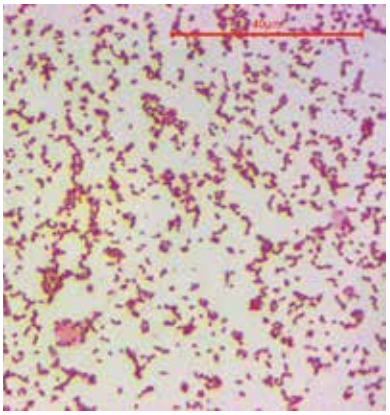
CHEMO-PROPHYLAXIS OF *ENTEROCYTOZOON HEPATOPENAEI* (EHP)

Enterocytozoon hepatopenaei (EHP) the causative agent of hepatopancreatic microsporidiosis is causing severe economic losses in Indian shrimp farming. At present the recommended protocol for control of EHP is application of 2.5% sodium hydroxide solution for hatcheries and 6 ton/ha quick lime (CaO) for pond. The limited options have failed to control the EHP in shrimp farming. In the present study, several commonly used disinfectant in aquaculture such as pottassium permanganate, calcium hypochlorite, sodium hydroxide, formalin and hydrogen peroxide were tested at different concentration and time interval for the germination of EHP spores. Sodium hydroxide at 2% was not found effective in preventing the 100% polar tube extrusion of EHP spores. But, the overnight treatment of pottassium permanganate (10, 15, 20 ppm), formalin (100, 150, 200 ppm), calcium hypochlorite (20, 30, 40 ppm), sodium hydroxide (3%, 3.5%) and hydrogen peroxide (2%,3%,4%) were found effective in preventing the 100% polar tubule extrusion of purified EHP spores. At higher concentration of disinfectants $KMnO_4$ (15, 20 ppm), formalin (150, 200 ppm), calcium hypochlorite (40 ppm), sodium hydroxide (3%, 3.5%) and hydrogen peroxide (2%, 3%, 4%), disintegration and denaturation of purified EHP spores were observed with SEM. Disinfectants at standardized dosage were further tested for 2-3 days against the EHP spores infectivity in soil. Based upon the result, pottassium permanganate 15 ppm, formalin 100ppm, calcium hypochlorite 20 ppm, sodium hydroxide 3%, hydrogen peroxide 3% are suggested for controlling the EHP spores infection.

ISOLATION OF ANTAGONISTIC LACTIC ACID BACTERIA, *PEDIOCOCCUS PENTOSACEUS* FROM GUT OF MILK FISH

Pediococcus pentosaceus, a lactic acid bacterium, was isolated from the gut of cultured milk fish at the farm facility of Kakdwip Research Centre of CIBA. The species was confirmed by 16S rRNA gene sequencing. The isolate could grow at 8% salt and 1.25% bile salt concentration. The bacterium was analysed for antimicrobial activity by agar overlay assay. It produced a strong inhibitory zone of 49 mm against luminescent bacterium *V. campbellii*. The cell free culture supernatant of *P. pentosaceus* showed inhibitory effect up to 100 fold dilution. The result suggests that *P. pentosaceus* could be a promising probiotic in aquaculture.

Asian seabass fingerlings weighing 92 g average body weight were vaccinated against NNV using the recombinant protein vaccine by administering the vaccine at a dose rate of 1 µg g^{-1} body weight of fish intraperitoneally



Micrograph of lactic acid bacterium *Pediococcus pentosaceus* (1000×)

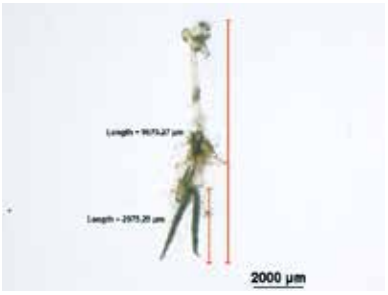
AQUACULTURE MEDICINE

LERNAEOSIS IN ASIAN SEABASS, *LATES CALCARIFER* FRY EFFECTIVELY CONTROLLED WITH EMAMECTIN BENZOATE (EMB)

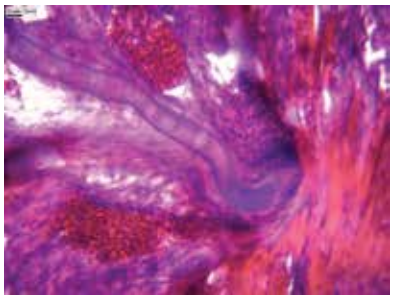
Intensive production of Asian seabass (*L. calcarifer*) in pond, cage and open water is gaining momentum because of its tasty white meat and high export market value. After 35 days post hatch culture at Muttukadu Experimental Station of ICAR-CIBA hatchery, the nursery rearing of seabass fry was carried out at Thengaithittu village, Puducherry. The mortality among the fry was observed after 14 days at nursery with clinical signs such as dullness, depression, inappetence, erratic swimming, lethargy, hanging at the surface, poor body condition, emaciation, loss of equilibrium and anaemia. Post-mortem examination of the moribund fry revealed that there were cutaneous haemorrhages, skin ulcerations, anaemic, pallor gill and blanched abdominal viscera with heavy infestation of external parasites on the trunk

Asian seabass, *Lates calcarifer* fry infested with crustacean ecto parasite, *Lernaea cyprinacea*.

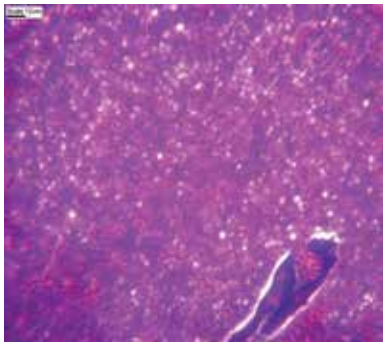
Male and female crustacean ecto-parasite, *Lernaea cyprinacea* collected from Asian seabass, *Lates calcarifer* fry. Scale bar : 1000 µm.



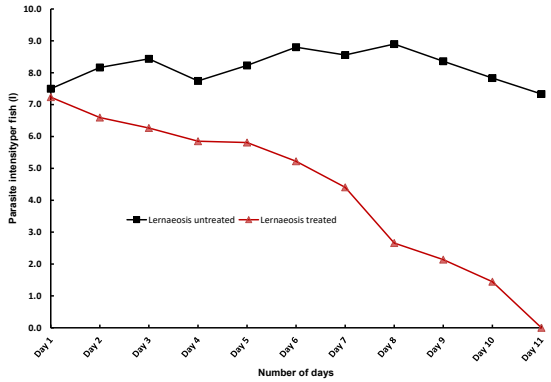
Female crustacean ecto-parasite, *Lernaea cyprinacea* collected from Asian seabass, *Lates calcarifer* fry. Scale bar : 2000 µm.



Presence of inflammatory mononuclear cells and erythrocytes surrounding the anchor of the parasite in the hypodermis. H&E. Scale bar : 12 µm.



Fatty degeneration with severe congestion and extensive hemorrhage in liver. H&E. Scale bar : 12 µm.



Efficacy of emamectin benzoate (EB) against lernaeosis in Asian seabass, *Lates calcarifer* fry.

woven by algae. The parasites were collected in 4% neutral buffered formalin (NBF) and identified as anchor worm, *Lernaea cyprinacea* based on the morphological characteristics.

Ninety fry (60 infested and 30 healthy fry) from the same stock were brought to the laboratory for evaluation of efficacy of emamectin benzoate (EMB) against *Lernaea cyprinacea*. Parasitic intensity per fish was estimated to be 8.17±0.15. The fishes were culled in to three groups (healthy [T1], infested untreated [T2] and infested treated [T3]) of 30 fish each in triplicate. The EB was administered to T3 through feed top dressing at a dose rate of 50 µg kg^{-1} of fish body weight (BW) day^{-1} for ten consecutive days. The T2 was maintained without medication for comparing the parasitic intensity, haematological, histopathological changes and mortality pattern. The parasitic intensity reduced significantly among T3 over a period of ten days. Mortality observed in T2 was 83.3% against 10% in treated group T3. Post-mortem examination revealed that there was a significant improvement in gross lesions of T3 as compared to that of T2.

Histopathologically, prominent lesions such as degeneration of epidermis, presence of inflammatory mononuclear cells and erythrocytes surrounding the anchor of the parasite in the hypodermis, fatty degeneration with severe congestion and extensive haemorrhage in liver and Bowman's capsule degeneration were observed in T3. It is concluded that the EMB is effective in controlling Lernaeosis in Asian seabass.

EMAMECTIN BENZOATE (EMB) EFFECTIVELY CONTROLLED SEA LICE, *CALIGUS MINIMUS* INFESTATION IN PEARLSPOT, *ETROPLUS SURATENSIS*

Increasing intensification with lack of adequate health management strategies result in increased incidences of parasitic infestations which are major concern for health, productivity and reproduction of fish. Pen culture of pearlspot, *E. suratensis* was practiced by a group of farmers using the back water source at Ponneri village, Tamil Nadu. Mortality was observed over a period of one week with clinical signs such as dullness, depression, inappetence, erratic swimming, gasping for air, lethargy, hanging at the surface,

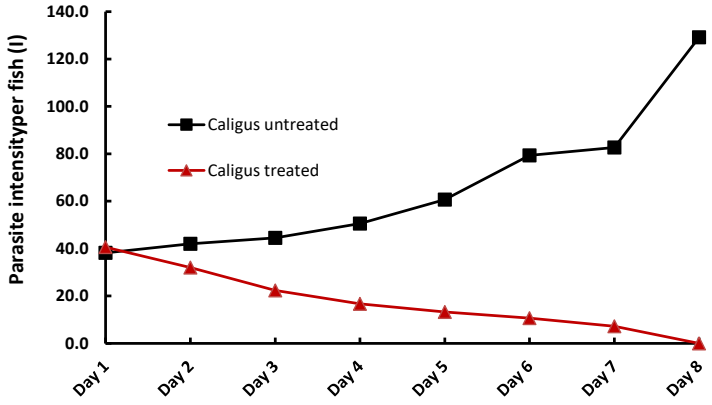
Post-mortem examination revealed that there was a significant improvement in gross lesions of T3 as compared to that of T2

poor body condition, emaciation, flashing and rubbing against surfaces, loss of equilibrium and anaemia. Post-mortem examination of the moribund fish revealed that there were cutaneous haemorrhages, skin ulcerations, anaemic, icteric, pallor gill and blanched abdominal viscera with heavy infestation of external crustacean parasite, *Caligus* spp. *Caligus* spp. was collected in 4% neutral buffered formalin (NBF) and identified as *Caligus minimus* based on the morphological characteristics.

To evaluatethe efficacy of emamectin benzoate (EMB) against *C. minimus*, one hundred

Female crustacean ecto parasite, *Caligus minimus* collected from pearlspot, *Etroplus suratensis*. Scale bar : 1000 µm.

Male crustacean ecto-parasite, *Caligus minimus* collected from pearlspot, *Etroplus suratensis*. Scale bar : 200 µm.



Efficacy of emamectin benzoate (EB) against *Caligus minimus* in Pearlspot, *Etroplus suratensis*

Efficacy of emamectin benzoate (EB) against *Caligus minimus* in Pearlspot, *Etroplus suratensis*.

and fifty fishes were grouped into 2 groups (treated, T1 and untreated, T2) of 75 fish each in triplicate. Parasitic intensity per fish was estimated to be 65.9±10.79. The average body weight (ABW) and length (ABL) of the fish in T1 were 20.97±0.09 g and 88.2±0.11 mm, while the same values in T2 were 20.36±0.10 g and 85.3±0.13 mm, respectively. EB was administered to the treatment group through feed top dressing at a dose rate of 50 µg kg^{-1} of fish body weight (BW) day^{-1} for seven consecutive days. The parasitic intensity significantly reduced among treated group over a period of eight days against significant increase in control. Overall mortality of 70% was observed among control while there was no mortality among treatment. Histopathologically, hyper cellularity and degenerative changes in gills, cloudy swelling, focal degeneration and fatty degeneration in liver, diffuse tubular degenerative changes in kidney and degenerative changes in intestine, and degeneration of epidermis were observed prominently in T2 as compared to that of T1. It is concluded the fishes infested with C. *minimus* can be effectively treated with emamectin benzoate.

EFFICACY OF MEDICATED FEED IN CONTROLLING PARASITIC INFESTATIONS IN FARMED FINFISH

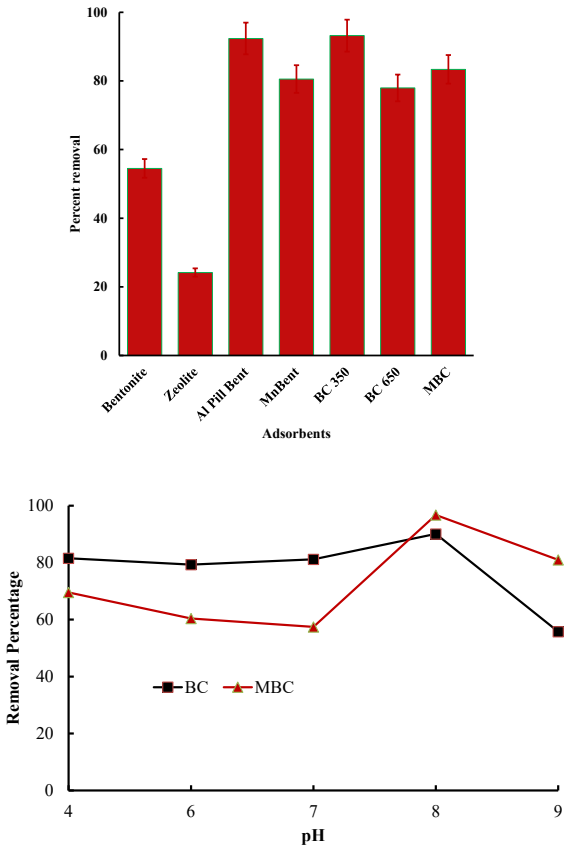
A medicated feed was prepared by coating emamectin benzoate, an anti-parasitic drug using a commercial binder, on a commercial pellet feed and evaluated for its efficacy at field level. Field efficacy of this medicated feed was conducted in different culture systems (pond, tank, cage, lake and aquarium) rearing different fish species (Asian seabass, grey mullet, pearlspot, Indian major carps, gold fish and koi carp) infected with various parasites (*Caligus* spp., *Argulus* spp., *Lernanthropus* spp. and *Lernaea* spp.). The fish were treated per os at the rate of 25g $tonne^{-1}$ biomass for a period of seven consecutive days in case of *Caligus* spp., *Argulus* spp. and *Lernanthropus* spp.The duration of the treatment was for a period of ten consecutive days in case of *Lernaea* spp. Daily observation revealed that there was 100% efficacy against *Argulus* spp.,*Caligus* spp. and *Lernanthropus* spp. on 7th day of treatment, and against *Lernaea* spp. on 10th day of treatment. Post medication, the fish were monitored for re-occurrence of the parasites for a period of 60 days and no parasite infestation was reported. Thus oral in-feed medication was effective in crustacean parasites controlling program in finfish aquaculture and aquarium.

ETHANOLIC EXTRACT OF *MORINGA OLEIFERA* (DRUMSTICK) LEAVES SHOW INHIBITORY EFFECT AGAINST AQUATIC BACTERIAL PATHOGENS

The emergence of antimicrobial resistance, residue concern and strict law regarding their application in aquaculture warrants search for alternative therapeutic strategies. Keeping this in mind, the present study was undertaken to assess the antimicrobial properties of medicinal plants such as *Moringa oleifera* against aquatic pathogens. *M. oleifera*, popularly called as drum stick has been widely used for centuries for its medicinal properties. In the present study, their ethanolic and aqueous extract was evaluated for antimicrobial activity against shrimp pathogen *V. campbellii* and fish pathogen *Edwardsiella tarda* using disc diffusion method. The ethanolic extract was found superior compared to aqueous

Zone of inhibition by moringa extract against aquatic bacterial pathogens		
Extraction method	***Vibrio campbellii***	***Edwardsiellatarda***
Ethanolic extract	19.25 ± 0.48 mm	18.5 ± 1.19 mm
Aqueous extract	13.0 ± 0.41 mm	14.0 ± 2.04 mm

Inhibitory effect of moringa leaf extract (alcoholic and aqueous) on *Edwardsiella tarda*



Adsorption of OTC by different adsorbents and effect of pH on adsorption

extract against both the pathogens.

ADSORPTIVE REMOVAL OF OXYTETRACYCLINE

Oxytetracycline (OTC) is one or the few antimicrobials approved by the USFDA for use in aquaculture. Persistence or such antibiotics in the environment is an important issue and needs to be understood withregard to environmental characteristics. Out of 15 adsorbents tested aluminium pillared bentonite (92%), biochar (90%), manganese oxide coated bentonite (81%), starch bentonite composite (78%) and magnetic biochar (73%) were found to be effective at pH 8. The observed Qmax of OTC for biochar and magnetic biochar was 111 and 74 mg/kg, respectively.

SERVICES TO THE STAKEHOLDERS IN THE SECTOR

NATIONAL REFERRAL LABORATORY FOR BRACKISHWATER AQUATIC ANIMAL DISEASES (NRLD)

ICAR-CIBA aquatic animal health and environment lab is a National Referral Laboratory for brackishwater aquatic animal disease (NRLD) and has been serving the stakeholders such as Aquatic Quarantine and

Certification Services (AQCS, Government of India), broodstock multiplication centres (BMCs), shrimp hatcheries and shrimp farmers. During 2019, the NRLD tested 65 samples from AQCS which included *Artemia* cyst (brine shrimp eggs), frozen tissue, Qrill™ and feed samples. Further the disease testing services were also extended to BMC (24 shrimp samples) and farmers (55 postlarvae and 1 crab samples). All the samples were tested for the OIE listed viral, bacterial and parasitic pathogens. Apart from that 25 soil samples from farmer's ponds and two brooders from the hatcheries were exclusively tested for EHP.

Sample Tested	No. Tested	Pathogens tested							
		DNA viruses		RNA viruses			Bacteria		Parasite
		WSSV	IHHNV	IMNV	TSV	YHV	AHPND	NHPB	EHP
ArteGold Medium artemia capsules	02	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Artemia cysts (Brine shrimp eggs, Vitellusstandars, *Vitellus* small, enriched adult artemia)	49	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Frozen enriched artemia biomass	01	**+ve**	-ve	-ve	-ve	-ve	-ve	-ve	**+ve**
Fish feed	05	ND	ND	ND	ND	ND	-ve	ND	ND
Prawn feed	06	ND	ND	ND	ND	ND	-ve	ND	ND
Qrill TM Antartic Krill meal	01	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
Shrimp larvae feed	01	-ve	ND	ND	ND	ND	ND	ND	ND
Total samples tested	65	**1+ve**	-ve	-ve	-ve	-ve	-ve	-ve	**1+ve**

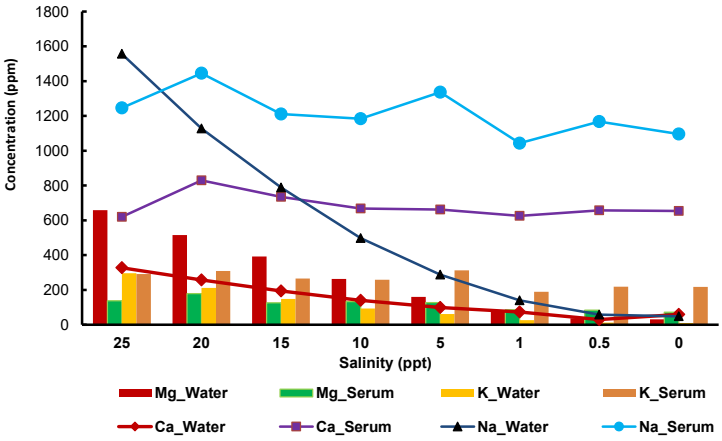
Aquaculture Environment And Climate Change

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

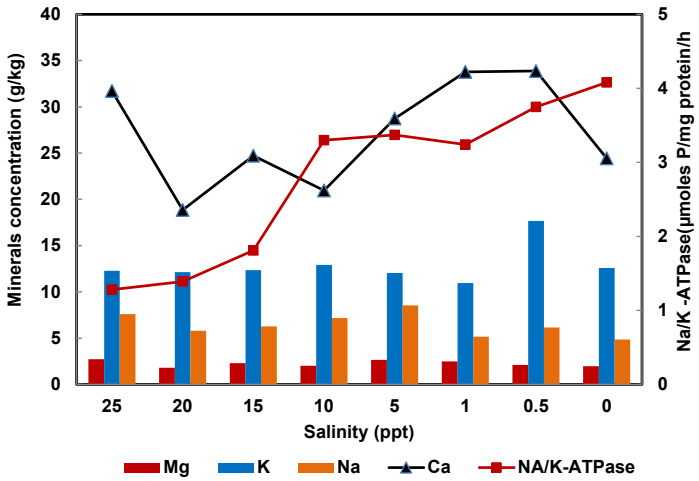
Aquaculture Environment And Climate Change

IONIC PROFILE AND Na-K-ATPase ACTIVITY OF SHRIMP EXPOSED TO A GRADUAL REDUCTION IN SALINITY

Pacific white shrimp, *P. vannamei* were exposed to a gradual reduction in salinity by 5 ppt from 25 to 0 ppt at 24 h interval. Water, serum and animal samples were analysed for ionic concentration and gills for Na-K-ATPase enzyme activity. The concentration of ions (Ca, Mg, K and Na) was high at 25 ppt and decreased significantly ($P<0.05$) at a wider range in a medium and narrow range in serum. The ionic concentration in the animal had no specific trend and was entirely different (Ca>K>Na>Mg) from the profiles of the serum (Na>Ca>K>Mg) and the medium (Na>Mg>Ca>K). The Na-K-ATPase activity was significantly ($P<0.05$) higher in all the salinities compared to 25 ppt and the value ranged from 1.39 to 4.08 µmol P/mg protein/h. The increase in enzyme activity and ionic concentration in animal tissue when shrimps were transferred from high to low saline medium supports the adaptability of animals at lower salinities.



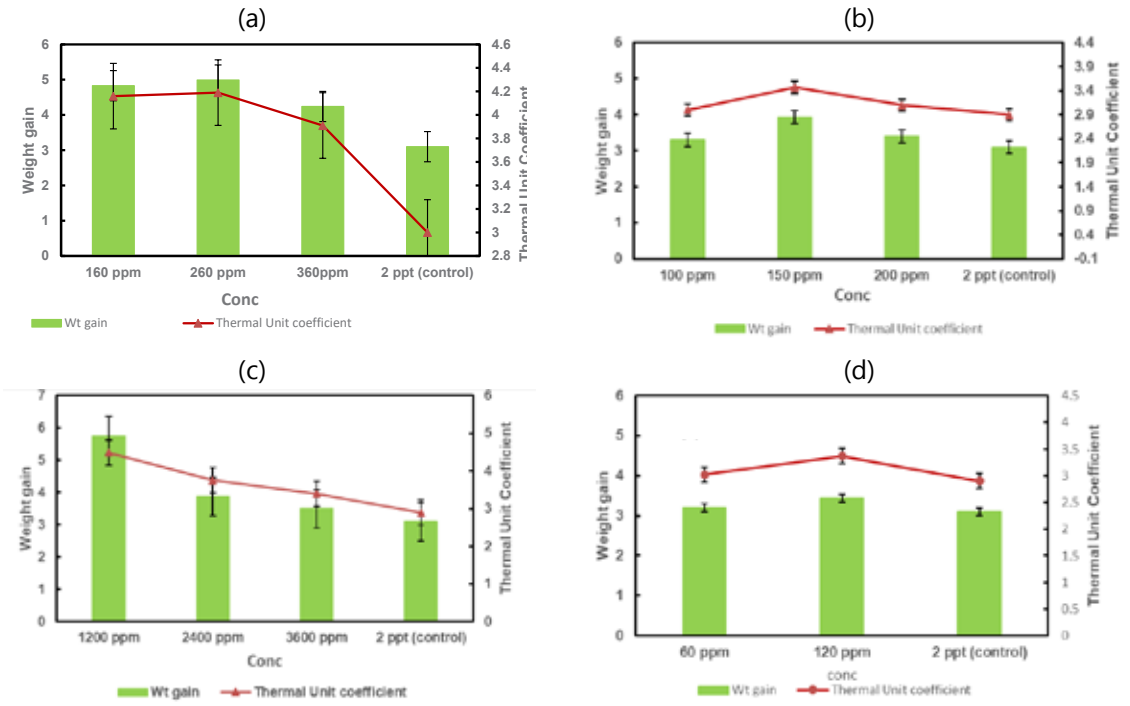
Ionic concentration in water and serum of shrimp exposed to gradual reduction in salinities



Variation in animal tissue mineralization and Na-K-ATPase activity in the gills of *P. vannamei* exposed to gradual reduction in salinities

REQUIREMENT OF MINIMAL OPTIMAL CONCENTRATION OF MINERALS IN LOW SALINE *P. VANNAMEI* CULTURE SYSTEM

A set of four different experiments were conducted to determine the minimum optimum concentration of magnesium, calcium, sodium and potassium required in low saline vannamei farming. The concentration of minerals was maintained separately a) Magnesium (Mg) - 160, 260 and 360 ppm; b) Calcium (Ca) - 100, 150 and 200 ppm; c) Sodium (Na) - 1200, 2400 and 3600 ppm; and d) Potassium (K) - 60, 120 and 240 ppm in 2 ppt water.



Effect of addition of a) Magnesium b) Calcium c) Sodium and d) Potassium on weight gain and Thermal unit growth coefficient of *P. vannamei*

The experiments were conducted with *P. vannamei* of 3 g for a period of 90 days in 2 ppt water (Control and minerals addition) and for comparison with optimum salinity in 25 ppt. The initial concentration of Ca, Mg, Na and K were 80, 108, 545 and 30 ppm, and 302, 905, 8250 and 269 ppm, in 2 ppt control and 25 ppt, respectively. The shrimp weight gain was 4.99, 3.93, 5.76 and 3.4 times at 260 ppm Mg, 150 ppm Ca, 1200 ppm sodium and 120 ppm potassium, respectively and comparatively higher than the other concentrations of respective mineral. The specific growth rate and thermal unit growth coefficient were also observed to be higher in these treatments. The osmolality was observed to increase with the increase in concentration of mineral. Na^+-K^+-ATPase activity varied from 0.89 to 1.5, 2.22 to 4.16, 2.73 to 4.28 and 1.88 to 1.92 µmole of ADP/mg of Ptn/h in Mg, Ca, Na and K addition treatments, respectively. The study suggested that the maintenance of a minimum concentration of Mg at 260 ppm, Ca at 150 ppm, Na at 1200 ppm and K at 120 ppm in 2 ppt water are required for vannamei as evidenced by the growth parameters, weight gain and thermal growth coefficient compared to 2 ppt control, but not on par with 25 ppt.

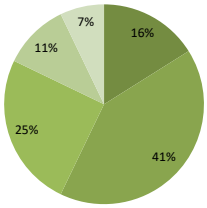
CHARACTERISATION OF SOURCE WATERS AND POND SOILS OF SHRIMP CULTURE OF KANNUR DISTRICT, KERALA

Shrimp culture pond soil and source water samples were collected during fallow period from Kannur District, Kerala and analysed for physico-chemical characteristics. Out of 56 soil and 80 water samples, about 41 per cent soils were of clay loam texture followed by loam (25%) and clay (16%). Soil pH was less than 7 and organic carbon content less than 0.5% in 46 and 55 per cent soils, respectively. Many soils had less than 10 mg (54%) and 2 mg (84%) available nitrogen and phosphorus per 100 g soil. Many source waters had pH greater than 7 (82%), less than 100 ppm alkalinity (61%), less than 30 NTU turbidity (79%), salinity range of 10-15 ppt (62%), 100 to 200 pm calcium (57%), 600 -900 ppm magnesium (55%), and 80-10 ppm potassium (57%).

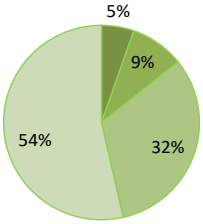
COMPARATIVE EFFICIENCY OF CLARIFYING AGENTS ON TURBIDITY REDUCTION UNDER VARYING SALINITIES

Clay turbidity is one of the important water parameters that affect the animal growth in

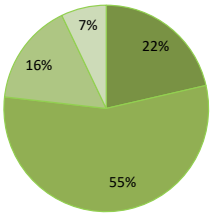
Soil Texture



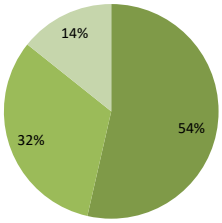
Soil pH



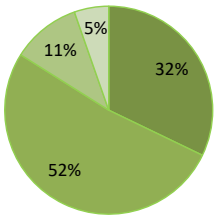
Soil Organic Carbon (%)



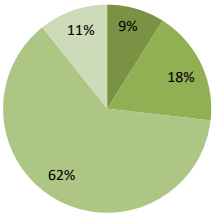
Soil - Available N (mg/100g)



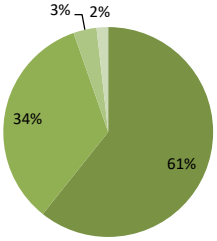
Soil - Available P (mg/100g)



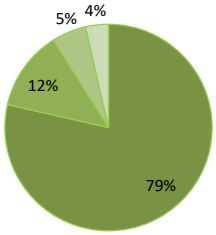
Water - Salinity (ppt)



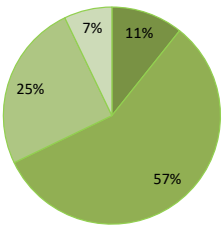
Water - Alkalinity (ppm)



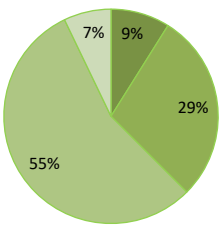
Water -Turbidity (NTU)



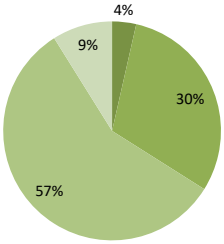
Water - Calcium (ppm)



Water - Magnesium (ppm)



Water - Potassium (ppm)

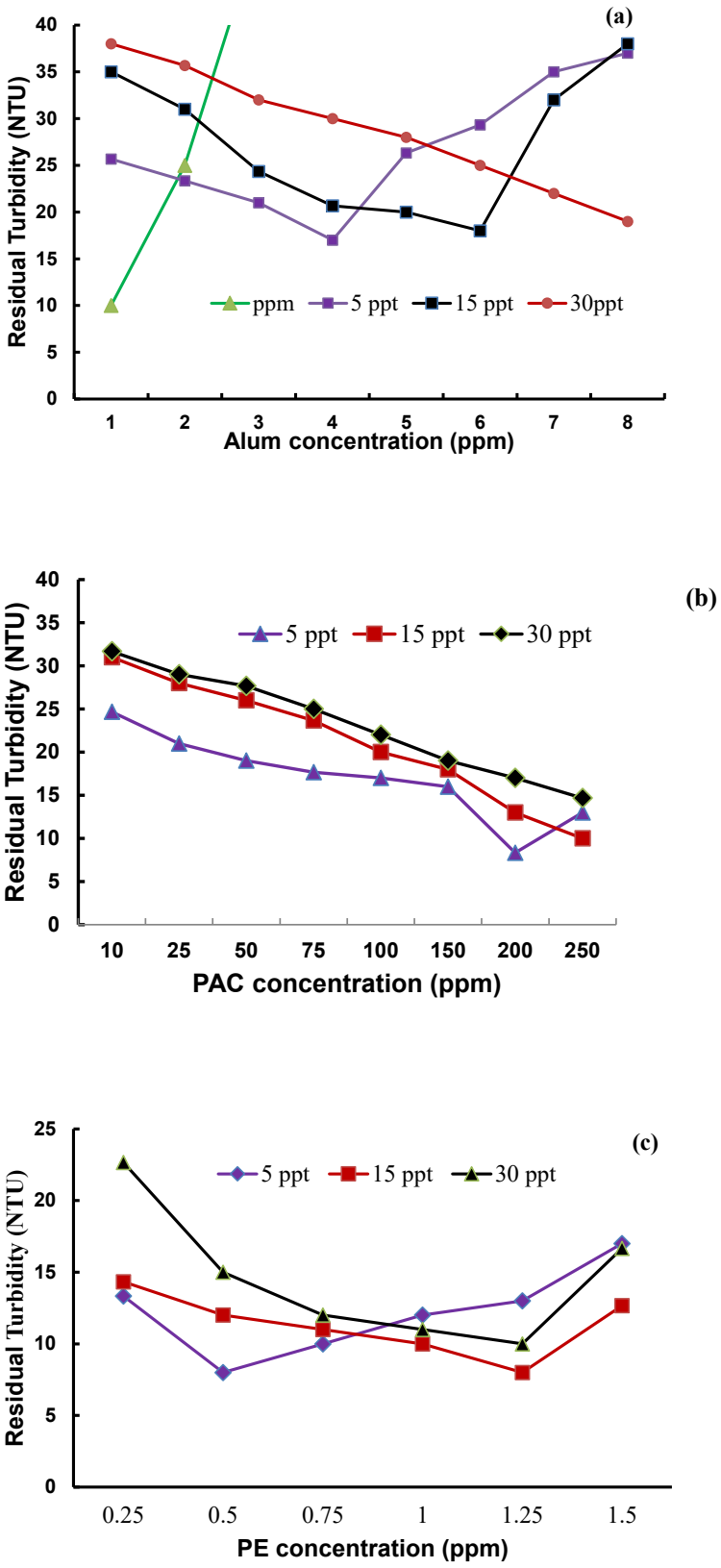


Characterization of source waters and pond soil in Kannur district

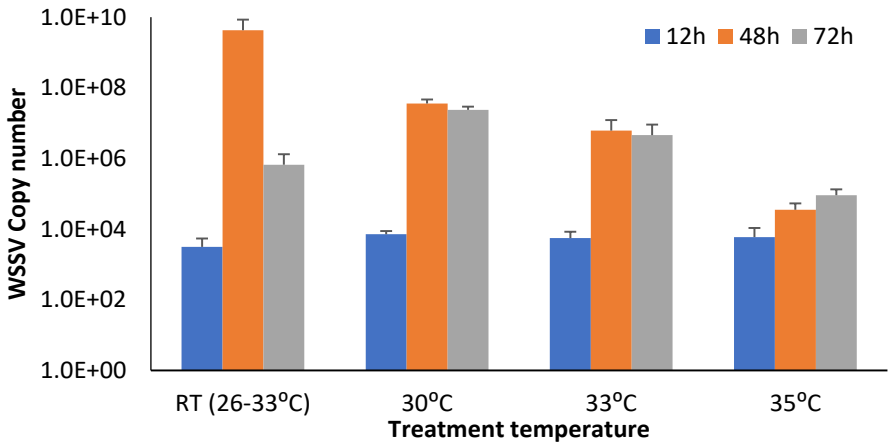
aquaculture ponds. The most common clarifying agent used to reduce the turbidity is alum. To assess the efficiency of non-conventional agent such as poly electrolyte (PE) in comparison to alum and poly aluminium chloride (PAC) laboratory experiments were conducted under three salinities 5, 15 and 30 ppt. Poly electrolytes are polymers with repeating units of electrolytes and on dissolution in water they act as polymers as well as electrolytes. The amount of poly electrolyte required to reduce 90% of the turbidity was 0.5 ppm at 5 ppt and 1.25 ppm at 15 and 30 ppt. Application of PAC at 250 ppm resulted in maximum reduction of turbidity at 15 (95%) and 30 (85%) ppt and 200 ppm was found to be optimum dose for 5 ppt salinity with 92% reduction. Alum application resulted in maximum reduction of 83, 80 and 78% at 5, 15 and 30 ppt respectively. The results indicated the polyelectrolyte could be used as a potential clarifying agent on par with PAC with an additional advantage of not affecting the water quality parameters such as pH and alkalinity, unlike alum and PAC.

EFFECT OF REARING WATER TEMPERATURE ON WSSV INDUCED MORTALITY IN *PENAEUS VANNAMEI*

Effect of water temperature on white spot syndrome virus (WSSV) infection in shrimps is well accepted fact. An experiment was conducted to understand WSSV replication at different rearing temperature and its correlation with mortality. In this study, *P. vannamei* were acclimatised in glass tanks with recirculatory system for one week at different temperature regime



Efficiency of Alum (a), Poly aluminium chloride (b) and polyelectrolyte (c) on turbidity reduction under different salinities



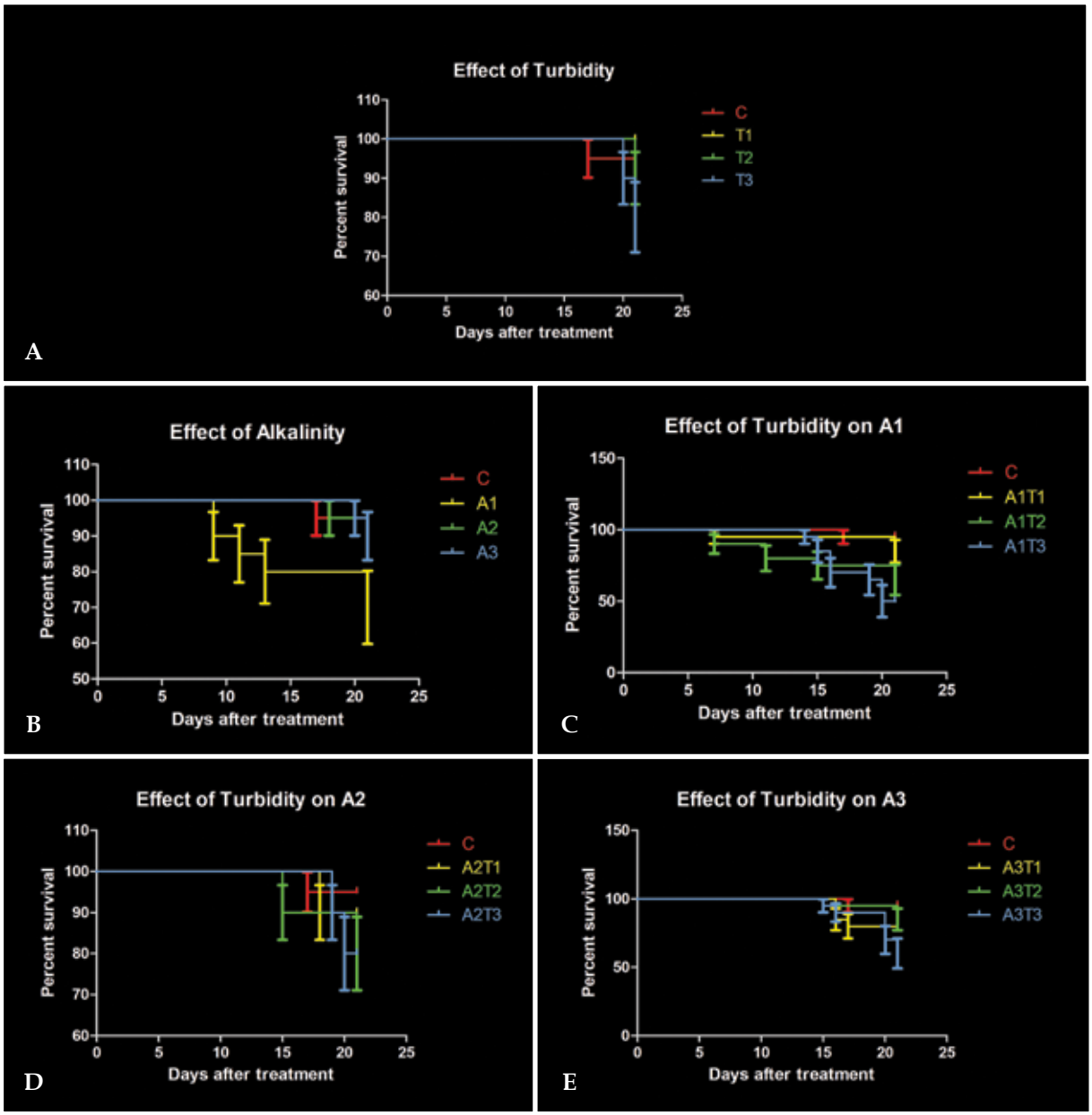
Viral copy number in gill tissue of WSSV challenged *P. vannamei* reared at different temperatures

[room temperature (RT): 26-33, 30, 33 and 35 °C]. WSSV challenged shrimp reared at or below 33°C experienced high mortality within seven days. The copy number of WSSV in the infected shrimp were determined by quantitative polymerase chain reaction (qPCR) targeting Vp28 region of the virus. The treatment groups showed similar viral load (10^3 copies) at 12-hour post infection (hpi) and a rapid increase was observed by 48 hpi in all the groups except 35°C group. The RT group experienced highest increase in the viral copies at 48 hpi, and was comparable with quicker mortality. Incremental WSSV load was recorded in the 30 and 33°C groups and remained high till 72 hpi (10^7 and 10^6 copies respectively), whereas in 35°C group, the viral load remained at 10^4. The study confirmed rapid increase in WSSV copies in shrimp maintained at or below 33°C; reciprocating with the mortality rate. Further studies on host immune and viral pathogenic factors will provide information on temperature dependant mortality of shrimp due to WSSV infection.

COMBINED EFFECT OF ALKALINITY AND TURBIDITY STRESS ON PACIFIC WHITE SHRIMP *PENAEUS VANNAMEI* AND ITS SUSCEPTIBILITY TO WSSV

The shrimps (N=30, ABW-8.1±1.4g) were exposed to three levels of individual alkalinity (mg/L): A1-100, A2-300, A3-600; turbidity (NTU): T1-30, T2-60, T3-120; combination treatments (A1T1, A1T2, A1T3; A2T1, A2T2, A2T3; A3T1, A3T2, A3T3) and control (Alkalinity - 223 mg /L; Turbidity - 1 NTU) for three weeks. After 3-week exposure to stressors, the shrimps were challenged orally with WSSV and survival data of shrimp was recorded in all the tanks for 10 days. Influence of stressors on the survival during stress and post stress challenge with WSSV was expressed in terms of Cox proportional hazard Exp (B) i.e., the risk of dying. Among the individual and combination treatments, A1 showed 7.1 times more risk of dying followed by 4 times in T3 and, A1T3 showed highest (13.6 times) risk of dying followed by 8.9 and 8.7 times risk of dying in A3T3 and A1T2 compared to control. In A1 combination treatments, risk factor increased with increasing turbidity, 3.1, 8.7 and 13.6 in A1T1, A1T2 and A1T3, respectively. Median survival i.e., 50% mortality was not observed in any of the treatment by the end of experiment except A1T3. Total heamocyte count (x 10^5cells/ml) and activity of phenol oxidase and superoxide dismutase (U /ml) decreased significantly from day-1 to day-21 in all the treatments.

The gill colour of the shrimp in control and T1 was dusky white, whereas pale brown gills and deposits were clearly seen on the gills with the naked eye in T3 and T2 from 9th and 14th day of exposure respectively. Exoskeleton and carapace colour change was observed in A3 only after 15 days of exposure. SEM images of gills and carapace of the shrimps in A3



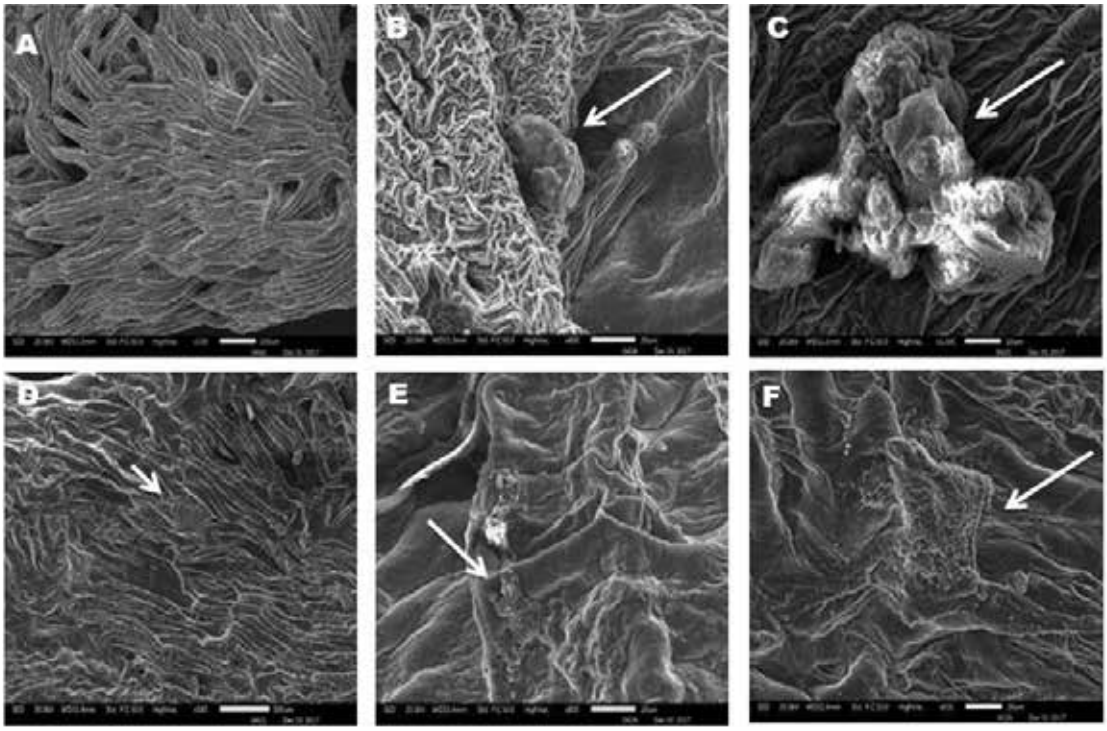
Survival proportions (%) of individual A and T and combined treatments (AXT). A. Effect of turbidity; B. Effect of alkalinity; C. A1 with different turbidity levels; D. A2 with different turbidity levels; E. A3 with different turbidity levels.

and its combination treatments showed deposits on the carapace. A3T3 showed crystal like salt deposit on its exoskeleton and more notably on the carapace.

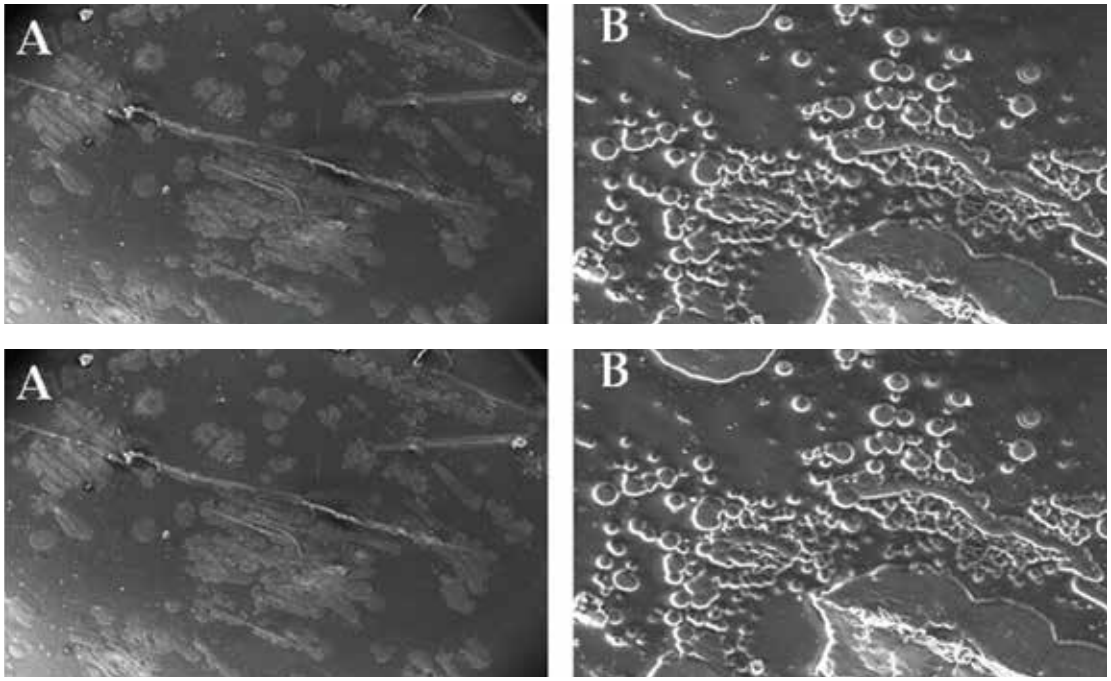
Post stress WSSV challenged shrimps in individual alkalinity and turbidity treatment showed median survival of 4 to 7 days and 3 to 7.5 days respectively compared to combination treatments (2.5 to 4 days), indicating more risk of susceptibility under combined treatments.

EFFICIENCY OF CALCIUM HYPOCHLORITE ON WSSV INACTIVATION IN POND SOILS VARYING IN TEXTURE

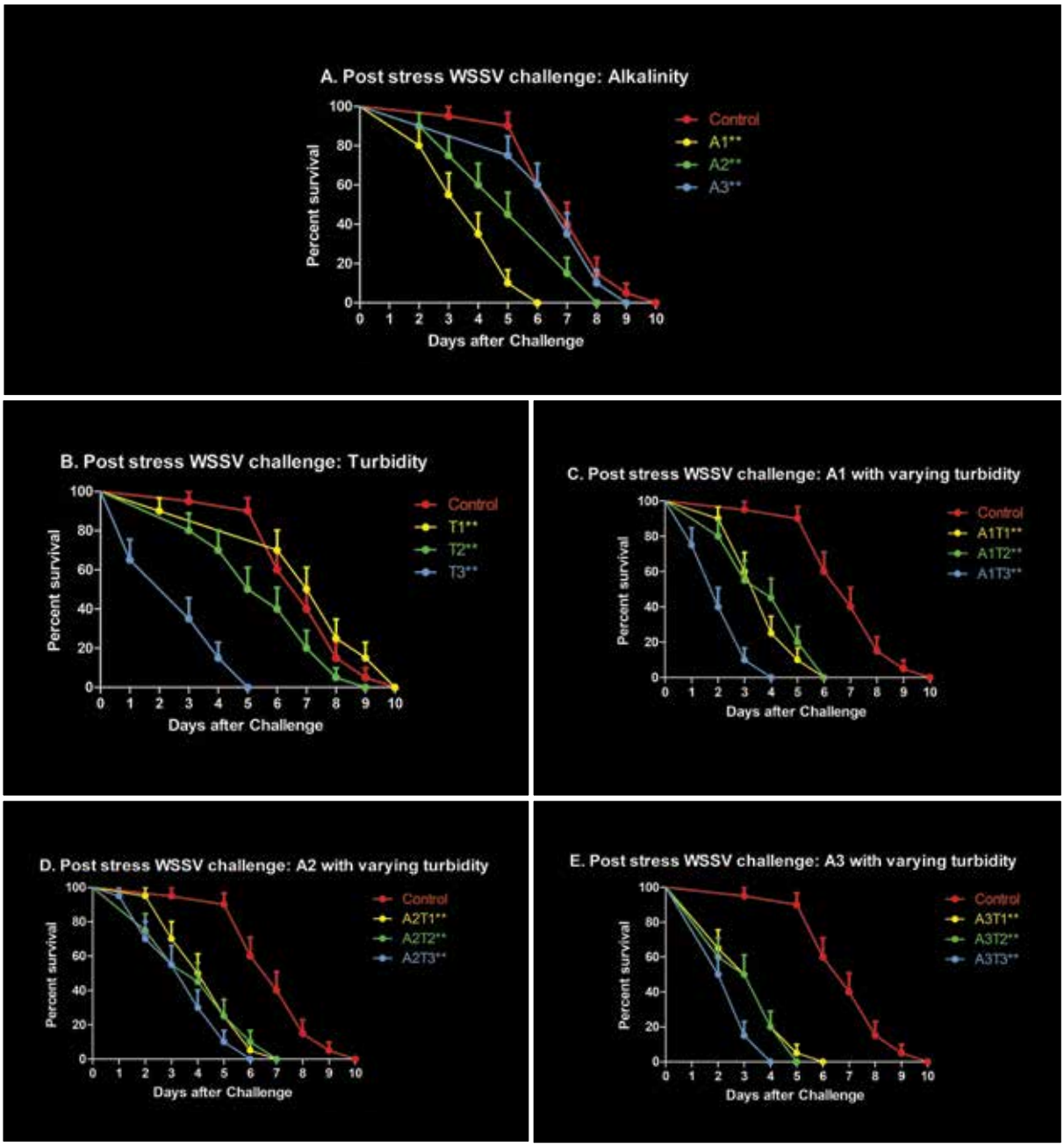
Application of bleaching agents during pond preparation in WSSV infected ponds is the common practice as a part of BMP. The bleaching requirement of the soil varies with the physico-chemical properties of soil such as texture, pH and organic matter content. With the objective of optimizing the dose for WSSV inactivation in pond soils varying in texture, three different doses of calcium hypochlorite (C_2-10,



Scanning electron micrographs showing effect of turbidity and alkalinity after 3-week exposure on gills of *P. vannamei*. A. Broad view of control shrimp gill filaments and lamellae showing normal morphological features; B. Magnified view of coagulated turbid particles in T2 (60 NTU); C. Magnified view of gills with turbid particles fusion of secondary lamellae, epithelium in the interlamellar regions after exposure to T3 (120NTU); D. Magnified view of gills with deposits of turbid particles and salts after exposure to A3T2 with disturbed lamellar arrangement; E&F. Magnified view of gills secondary lamellae with more deposits in intracellular region in A3T3.

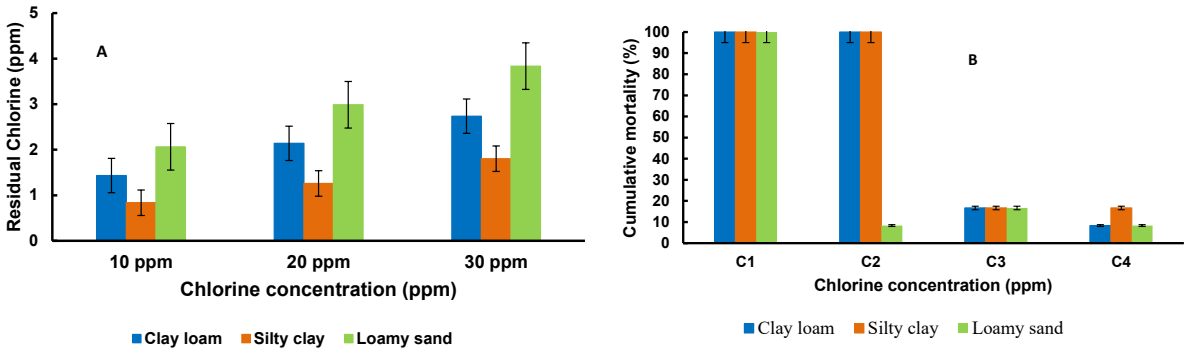


Scanning electron micrographs showing effects of turbidity and alkalinity after three week exposure on carapace of *P. vannamei*. A. Broad view of control shrimp carapace and lamellae showing normal features; B. Magnified view of carapace with deposits after exposure to A3; C. Magnified view of more deposits on the carapace of shrimp exposed to A3T2; D. Magnified view with crystal like mineral deposits on carapace of the shrimp exposed to A3T3.



Post WSSV challenge survival proportions (%) of individual A and T and combined treatments (AXT). A. Effect of alkalinity; B. Effect of turbidity; C. A1 with turbidity levels; D. A2 with turbidity levels; E. A3 with turbidity levels. Treatments with ** indicates P≤ 0.01.

C_3-20 and C_4-30 ppm chlorine) were applied to 4 kg soil of silty clay (S1), clay loam (S2) and loamy sand (S3). Prior to bleaching, soils were inoculated with WSSV at 10^5 copies/kg soil. After 24 h, soil-water microcosm was maintained by adding 10 L of water to each container and the residual chlorine (RC) content was measured. The RC content was 1.8, 2.7 and 3.8 ppm in S2, S1 and S3, respectively. The *P.vannamei* reared in soil-water microcosm showed 100% mortality in all the soils in control (C_1) and 10 ppm Cl treated clay loam and silty clay soils. The mortality in C_3 and C_4 were not due to WSSV infection as confirmed by PCR test. Chlorine requirement for WSSV inactivation was 10 ppm for loamy sand and 20 ppm for clay loam and silty clay soils. The



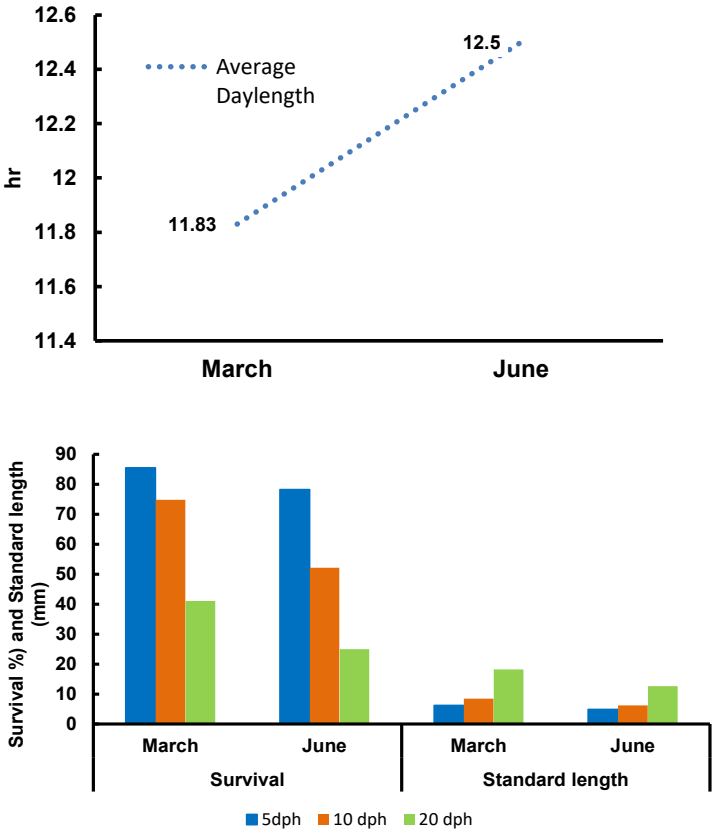
A) Residual chlorine concentartion and B) Cumulative shrimp mortality in varing textured soils at different chlorine concentration

chlorine demand of fine textured soil was higher than that of coarse textured soil and require higher dose of calcium hypochlorite for WSSV inactivation.

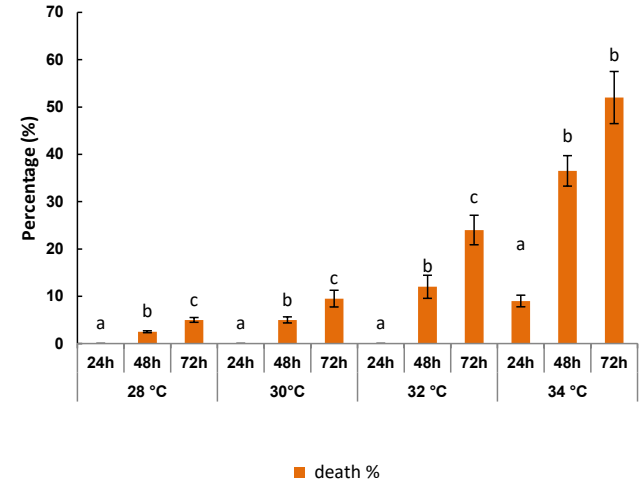
CHRONIC AND CYCLIC TEMPERATURE SENSITIVITY OF MILKFISH IN DIFFERENT LIFE STAGES

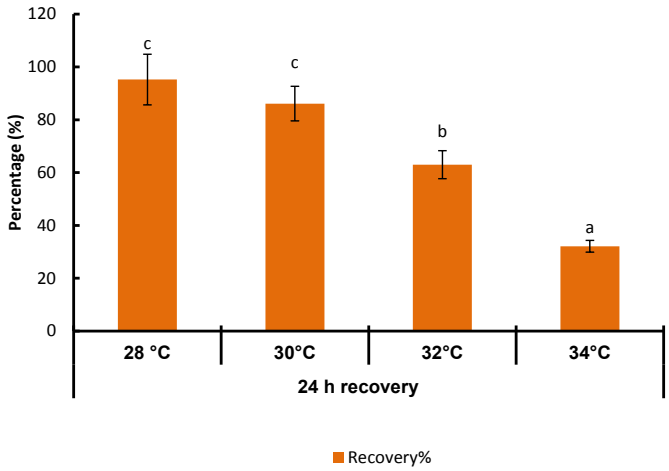
Larval stage: Experiments were carried out to understand the temperature sensitivity of milkfish larvae (0 to 21 dph) under different temperature regime during peak breeding months i.e. March (equinox) to June (summer solstice). Total of 0.9 million newly hatched larvae (TL - 3.4 ± 0.06 mm) of three cohorts (each 0.3 million larvae from three different spawning) were equally distributed in triplicate in 15 RCC tanks @ 20000 numbers/tank over three larval rearing cycles of each 21 days cycle. Water temperature above 30°C reduced the larval survival by reducing preying performance resulting in decreased overall growth. This data is preliminary in nature and needs to be validated with an in vivo experiment with controlled temperature regime.

Fry stage: A chronic heat shock study was conducted with Milkfish fry (30 dph) of 0.15 g body weight & 20- 22 mm length. The treatments were 28°C (C), 30°C (T1), 32°C (T2) and 34°C (T3). Total 400 animals were distributed in four treatments @ 50 numbers per duplicate and water flow was static in entire experiment with a 72 h temperature stress period followed by recovery in control temperature for 24 h. Maximum ($p < 0.05$) death of Milkfish (52% mortality) was observed at 34°C followed by 24% at 32°C and below 9.5 % at 30°C during first 72 h and less recovery at higher



Milkfish larvae survival in peak breeding months along with weather and environmental parameters

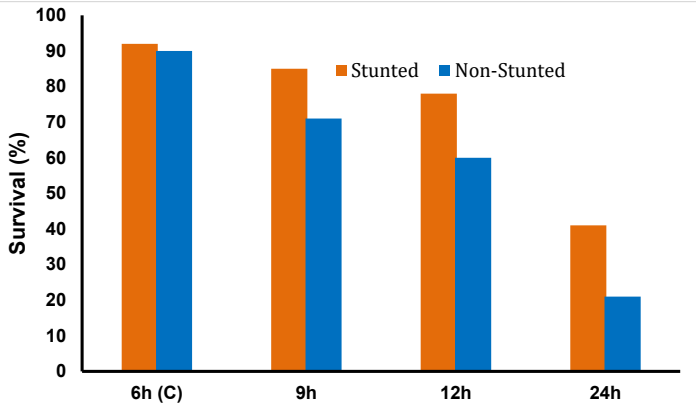




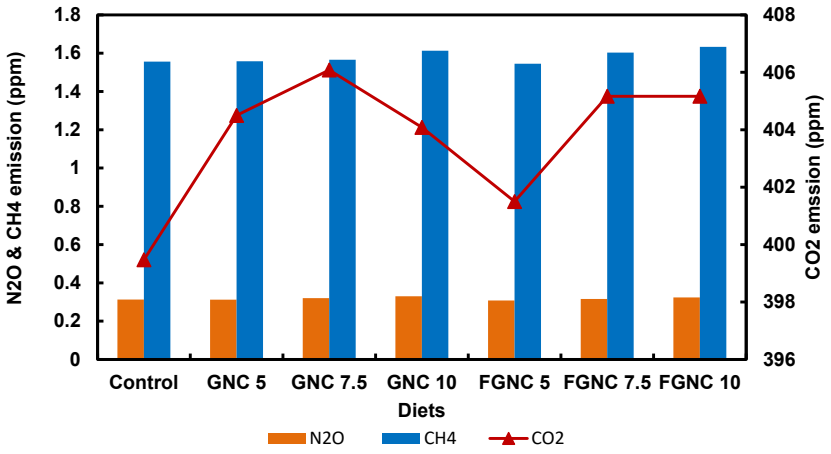
Cumulative death and per cent recovery of milkfish fry exposed to chronic heat shock

temperatures after thermal stress (32 % at 34°C, 63 % at 32°C, 86% at 30°C). It is not advisable for Milkfish nursery rearing beyond 32°C water temperature.

Stunted yearling & fingerling stage: Milkfish can be stunted easily with rearing under sub-optimal feeding and space. An experiment was conducted for 15 days to compare survival of stunted vs non-stunted milkfishes under cyclic and chronic heat shock of 34°C of different durations i.e. 9h (0006 h to 1500 h), 12h (0006 h to 1800 h) and 24h (chronic) generated using the heaters with automatic electronic timers. Stunted milkfishes (yearlings) are more temperature resilient compared to same length fingerlings (3 month) as evidenced by 41 % survival even at 24 h chronic stress.



Per cent survival of milkfish stunted and non-stunted fingerlings exposed to cyclic heat shock



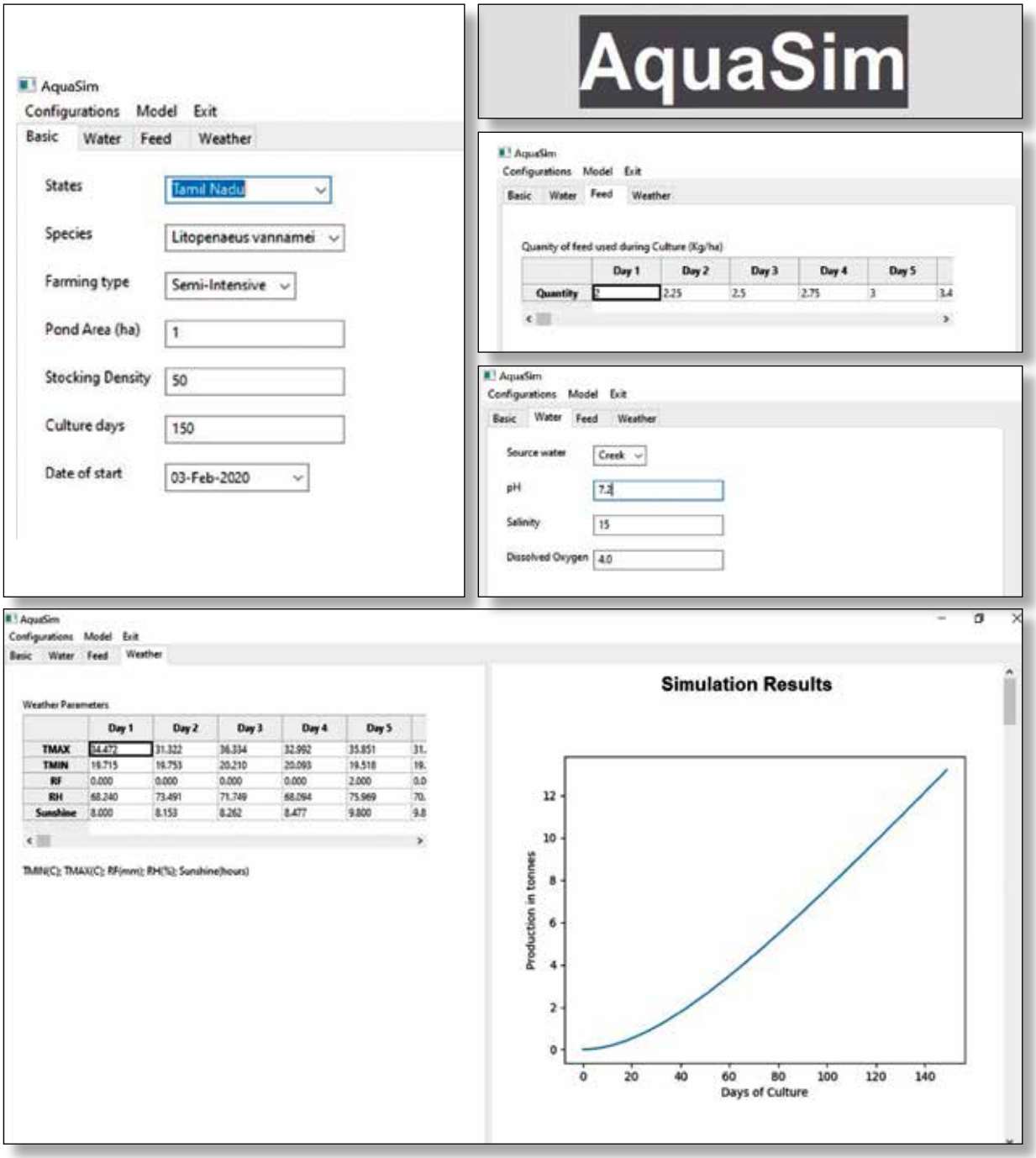
Effect of fish meal replacement with varying levels of unfermented and fermented groundnut oil cake in the diets of *P. vannamei* on GHGs emission

DIETARY INTERVENTIONS FOR ABATEMENT OF GREENHOUSE GASES EMISSION

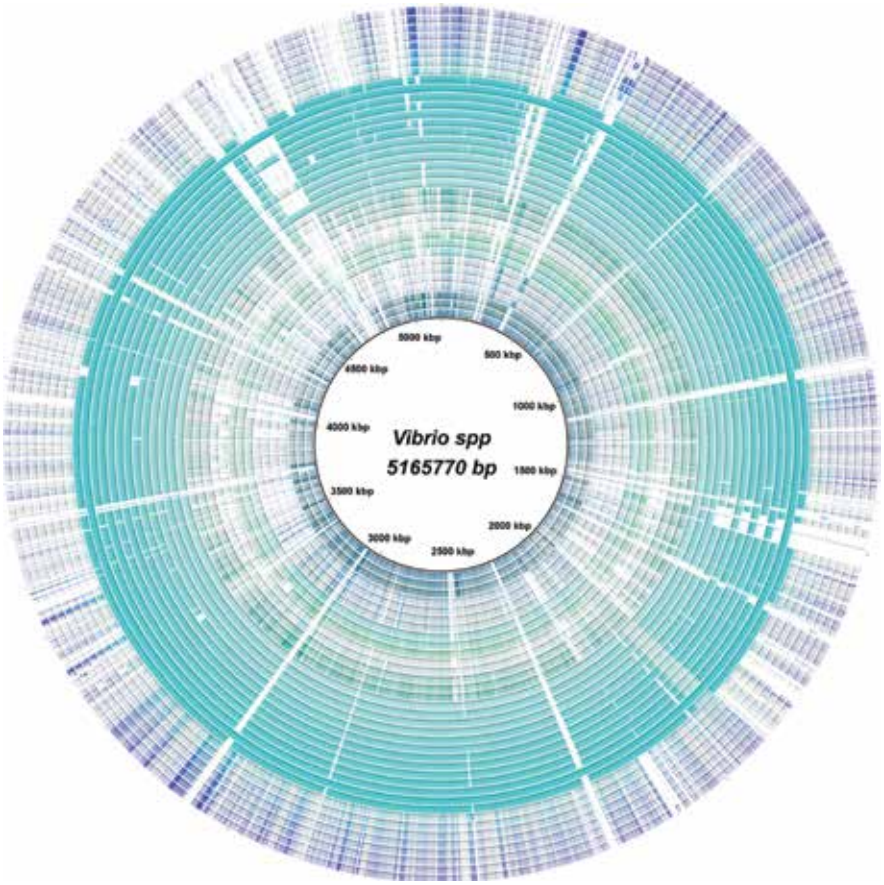
The development of cost effective alternatives to fish meal is the priority area of research and should not compromise the environmental sustainability in terms of emission of greenhouse gasses (GHGs) to the environment. Seven experimental shrimp diets prepared by incorporating various levels of raw groundnut oil cake (GNC) and solid state fermented GNC (FGNC) using *Aspergillus niger* as fish meal replacement viz., 0% as control, and 5, 7.5 and 10% of GNC and FGNC separately were fed to the juveniles of *P.vannamei* (3.89 ±0.046 g) for evaluation of growth and nutrient utilization in 500 L FRP tanks with three replications for each diet. After 45 days of growth trail, six shrimp from each replicate tank were transferred to 100 L FRP tank specifically designed for measuring the GHGs emission once in three days for 12 days. The changes in GHGs emission were influenced differently by the dietary treatments. Nitrous oxide emission is correlated with the lower apparent dry matter and crude protein digestibility values of GNC (57.52 and 78.84%) compared to FGNC (62.96 and 87.09%), respectively.

SYSTEM DYNAMIC MODELS FOR SHRIMP AQUACULTURE

System dynamics models are simulation models to abstract individual processes involved in aquaculture through mathematical functions. During the culture period of 120 days, shrimp grows up to 25 to 30 g size and various processes that need to be captured include feed conversion, growth dynamics, biomass production, nitrogen dynamics, carbon dynamics and changes that affect growth of the animal due to several biotic and abiotic factors. All these processes were modelled using Python library scipy. Matplotlib was used for building and plotting the models respectively. 'AquaSIM' a preliminary version of shrimp simulation growth model was developed to predict the shrimp growth and production based on weather parameters, water quality, feed management etc. Many more modules are to be inserted into this simulation for refining the output.



Screen shots of AquaSim software



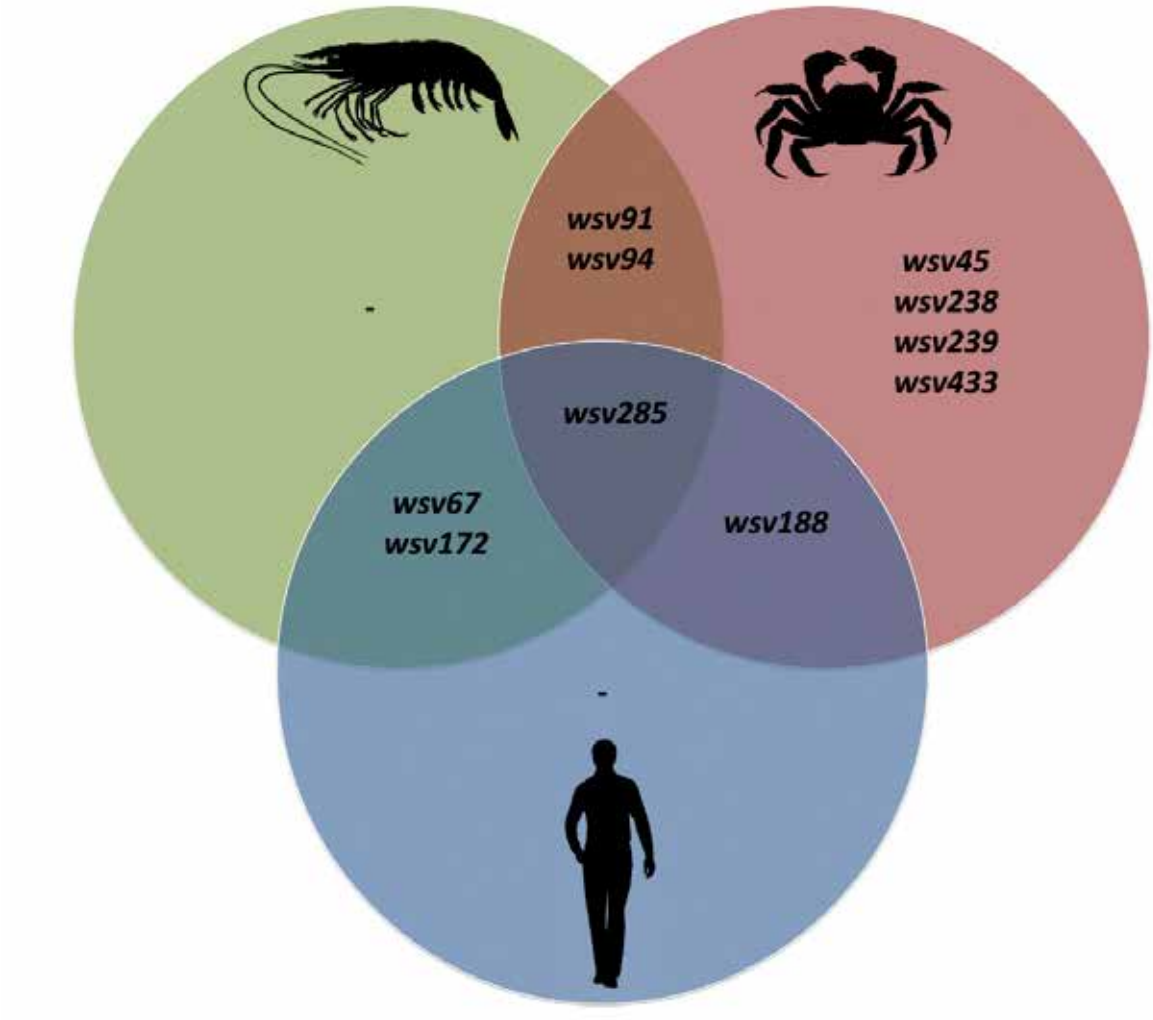
Genetics and Biotechnology

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

Genetics & Biotechnology

STABILITY OF WSSV IS LINKED TO THE HOMOLOGOUS GENES IT SHARES WITH HOST SPECIES

The white spot syndrome virus (WSSV) continues to be the major pathogen affecting shrimp production around the globe. The WSSV is a very stable DNA virus with abilities to infect wide range of hosts and to survive in pond sediments. As shrimp genome is made available in public domain, a genome survey was conducted on WSSV and its host genomes to find any clues to its stability. A homology search was conducted between WSSV genes and the genes/ genomes of two susceptible hosts, *Penaeus vannamei* (assembly ASM378908v1) and *Eriocheir sinensis* (assembly ASM333651v1). The homology search was also extended to a completely resistant species,



Homologous genes between WSSV and *Penaeus vannamei, Eriocheir sinensis* and *Homo sapiens*.

Homo sapiens (assembly GRCh38.p13) with the objective of finding homologous genes. The blastn option of Blast2GO v4.1.9 software was used for homology search and the positive search hits with an e value of 1e-03 and an alignment length of >200bp were selected as homologous genes. The sequence of a WSSV gene, wsv285, an unannotated protein showed homology in all the three species tested in the study. The human gene sequence showing homology to wsv285 is annotated as proline, glutamate and leucine rich protein 1 (PELP1). Out of 524 coding sequences of CN isolate, only 4 of them showed significant (1e-05) similarity to shrimp genes. These four are wsv67 (thymidylate synthetase, 553 bp), wsv91 (immediate early protein, 240 bp), wsv172 (ribonucleotide reductase large subunit, 545 bp) and wsv285 (202 bp). All these genes except wsv91 also showed similarity to genes of the human genome. In addition, the wsv188, ribonucleotide reductase small subunit of WSSV also matches with similar gene of humans. The fragments of chinese mitten crab genome showed similarity to wsv91, wsv188, wsv238 (VP52A) and few other unannotated genes of WSSV.

Earlier, it was known that the acquisition of unique genes and gene duplication events were responsible for virulence and broad host range for WSSV. In fact, three of the major structural proteins of WSSV, the VP24, VP26 and VP28 were proposed to have evolved by gene duplication which later acquired different functions. The analyses on homologous genes between WSSV and host species revealed other interesting facts in this direction. One class of genes that WSSV genome showed homology to other host and non-host species is wsv172 and wsv188, the ribonucleotide reductases (RNRs). In living organisms, the RNR gene helps in DNA synthesis by catalyzing the formation of deoxyribonucleotide triphosphates (dNTPs) from ribonucleotide triphosphates. The formation of one of the dNTPs requires an additional enzyme, the thymidylate synthetase. The WSSV genome also has thymidylate synthetase, wsv67 which has showed similarity to shrimp and human thymidylate synthetase that catalyzes the synthesis of thymidylate, a precursor for DNA synthesis. Many viruses lack thymidylate synthetase protein and depend on host machinery for viral replication. The observations indicate that the WSSV is capable of synthesizing all the four dNTPs required for the synthesis of DNA. The presence of these DNA synthesis related enzymes in WSSV might have benefitted the virus in viral genome replication, persistence of infection and capacity to infect a wide range of host.

DELETIONS IN WSSV GENOME AND THEIR SIGNIFICANCE

Previous year, we have reported about Missing Regions Finder (MRF) tool that helps in overcoming the inconsistencies in WSSV genomes and performing comparative genomics studies. This year, we have analyzed genomes of 14 WSSV isolates keeping the genome of WSSV-CN isolate as reference using MRF tool. The coding sequences (CDS) missing in study isolates are inferred in the annotation nomenclature of single WSSV-CN isolate. The CN isolate has 524 CDS, out of which 82 CDS are either completely or partially lost in at least one of the other WSSV isolates. There are 46 CDS that show complete deletion in at least one isolate compared to CN isolate. Some of them are deleted in only one isolate while others in as many as 10 isolates.

In this study, we report three deletion hotspots in WSSV genome which are wsv481/wsv499 (read as wsv481 through wsv499), wsv237/wsv241 and wsv178/wsv180. Few envelope proteins, VP41A, VP52A, VP35 and an immediate early protein are present in these hotspots. The deletion hotspot, wsv481/wsv499 which is a widely studied variable region is retained completely by CN, CN01, EG3 and Taiwan isolates when rest of other genomes has suffered major deletions. So far there is no evidence associating the presence or absence of this segment with the virulence of WSSV. As majority of recently sequenced genomes lack many proteins in this stretch, probably the virus might not require them for infection and propagation.

The coding sequences of certain proteins that have possible or confirmed roles in viral pathogenesis remain preserved in all isolates. The structural proteins VP19, VP26 and VP28 have been retained in all isolates of WSSV without displaying even minor deletions whereas the envelope protein, VP24 is partially lost (47%) in CN04 isolate. The *per os* infectivity factors (PIFs) homologues, wsv35 (VP110), wsv115, wsv209 (VP187) and wsv306 (VP39A) did not exhibit any deletion in all the WSSV isolates used in this study. The RING-H2 domain containing proteins, wsv199,

wsv222, wsv249 and wsv403 capable of functioning as E3 ubiquitin protein ligases also did not exhibit deletion in any of the isolates. The VP9 (wsv230), a metal ion binding, non-structural protein capable of regulating transcription in WSSV is retained by all isolates. Five WSSV proteins linked to nucleotide metabolism, wsv67, wsv112, wsv172, wsv188 and wsv395 are again retained in all the isolates. Therefore ubiquitination, transcription regulation and nucleotide metabolism might be few functions that are essentially required for WSSV pathogenesis. The nimaviral core genes associated with viral gene expression, DNA replication and DNA packaging are retained in all WSSV isolates used in this study. Only exception is with wsv313 which showed partial deletion in only IN_AP4RU isolate. Several immediate-early (IE) genes that are expressed during early stages of WSSV infection have been retained in all WSSV isolates considered in this study. Only exception is with wsv178 which is completely deleted in CN03, CN04 and AU isolates while showing partial deletions in many other isolates.

Analyses of these structural proteins, PIFs, RING proteins, IE genes and other genes related to DNA replication and DNA packaging indicates that these are the major genes essential for virus and have been conserved in all WSSV isolates used in the study though wide difference is noticed in genome length between isolates. The MRF tool helped in comprehensive analyses of WSSV isolates by quickly tabulating the missing CDS in all isolates in one annotation nomenclature.

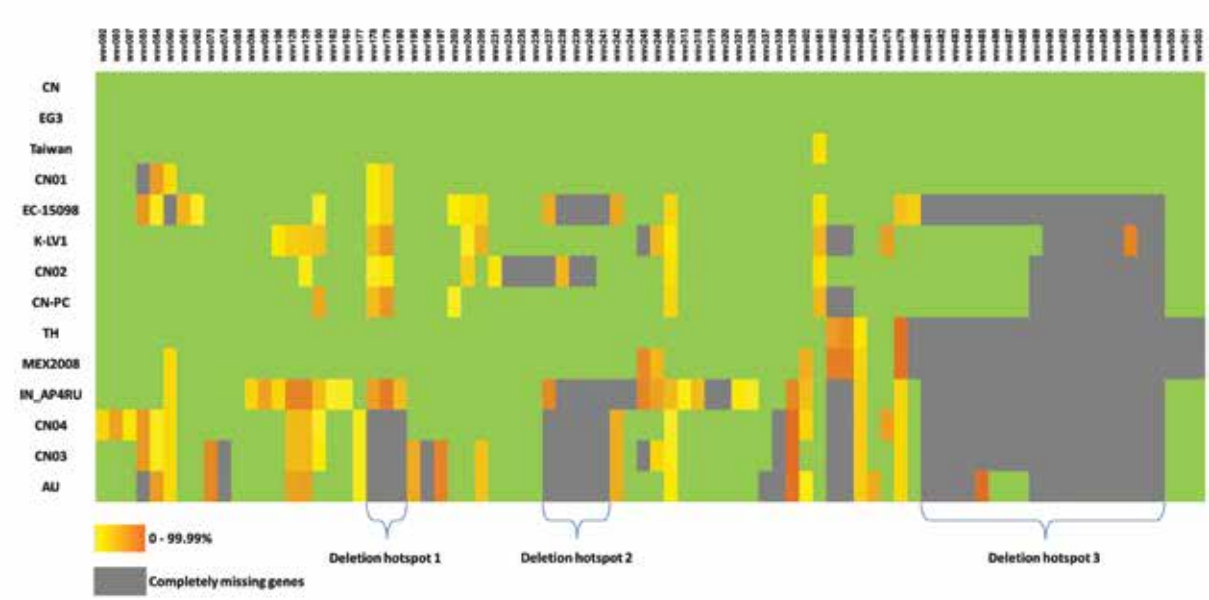
PUTATIVE MARKERS FOR WSSV ISOLATE IDENTIFICATION

This year, using MRF tool, we have documented deletion profiles for coding sequences (CDS) in genomes of WSSV isolates. The CDS that are completely lost in only one isolate could become potential markers for isolate identification.

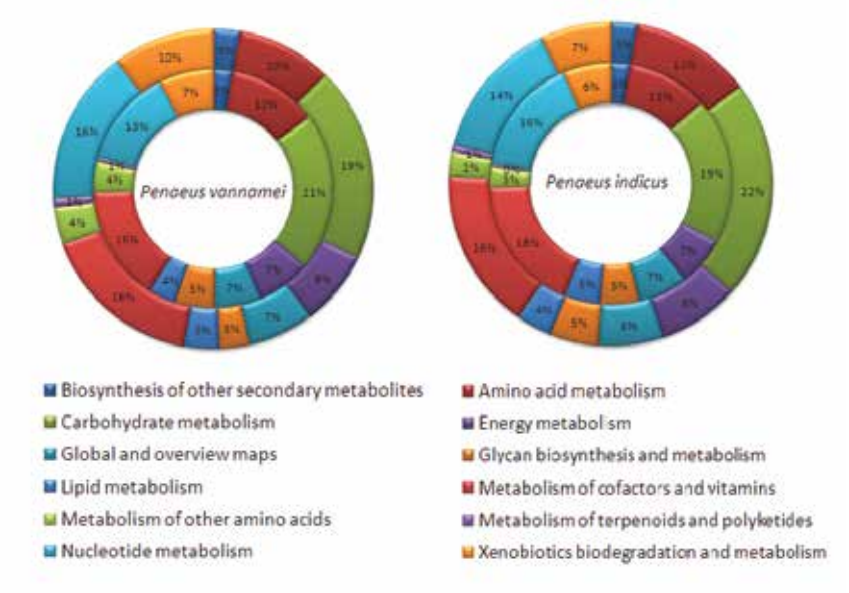
For example, wsv337 is completely deleted in only AU isolate. Therefore a PCR-based method where the amplicon falls within coding sequence for wsv337 could become a strategy for identification of AU isolate. Such sequences with utility for identification of an isolate exist for AU, CN02 and IN_AP4RU isolates. Therefore we propose them as putative markers for identification of these individual isolates. These markers would have potential in epidemiological investigations and monitoring the movement of WSSV pathogen across geographical boundaries.

Table 1. The deleted coding sequences having potential as markers for WSSV isolate identification.

Sr. No.	CDS, complete deletion	Isolate
1	wsv337	AU
2	wsv234, wsv235, wsv236	CN02
3	wsv244, wsv319, wsv320	IN_AP4RU



Heat map of the deleted CDS and deletion hot spots in WSSV genomes. Each row represents one WSSV isolate and each column represents one coding sequence



Polymorphisms in expressed transcripts of *P. indicus* and *P. vannamei*

POLYMORPHISMS IN EXPRESSED TRANSCRIPTS OF *P. INDICUS* AND *P. VANNAMEI*

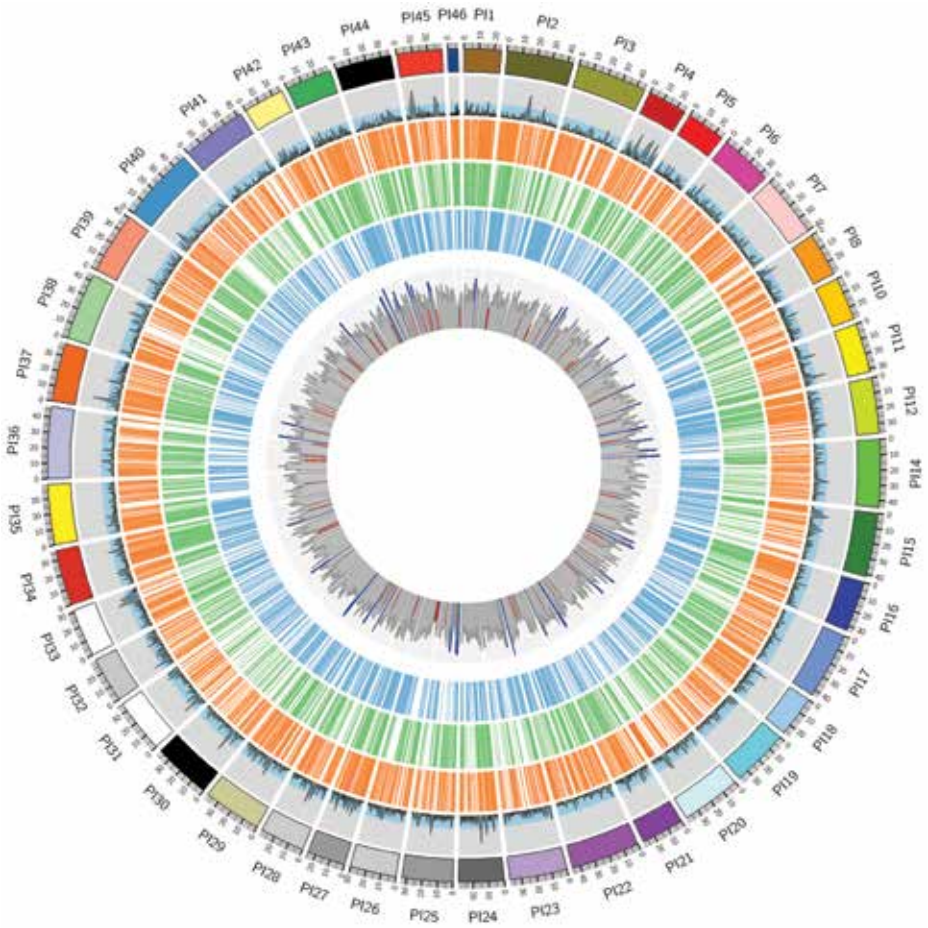
Utilizing the pooled RNA sequencing datasets we have documented Single Nucleotide Polymorphisms (SNPs) in two shrimp species, *P. indicus* and *P. vannamei*. As reported earlier, a web-tool called dbVAST (database of variations associated with shrimp transcripts) has been developed for searching SNPs based on an input query sequence. This database hosts about 27,991 and 21,970 SNPs for *P. indicus* and *P. vannamei* respectively. To our knowledge, so far a database of SNPs for shrimp does not exist. The dbVAST is the first open-access database for searching SNPs in shrimp and is available at www.bioinfo.ciba.res.in/dbvast. All the annotated transcripts containing the SNPs were further analyzed in Blast2GO v4.1.9 to obtain enzyme codes and later the transcripts with enzyme codes were mapped to metabolic pathways in KEGG maps.

About 38.6 % of annotated transcripts in *P. indicus* have SNPs which is lower compared to 40.9% of annotated transcripts in *P. vannamei* that have SNPs. Of the annotated transcripts, 19% and 15% respectively for *P. indicus* and *P. vannamei* have been annotated with enzyme codes. These transcripts with enzyme codes are mapped to KEGG pathways to assess the number of SNPs in different pathways. More number of pathways related to carbohydrate metabolism, aminoacid metabolism, lipid metabolism and biosynthesis of other secondary metabolites contains transcripts with SNPs. For a majority of pathways, the average number of SNPs per transcript ranges between 3 to 8 for *P. indicus* and 5 to 14 for *P. vannamei*. The proportion of enzyme code mapped, annotated transcripts that contain SNPs is 40.1 % in *P. indicus* which is again lower compared to that of 44.6 % observed for *P. vannamei*.

To conclude, the dbVAST hosts about 50K SNP data related to transcripts of many important metabolic pathways of *P. indicus* and *P. vannamei* which could be put to use in functional studies. In future, we would be expanding the scope of dbVAST with SNP data of other shrimp species.

SCAFFOLD-LEVEL ASSEMBLY OF *P. INDICUS* GENOME – THE BEST AMONG CRUSTACEANS

With the genomics revolution, there is great interest and focus to decipher the whole genome sequence of several aquaculture species with an aim to integrate genomic information into breeding programs with desired economically important traits. Long read sequence data at 85x coverage of shrimp genome has been generated on Pacbio sequel platform. The WTDBG2.5 generated better assembly over other assemblers in terms of N50 statistics and complete single copy genes. The long reads enabled us to build an assembly of 1.93 Gb which is about 78% of the estimated total genome length and has 12,460 scaffolds

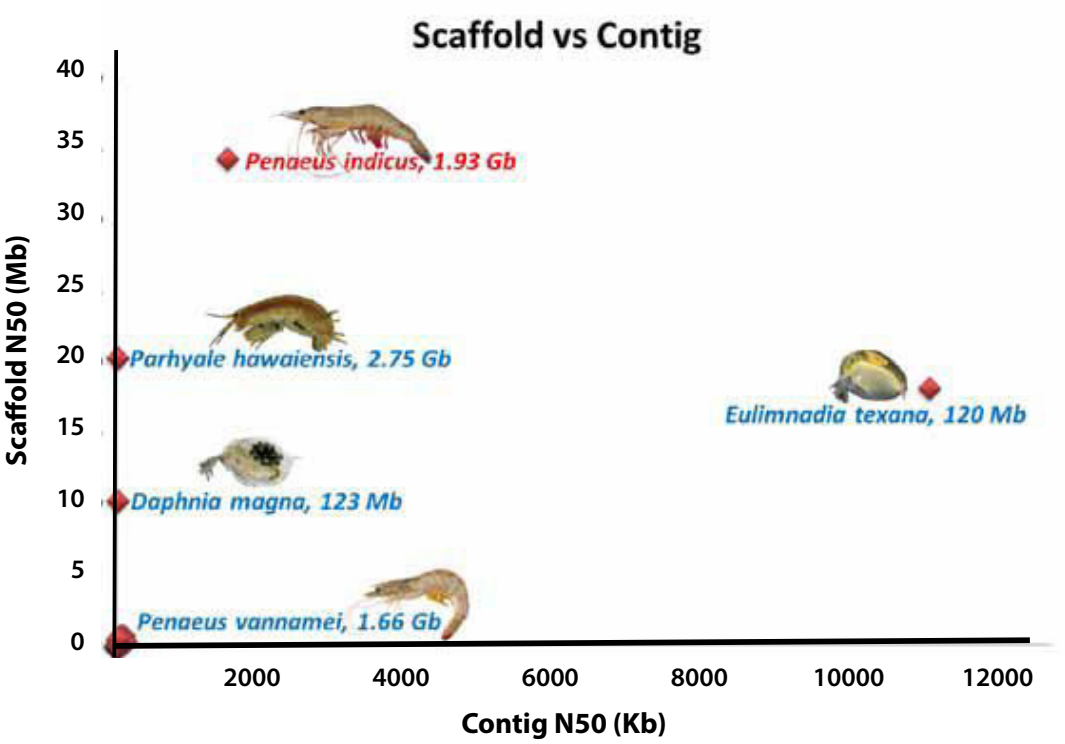


Circos plot of Indian white shrimp, Penaeus indicus depicting the alignments and structural variation

with N50 of 34 Mb. To our knowledge, the *P. indicus* genome is the best among crustaceans, including the recently published *P. vannamei* shrimp genome based on N50 statistics. Benchmarking of the *P. indicus* genome with Arthropod BUSCO gene groups (n = 1066) indicated the presence of 88.9 % of complete orthologs in the genome of which only 4.8 % are duplicates. About 6 % of BUSCO genes are fragmented and the remaining 5.1 % are missing. The genome would be annotated in coming days to delineate the number of genes and their functions.

ANALYSIS OF THE TRANSCRIPTOME CHANGES WITH TIME COURSE INFECTION OF *PENAEUS VANNAMEI* WITH WSSV

In recent years there has been an increased effort in trying to understand host/virus interactions by characterizing changes in gene expression following WSSV infection. To date many transcriptomic studies have reported changes in gene expression resulting from WSSV infection, but so far these studies were limited on a single time point, providing no insight into dynamic changes in gene expression happening during the course of infection. The use of time course analysis allowed us to identify genes with significant differences between treatments and between different time points that were subsequently mapped to identify altered cellular processes or pathways during WSSV infection. Using RNA-Seq, we studied gene expression changes in gills of *Penaeus vannamei* at different stages of infection, namely 1.5, 18 and 56 hours-post-infection (hpi), challenged with WSSV. Time course analysis performed on this transcriptome revealed 5097 differentially expressed genes, that could be grouped (based on the temporal profile of expression) into 9 clusters. 63 differentially expressed genes were viral genes and their expression level in WSSV group either peaked at 18hpi



Comparison of the best genomes among Crustaceans based on N50 statistics

(and decreased at 56hpi) or increased linearly up to 56hpi, suggesting a different role played by these genes during the course of infection. The remaining differentially expressed genes, grouped in different pathways, showed that WSSV was able to alter the expression of metabolic, immune, apoptotic and cytoskeletal genes and was able to inhibit immune related pathways such as NF-kappaB and JAK/STAT. Enrichment analysis on all up-regulated genes in WSSV group revealed an over-representation of categories involved in sugar uptake across membranes (i.e. "phosphoenolpyruvate-dependent sugar phosphotransferase system" and "protein-N(PI)-phosphohistidine-sugar phosphotransferase activity"), of "ATP-binding cassette (ABC) transporters" and "viral envelope". Interestingly, gene expression changes were not consistent through the course of infection but were dynamic with time, suggesting the complexity of host-pathogen interaction. These data offer novel insights into the cellular functions that are affected at different times during the course of infection and ultimately provide a valuable resource towards our understanding of the host-pathogen dynamics and its variation with time.

EFFECT OF NORWEGIAN KELP, *ASCOPHYLLUM NODOSUM* EXTRACT ON THE GROWTH PERFORMANCE OF ASIAN SEABASS, *LATES CALCARIFER*

The objective of this study was to evaluate the effect of *Ascophyllum nodosum*, brown seaweed extract (SWE) on the growth performance of Asian seabass. The experiment was conducted for a period of 21 days using 360 seabass fingerlings, with age of 60 days, distributed in 12 tanks. A diet including SWE at 10µL/g of 350 -500µm size formulated feed in three dilutions (A: 10^{-1}, B: 10^{-3} and C: 10^{-5}) and a control diet (D: without SWE) were provided which constituted the treatments. The averages of growth after 21 experimental days, of the Seabass fingerlings submitted to diets containing SWE, are presented. After analyzing the growth performance, it was observed that, even though there is growth increment in treatments fed with SWE there is no significant difference in growth between the treatments. The standard error value was found to be less in treatment fed with feed A, than in any other treatments. This implies that the growth differentiation was also less in higher dilution SWE than for lower dilutions. Further, gene expression studies

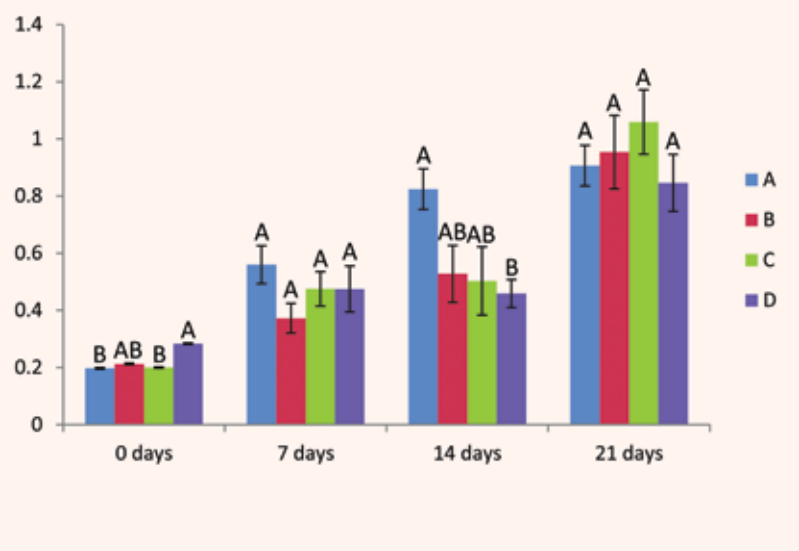
can give clear representation of the effect of SWE on growth of seabass fingerlings.

MOLECULAR CLONING OF PROMOTER REGIONS FROM BRACKISHWATER MODEL FISH FOR TRANSGENIC STUDIES

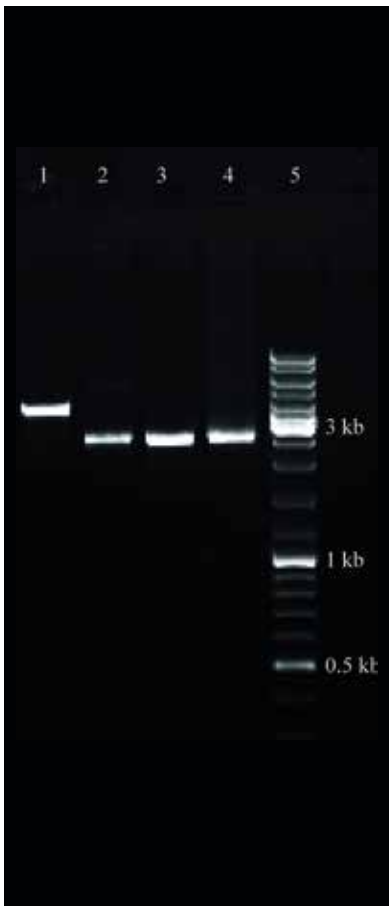
Several fishes have been used to exploit the technology of gene transfer for many purposes, including non-commercial model species such as the Loach, Misgurnus anguillicaudtis, Japanese Medaka, *Oryzias latipes*, and *Zebrafish, Brachydanio rerio*. The choice of promoter/ enhancer could determine the success in obtaining expression of transgenes in transgenic fish. The promoter is responsible for the transcription of the structural gene, which in turn is responsible for the desired phenotypic character. The aim of the present study was to isolate and characterize promoter regions from a brackishwater model fish, Javanese ricefish, *Oryzias javanicus*, which was reported last year from Indian waters by ICAR-CIBA.

Zebrafish being a noted model fish for transgenic studies, we cloned the promoters of three zebrafish genes and one ricefish gene that likely are transcribed ubiquitously throughout development and into the adult. The three genes isolated from zebrafish were the taube nuss-like gene (TBN-1), the eukaryotic elongation factor 1-gamma gene (EEF-1), and the beta-actin-1 gene (BA-1) and the one isolated from ricefish was the myosin light chain 2 gene (MLC 2).

Approximately a 2.5 kb of the region upstream of the putative translational start site for each of the promoter genes, including taube nuss-like gene, the eukaryotic elongation factor 1-gamma gene, and the beta-actin-1 gene (3.5 kb) from zebra fish and the myosin light chain 2 gene of rice fish were independently cloned into a cloning vector Pmini T 2.0 for gene expression studies.



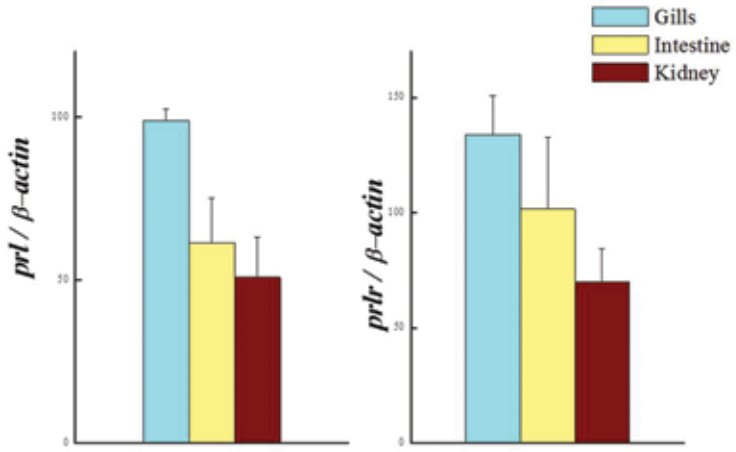
Graph showing growth performance of Asian seabass fingerlings fed with *Ascophyllum nodosum* extract



Gel electrophoresis of promoter region - Lane 1: Zebra fish beta-actin-1 gene, Lane 2: the Zebra fish eukaryotic elongation factor 1-gamma gene, Lane 3: Zebra fish taube nuss-like gene, Lane 4: Rice fish myosin light chain 2 gene, Lane 5: 1 kb GeneRuler™ DNA Ladder.

EXPRESSION OF OSMOREGULATORY GENES IN *SIGANUS JAVUS*

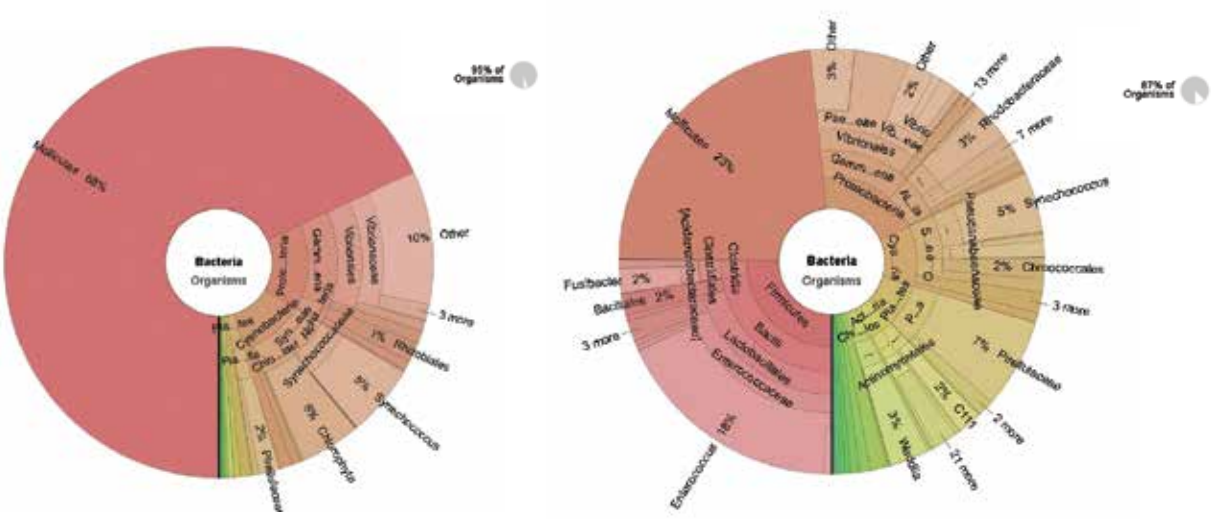
Siganus javus, a herbivorous fish with fast growth rate and ability to tolerate wide salinity ranges, is a potential candidate for brackishwater aquaculture. The differential expression of osmoregulatory genes prolactin (*prl*) and its receptor (*prlr*) were examined in gills, intestine and kidneys in fish maintained at 20ppt. Real-time quantitative PCR indicated higher expression of the genes in gills. Gills of euryhaline teleosts are excellent models for studying osmotic-stress adaptation because they are in direct contact with the aquatic environment.



The differential expression of osmoregulatory genes prolactin (prl) and its receptor (prlr) in gills, intestine and kidneys

GUT MICROBIAL COMPOSITION OF SHRIMP INFECTED WITH WHITE FECES SYNDROME

Presently shrimp aquaculture is facing issues related to emerging diseases. In recent times, white feces syndrome is impacting shrimp growth and becoming cause of concern among the farming community. There has been increasing evidences on intestinal microbiota and their association with health of the organisms. Work was taken up to study gut microbiota of shrimp infected with white feces syndrome. Infected, uninfected and recovered samples from white feces syndrome were collected and seven pooled sets were sequenced with 16s amplicon sequencing chemistry. Samples were analysed using QIIME pipeline and functional analysis was carried out using PICRUSt. Microbial communities viz., *Mollicutes, Vibrionales, Synechococcus, Photobacterium, Phyllobacteriaceae, Cyanobacteria, Flavobacteriales* were found to be significantly abundant in Disease group compared to control group. While *Phormidiaceae, Planctomyces, Pseudoalteromonadaceae, Rhodobacteraceae, Enterococcus, Pirellulaceae, Pseudoalteromonadaceae, Waddlia, Rhodobacteraceae, Fusibacter* were more abundant in control group than disease group. Microbial colonies in disease group represent mostly pathogenic, mucin and chitin degrading and involved in producing toxins. While the microbial colonies found in control group are mostly related to bioremediation, mineralization of metabolic wastes and probiotic in nature. Microbial diversity in control group is found to be higher than the diseased group. Improved microbial diversity was observed in the recovered group however, the abundance of the harmful/disease causing bacteria remained high. There is a need to further investigate on host pathogen interactions by concentrating on disease causing microbial colonies found in this study.



Gut microbial composition of shrimp infected with White Feces Syndrome

GENOMIC DIVERSITY OF IMPORTANT *VIBRIO* SPP. THROUGH PAN-GENOME ANALYSIS

The aquaculture sector is a major contributor to the economic and nutritional security for a number of countries. India's total seafood exports for the year 2017–2018 accounted for US$ Million 7082. One of the major setbacks in this sector is the frequent outbreaks of diseases often due to bacterial pathogens. Vibriosis is one of the major diseases caused by bacteria of *Vibrio* spp., causing significant economic loss to the aquaculture sector. The objective of this study was to understand the genetic composition of *Vibrio* spp.Thirty-five complete genomes were downloaded from GenBank comprising seven vibrio species, namely, Vibrio alginolyticus, *V. anguillarum, V. campbellii, V. harveyi, V. furnissii, V. parahaemolyticus,* and *V. vulnificus*. Pan-genome analysis was carried out with coding sequences (CDS) generated from all the *Vibrio* genomes. In addition, genomes were mined for genes coding for toxin-antitoxin systems, antibiotic resistance, genomic islands, and virulence factors.

Results revealed an open pan-genome comprising of 2004 core, 8249 accessory, and 6780 unique genes. Downstream analysis of genomes and the identified unique genes resulted in 312 antibiotic resistance genes, 430 genes coding for toxin and antitoxin systems along with 4802, and 4825 putative virulent genes from genomic island regions and unique gene sets, respectively.

Pan-genome analysis has the potential to predict strain specific genes and their association with habitat and pathogenicity

Pan-genome and other downstream analytical procedures followed in this study have the potential to predict strain-specific genes and their association with

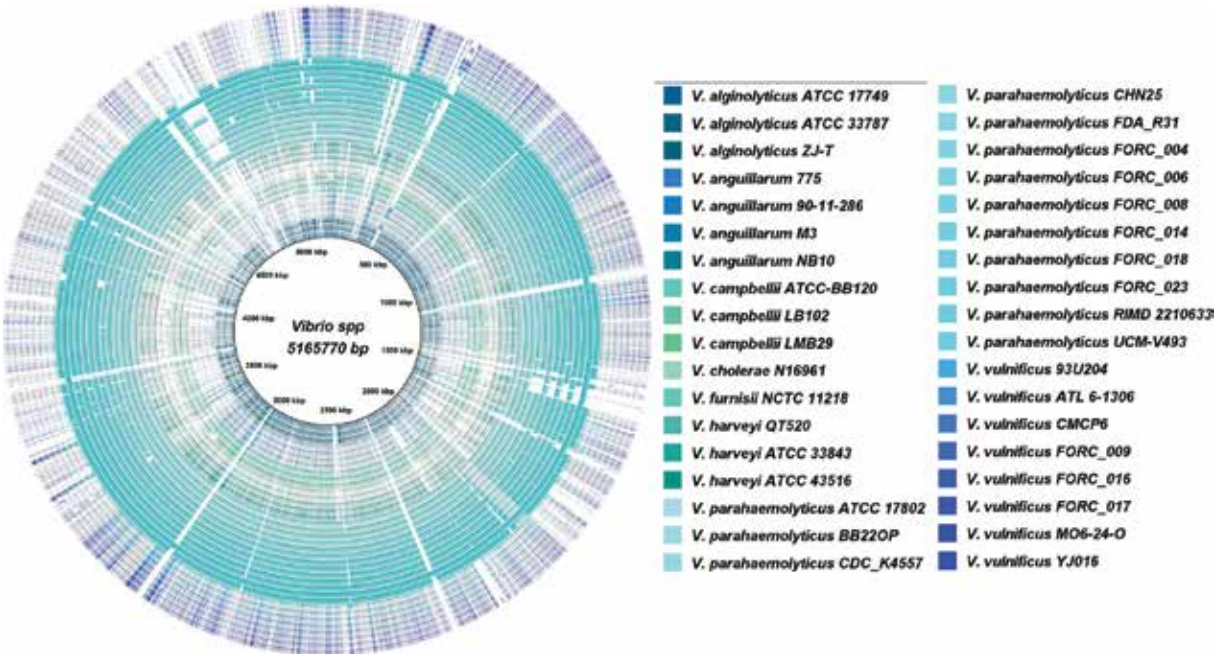
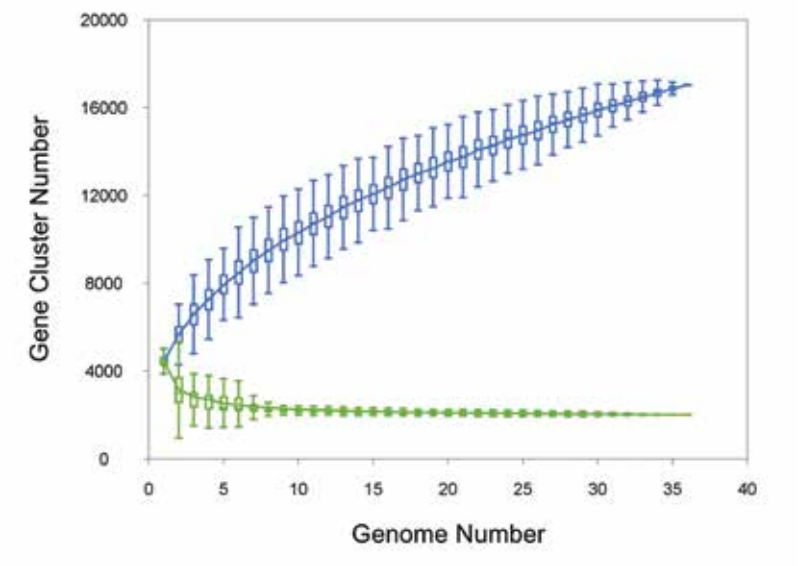


Image showing the BLAST results of the 35 genome against the reference genome in the form of circular consecutive ring



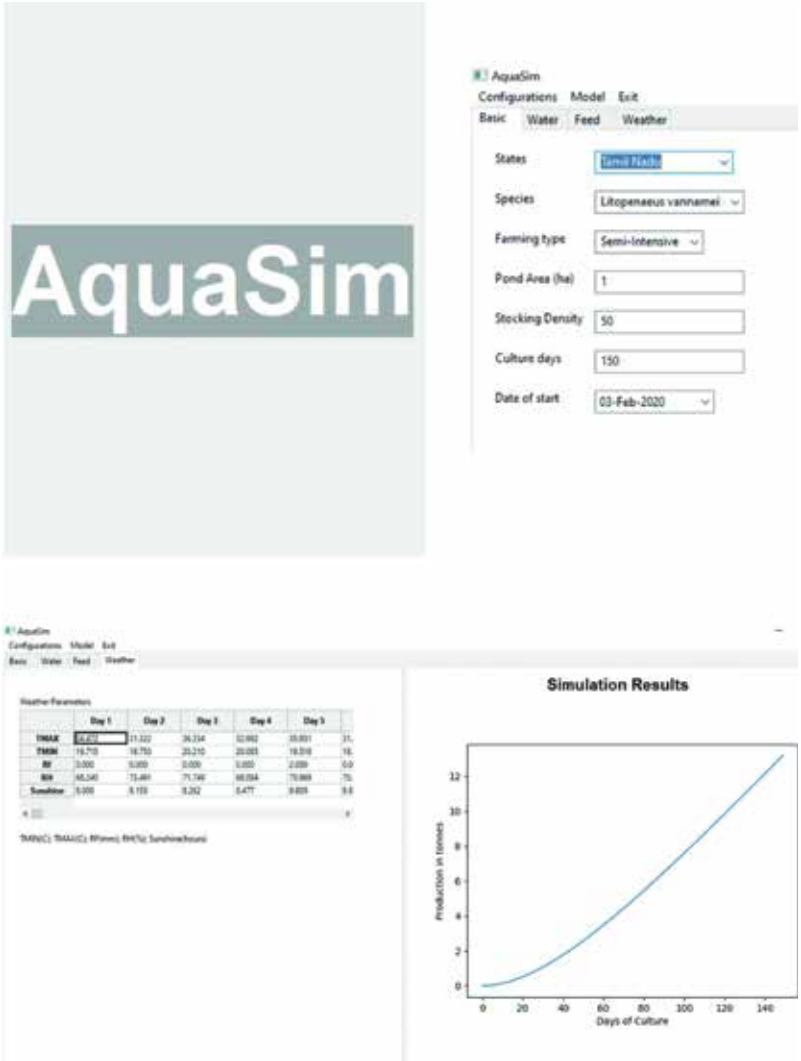
Core-Pan profile of the Vibrio genomes

habitat and pathogenicity.

SYSTEM DYNAMIC MODELS FOR SHRIMP AQUACULTURE

System dynamics models are simulation models to abstract individual processes involved in aquaculture through mathematical functions. Shrimp aquaculture is done for a period of 120 days and during this period shrimp grows up to 25 to 30 grams size. Various processes that need to be captured include feed conversion, growth dynamics, biomass production, nitrogen dynamics, carbon dynamics and changes that affect growth of the animal due to several biotic and abiotic factors.

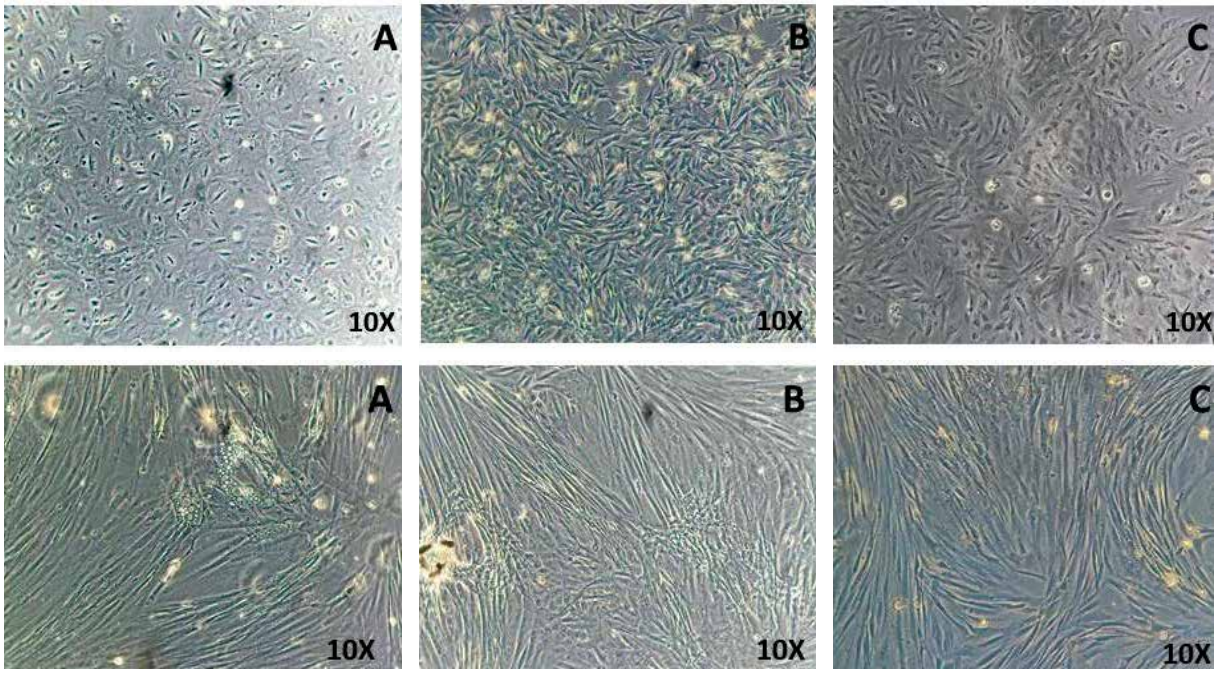
Different sub processes modelled include biomass production, feed conversion, nitrogen dynamics, and carbon dynamics. All these processes were modelled using Python library scipy. Matplotlib was used for building and plotting the models respectively. Software named "Aquasim" was developed for simulating biomass and nitrogen dynamics with varying inputs of pond parameters, soil and water, feed and weather parameters. Screen shots of the software are given below.



Screenshots of Aquasim simulation software

DEVELOPMENT OF PRIMARY CELL CULTURE OF DIFFERENT ORGANS OF MILKFISH AND PEARLSPOT FOR IN VITRO EXPERIMENTS

Milkfish are euryhaline, herbivorous, pelagic migratory fish that have a high potential in the brackishwater aquaculture sector in our country. Neither disease outbreaks nor mass mortality in the milkfish aquaculture is known to be very



Primary cell culture of different organs of Etroplus suratensis A) Brain B) Kidney C) Muscle

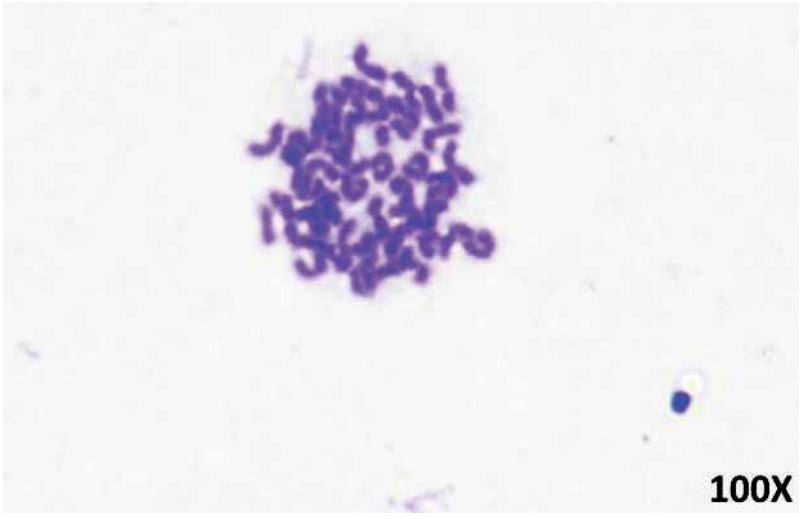
rare and seldom reported. In this line to study the disease resistance in Milkfish, the present work attempted to develop a primary cell culture of different organs such as the brain, kidney and liver. The organs were collected aseptically and were cultured in L15 medium and Foetal Bovine Serum (FBS). The monolayer with 100% confluence formed within 17 days of incubation. The cells were further passaged to develop a stable cell line.

PRIMARY CELL CULTURE OF *ETROPLUS SURATENSIS* FOR IN VITRO STUDIES OF CRISPR/ CAS9

The present study attempts to develop primary cell culture of selected organs of *Etroplus suratensis* in order to evaluate the efficiency of guide RNAs in cell lines. Brain, kidney and muscle tissues, were collected aseptically and cultured in L15 media with 20% Foetal bovine serum. In case of brain and kidney tissues, monolayer has been formed after 15 days and was further sub cultured. Muscle tissues took comparatively longer duration to form monolayer. The cells were further passaged to develop stable cell line.

KARYOTYPING OF *ETROPLUS SURATENSIS*

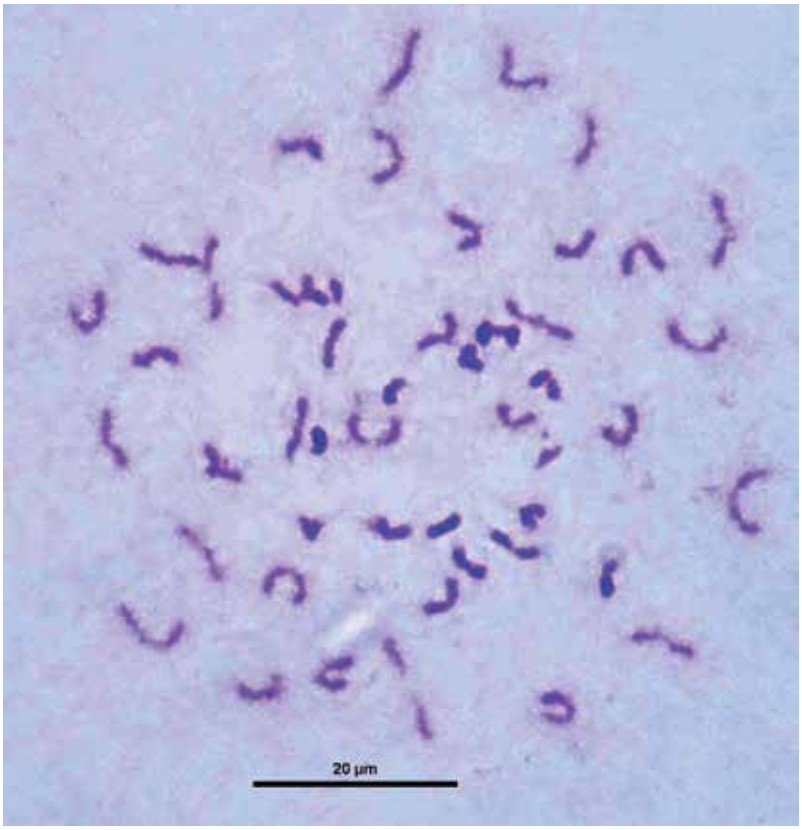
For chromosome analysis, Pearl spot of size 17g was injected with 0.5% colchicine to arrest the metaphase stage of cells. The injected fish allowed to swim for 1 hour at 28°C, and later, gills were dissected out, macerated, and incubated in 0.56% Potassium chloride solution for 45 minutes at room temperature. For fixation, 1 ml of ice-cold Carnoy's fixative (methanol: acetic acid 3:1) was added dropwise to the solution and centrifuged at 1500



Metaphase spread of gills cells of Etroplus suratensis stained with (a) Giemsa stain (b) chromosome 2n=48

rpm for 5 min. The cell pellet was washed twice with two changes in Carnoy's fixative for 10 min each. Finally, the fixed cells were re-suspended in 500 µl of Carnoy's fixative and were dropped on glass slides and air-dried. The slides then stained with 10% Giemsa stain for 10 minutes and observed under a bright-field microscope at 100X magnification, and chromosome numbers were determined. The chromosome number was found to be 48.

The images were analysed using Ideokar1.2 software. Three metaphase spreads were examined and identified that the pearlspot fish had 48 diploid chromosomes (2n=48) in their cells. Among the 24 pairs of chromosomes 21pairs were metacentric with arm ratio ranging from 1.05 to 1.67 relative length from 1.94 to 6.83% and the centromeric index varies from 38 to 49. Two pairs of chromosomes were Submeta centric with the arm ratio of 1.84 and 2.89 relative length of 4.18 and 2.86 and centromeric index of 25 and 35. One more pair of Subtelocentric with arm ratio of 4.75 relative length of 5.33% and centromeric index was 18. The identified chromosome pattern would be useful as secondary species confirmation methods.



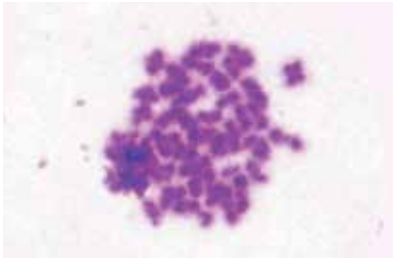
Mitotic metaphase spread of pearlspot fish (2n=48)

Table 3: Chromosome pattern of pearlspot fish

Number of Chromosome pairs	Arm ratio	Relative length	Centromeric Index	Type
21	1.05 to 1.67	1.94 to 6.83%	38 to 49	Metacentric (M)
2	1.84 and 2.89	4.18 and 2.86	25 and 35	Sub-Meta centric (SM)
1	4.75	5.33%	18	Sub-Telocentric (ST)

KARYOTYPING OF *P. INDICUS*

The Karyotype information of an organism is useful for developing molecular breeding, genetic selection, chromosome manipulation, construction of genomic and linkage maps and evolutionary studies of crustaceans. *P. indicus,* which is a candidate brackishwater and native shrimp species is of economic importance and is being studied for generation of whole genome sequence information. Therefore it is important to to obtain mitotic chromosome metaphases to find the exact chromosome number and the tentative karyotype of the marine shrimp *P. indicus* that will improve karyotype analysis. For chromosome analysis, 20-25 g in body weight, shrimp was injected colchicine and chromosomes were prepared from the testicular lobes. After hypotonic and Carnoy's fixative solution treatment the chromosomal was stained with 5% Giemsa. Mitotic chromosomes were observed at 100x magnification.



Mitotic metaphase spread of *Penaeus indicus*

Social Science & Development

One of the major themes of research and development of CIBA is to assess the social and economic dimensions of the brackishwater aquaculture in the context of changing world. While shrimp farming remains as the major economic engine of Indian brackishwater aquaculture, farming of other brackishwater species has the potential to bring forward the marginalized coastal communites with limited livelihood options.

Social Science & Development

MACRO LEVEL IMPACT OF TECHNOLOGIES ON FARMERS INCOME

The macro level impact of technologies in brackishwater aquaculture in doubling farmers' income was studied. Shrimp area, production and productivity data from 2001-02 to 2017-18 were used to quantify farmer's income and projected till 2021-22 by using time series analysis. The country level estimates based on polynomial function at constant prices revealed that farmers' income in real terms was Rs. 21.77 lakh per farm in 2017-18 which would increase to Rs. 31.32 lakh per farm in India during 2021-22 (43.9%) In other words, the farm income grew at the compounded rate of 9.1% per annum and increased by 1.44 times during 2017-18 to 2021-22.

Farm level impact of shrimp technologies on doubling of income was studied by CIBA using linear regression model from the time series data available on Area Under Culture, Estimated Production and Average Price per kg of shrimp and the results are depicted in Table 4. At the farm level, the realized income was Rs. 22.75 lakhs during 2015-16 and projected income was Rs 36.13 lakhs during 2021-22.

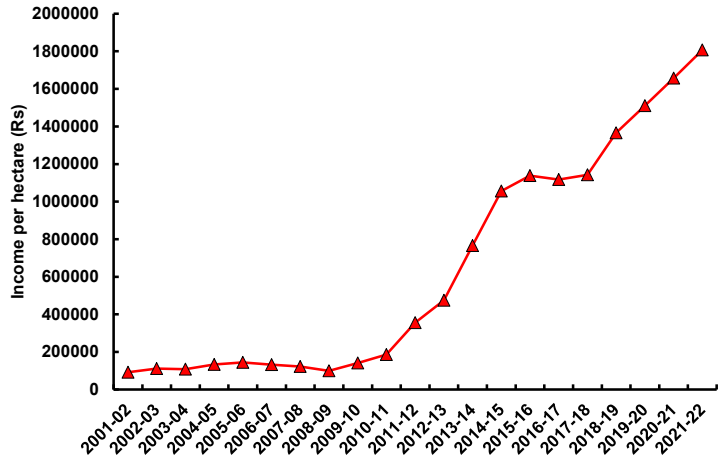
Therefore, shrimp industry is the most lucrative farm industry, which would double the farmers income by 2021-22. However for achieving this sustainable growth, the shrimp sector in India need to be supported by both Union Government and respective State Governments through major policy decisions and institutional support mechanisms.

Table. Actual and projected farm income per shrimp farm in various states of India

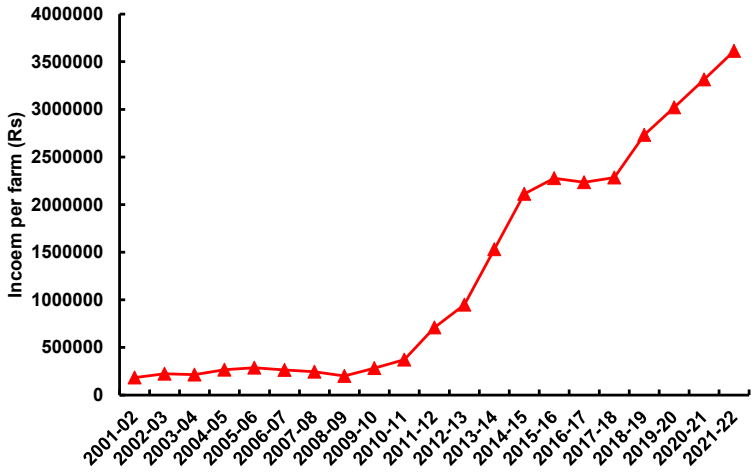
Particulars	2017-18	2021-22	Increased by (No of times)
Andhra Pradesh	36.40	54.00	1.48
Tamil Nadu	25.00	45.00	1.80
West Bengal	7.30	10.63	1.46
Orissa	20.97	27.54	1.31
Kerala	2.08	3.07	1.48
Karnataka	7.88	11.57	1.47
Goa	15.00	22.5	1.50
Gujarat	38.07	57.07	1.50
Maharashtra	25.07	38.55	1.54
India	21.77	31.32	1.44

Forecasted trend in Farm Income of shrimp industry in India

S.No	year	Area Under Culture	Estimated Production	Average Productivity (MT/ha)	Average Price per kg	Gross Income Rs./ha in lakhs	Per farm income Rs. in lakhs
01	2001-02	157400	102940	0.65	140.34	0.92	1.84
02	2004-05	136393	125668	0.92	144.08	1.33	2.65
03	2009-10	102542	97650	0.95	148.11	1.41	2.82
04	2015-16	140666	497622	3.54	321.61	11.38	22.75
05	2021-22	298970	1136105	3.80	475.40	18.07	36.13



Per ha income increase

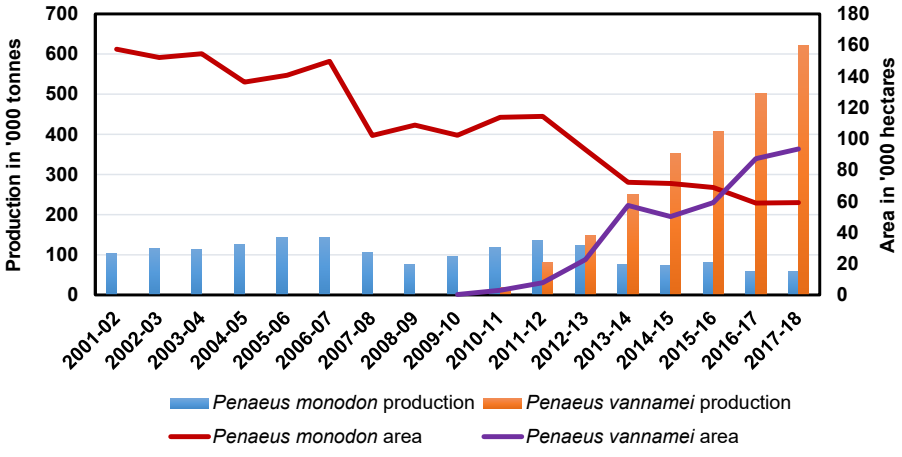


Per farm income increase

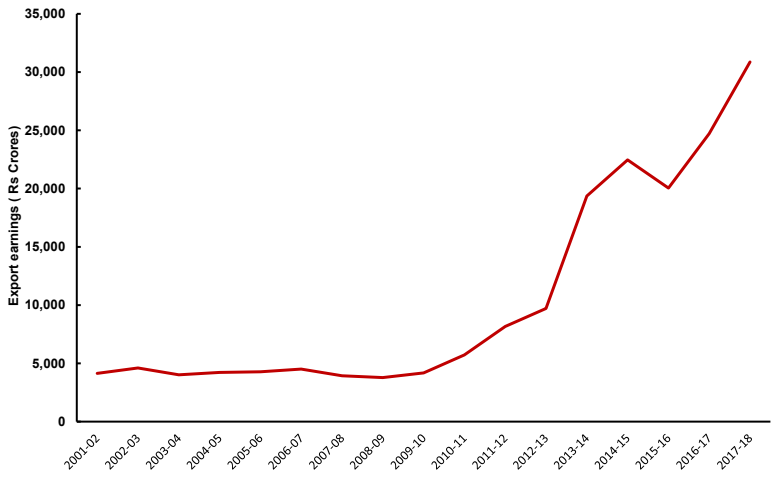
ASSESSMENT OF IMPACT OF SHRIMP FARMING WITH SPECIFIC PATHOGEN FREE *PENAEUS VANNAMEI* SPP.

Specific Pathogen Free Pacific White. *Penaeus vannamei* (SPF-PV), was introduced in India in 2008 by the Ministry of Agriculture with the *Ex-ante* Risk analysis, aquatic quarantine protocols along with continuous disease referral laboratory services provided by ICAR-CIBA along with other Institutions (CAA, 2010). The stocking densities increased from 20- 30/ m^2 (conventionally used for *P. mondon*) to 60 m^2 The higher stocking and higher production of SPF-PV made cost of production per kg come down as compared to the Tiger Shrimp (*Penaeus monodon*). SPF-PV has ready international market for 40 to 50 counts per kg, which can be produced in less than 110 days resulting in reduced crop duration of 20 to 40 days.

Shrimp farmers have adopted SPF-PV in 56.2% of the area under shrimp farming, with a share of 88.6 % in the total shrimp output from the country in the triennium ending 2018.While Andhra Pradesh, Tamil Nadu, and Gujarat



Area and production of *P. vannamei* and *P. monodon*



Export earning from farmed shrimp

produce about 90 per cent of SPF-PV. The traditional shrimp farming systems of Kerala and West Bengal are not amenable for creating bio secured facilities that continue with mixed farming and poly culture systems. The SPF-PV was adopted rapidly in the last ten years due to higher production and profits to the farmers.

TARGET BENEFICIARIES AND KEY BENEFITS

Presently there are 65,265 aqua farms enrolled with a water spread area of 1,62,431 ha, supported by 133 registered shrimp hatcheries (Min. of Commerce, 2019). Small farm holdings dominate the Indian shrimp farming sector. More than 90% of shrimp farms are of size 2 ha Shrimp farms are in coastal areas where other employment options minimally exist. The coastal rural poor are less endowed and economically weak. Hence shrimp farming activities are considered as one of the economic engines. Many a time, it is taken up as a family farming activity which ensures women empowerment also. SPF-PV export is mostly to the USA, EU, Middle East, and Japan. This activity brings in valuable foreign exchange, apart from providing jobs in remote coastal zones.

ECONOMIC BENEFITS

SPF-PV is a high value export item. Out of 7 billion USD worth seafood exports during the financial year 2017-18, frozen shrimp contributed 5 billion USD, which consists mainly of SPF-PV. India was the lead exporter of the global shrimp market with 36% market share (FAO, 2019). The total economic surplus generated by SPF-PV is estimated at Rs.3, 96,156 crores during the 9 years (2009-10 to 2017-18). The Internal rate of Returns is estimated at 51%. The estimated ratio between consumers and producers surplus is 66%:33%. Reduced diseases under bio secure conditions have made per ha productivity to 6.42 t/ha in the triennium ending 2018 compared to 1.4 t/ha of pre vannamei scenario (before 2009).

AQUASTAT INDIA 2019: DATA BASE MANAGEMENT ON BRACKISHWATER AQUACULTURE SECTOR

Aquastat India 2019, comprehensive database on world and Indian scenario of brackishwater aquaculture production and trade statistics were updated for the years 2017 and 2018. This compendium has also been updated with information in brief about the various technical aspects of the brackishwater aquaculture sector viz., Brackishwater aquaculture sector contribution in Indian economy Reinstatement of nomenclature of genus *Penaeus* and Brackishwater ornamental aquaculture in India The database is named as Aquastat India 2019 and will be uploaded in CIBA website after cross validating with the various available data sources.

TECHNICAL EFFICIENCY OF SHRIMP PRODUCTION IN PULICAT, TAMIL NADU

In order to evaluate the technical efficiency of shrimp production, a shrimp farming village, Pulicat, in Tamil Nadu was identified and data was obtained from randomly selected 35 shrimp farmers. Stochastic frontier production model was used to estimate the technical efficiency of the sample farms. Battese and Coelli (1995) model was used to estimate the technical efficiency.

All the estimated β coefficients have positive signs except for the electricity. Only feed and manure are significantly different from zero at 1% level which imply that these inputs have major influence on shrimp production in Pulicat, Tamil Nadu. However, seed, electricity and labour have not depicted any significant relationship with TE. (Table 1) The predicted technical efficiencies (TE) of all the sample farms ranged from 0.4 to 0.99 with the mean technical efficiency of 0.9. (Fig 1) This indicates that if shrimp farmers use their existing level of inputs in an efficient manner, output an average can be increased by 10%. The results indicated that sample farms are technically efficient. The estimated value of variance parameter Y was 0.25 and highly significant, suggesting that technical inefficiency effects and not significant in explaining the levels of and variations in shrimp production in Pulicat.

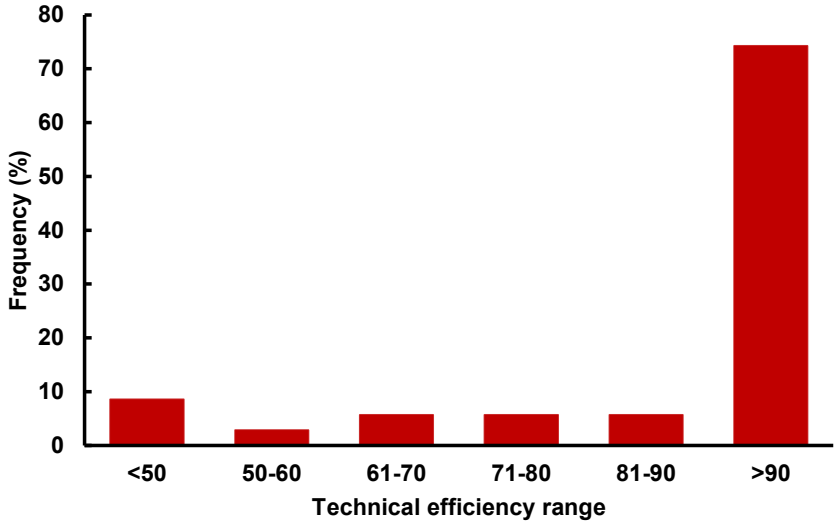
Table. Parameter estimates of stochastic production frontier model

Independent variables	Estimated coefficient	Standard error
Constant	-2.2228*	1.2236
Seed (X1)	0.1295	0.1939
Feed (X2)	0.3956***	0.1467
Manure (X3)	0.5071***	0.0874
Electricity (X4)	-0.1243	0.1329
Labour (X5)	0.0068	0.1486
Generator (X6)	0.0377	0.1504

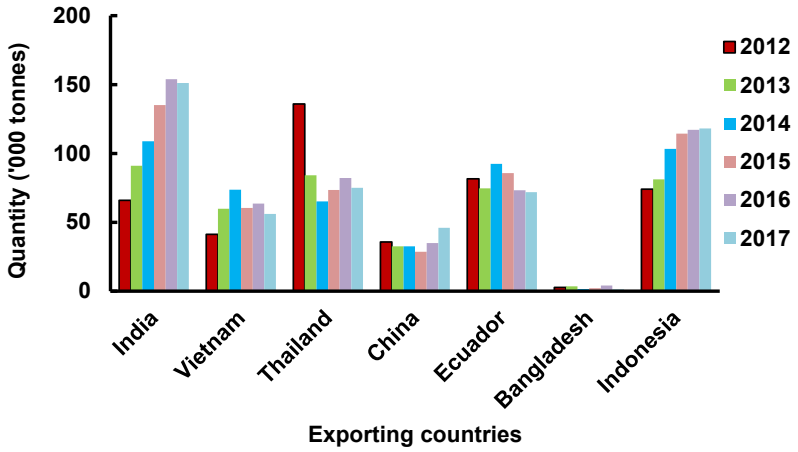
***p≤0.01; *p≤0.1

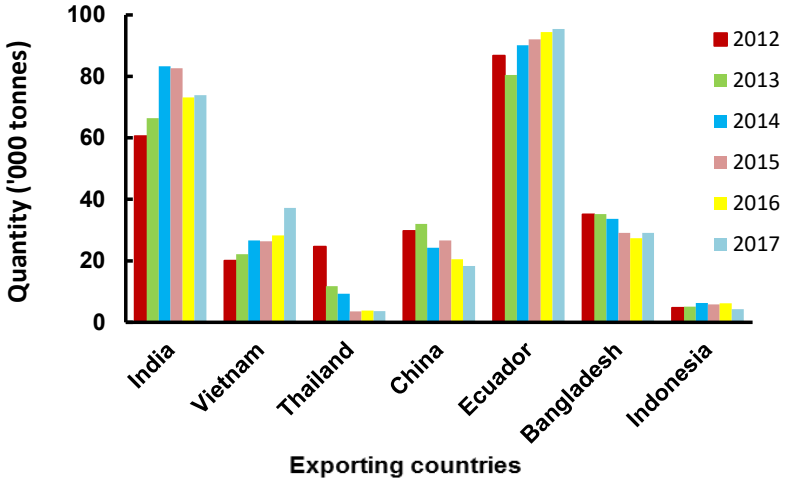
TREND IN SHRIMP EXPORT PERFORMANCE

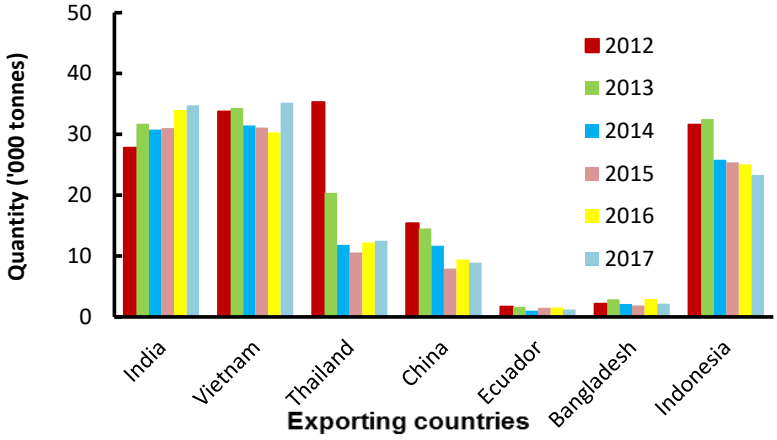
Import of shrimp to the USA, EU, and Japan dominates the International shrimp trade. USA shrimp import was dominated by Thailand till 2012 barring initial couple of years (2002-2004) of strong presence China. In the last five years, India exported annually more than 130,000 t of shrimp, and became the major supplier to the USA market followed by Indonesia (100,000 t). Vietnam and Ecuador exports have shown a steady increase after a fall in 2004 while shrimp exports from Bangladesh have declined considerably (Fig.6.1a). Share of shrimp exports to EU member states by India, Ecuador Bangladesh, and Indonesia maintained, while that of China and Thailand declined marginally in the last six years. Ecuador annually exported 90,000 t followed by India (75,000 t), while Vietnamese shrimp exports showed improvement by 2017. Indian shrimp exports showed a increase until 2015 (82,700 t) and managed to retain its share in subsequent years (Fig. 6.1.b). Indian shrimp exports to Japan maintained around 35,000 t with a



Frequency distribution of technical efficiency indices for shrimp culture in Pulicat







Trends in quantum of shrimp imported from major exporting countries by USA (top panel), European Union (middle panel) and Japan (lower panel).

transient decline during 2008-09. Indonesia, leader of shrimp exporting country for Japan in 2002 has reduced less than half reaching 23,312 t in 2017 and Vietnam and China also showed a similar trend. (Fig. 6.1 c).

DETERMINANTS OF EXPORT REJECTIONS BY USA, EU AND JAPAN - GRAVITY MODEL APPROACH

Determinants of Indian shrimp imports of USA, EU and Japan examined using an augmented gravity model of international trade to explain the effect of economic and noneconomic variables in the international shrimp market. Secondary data was used in a panel dataset that consists of both time series and cross-sectional data. The number of an observational period as the time series data is 17 years, from 2001 to 2017. The cross-sectional data consists of seven countries, which are the main export destination countries of the USA, EU and Japan such as Bangladesh, China, Ecuador, India, Indonesia, Thailand, and Vietnam.

The Hausman test was conducted and found that the resulting Chi square value is 23.37 and the corresponding value of probability is less than 0.01 for EU. Therefore,

Determinants of Indian shrimp imports of USA, EU and Japan examined using an augmented gravity model of international trade to explain the effect of economic and noneconomic variables in the international shrimp market

Table Gravity Model Estimates of U.S, EU and Japan shrimp Imports, 2001-2017

Variable	USA(Random effect)	EU(Fixed effect)	Japan(Random effect)
NoR_{it}	0.992***±0.005	0.818***±0.108	0.845***±0.029
SOR_{it}	-0.965***±0.017	0.003±0.020	-0.184*±0.099
URR_{it}	-0.024±0.018	-0.779***±0.141	-0.578***±0.091
RRR_{it}	-0.004±0.003	-0.052±0.096	-0.110***±0.037
GDP_{it}	-0.133±0.172	-0.909**±0.416	0.205±0.205
GDP_{j}	0.022***±0.009	-0.862***±0.594	-0.137***±0.043
ECD_{it}	-0.002±0.012	0.479***±1.053	-0.256***±0.063
POP_{it}	-0.021±0.558	40.433±54.102	-11.761±9.152
POP_{j}	-0.024***±0.010	-2.275*±1.928	0.122***±0.037
PGD_{it}	0.067±0.241	-0.005±2.570	-0.226±0.635
PGD_{j}	-0.001±0.007	0.245***±0.538	-0.108***±0.029
Constant	11.051±7.813	-727.545±1041.521	-213.169±170.550
rho	0.00	0.99	0.09
Hausman significance test	0.99	23.37***	0.807
Observations	119	119	119
Wald Chi^2	179577***		2212.5***
F test		11.86***	

***significance at 1%; **significance at 5%; * significance at 10%; Mean±standard error are given in the Table

the study concluded that for this data, a fixed-effect model would be more appropriate for EU. The Hausman test ratio of USA and Japan suggest that random effects model is better than fixed-effects model for this study. The US shrimp imports are positively affected by number of rejections and GDP of exporting countries but negatively affected by the share of rejections to shrimp imports, Unit Rejection Rate, Relative Rejection Rate, US GDP and population of exporting countries. The results reveal that EU imports from the seven exporting countries are significantly affected by the number of rejections, Unit Rejection Rate, EU GDP, GDP of exporting countries, the economic distance between counties, population of EU and per capita GDP of importing countries. The coefficient of share of rejection to Japan shrimp imports, unit rejection rate and relative rejection rate are negative and statistically significant with the values of -0.18, -0.58 and -0.11 respectively. On the contrary, number of rejections and population of importing country show a positive significant effect on the shrimp imports of Japan. The total number of observations is 119 for this model.

ORNAMENTAL FISH FARMING FOR PROFITABLE INCOME GENERATION AND COMMUNITY DEVELOPMENT AMONG COASTAL FAMILIES OF KOVALAM VILLAGE (CHENGALPATTU, TAMIL NADU.)

Although pearl spot (*Etroplus suratensis*) is a high valued food fish in some sates, in many other states it has been traded as ornamental species. Therefore,

Homestead *Etroplus suratensis* (Pearlspot) fish rearing unit

homestead Pearlspot fish rearing unit was developed for profitable income generation and community development among 10 coastal families at Kovalam village. In a fabricated shed 6.7 m X 3 m), four concrete tanks (500 L capacity). A total of 2000 pearl spot seeds (0.5 cm; 500 per tank) was reared for two months until reaching 2.5 cm to 4 cm size. The salinity during the culture period was 5 ppt. After two months of rearing, Rs.15,000/- was realized from this sales.

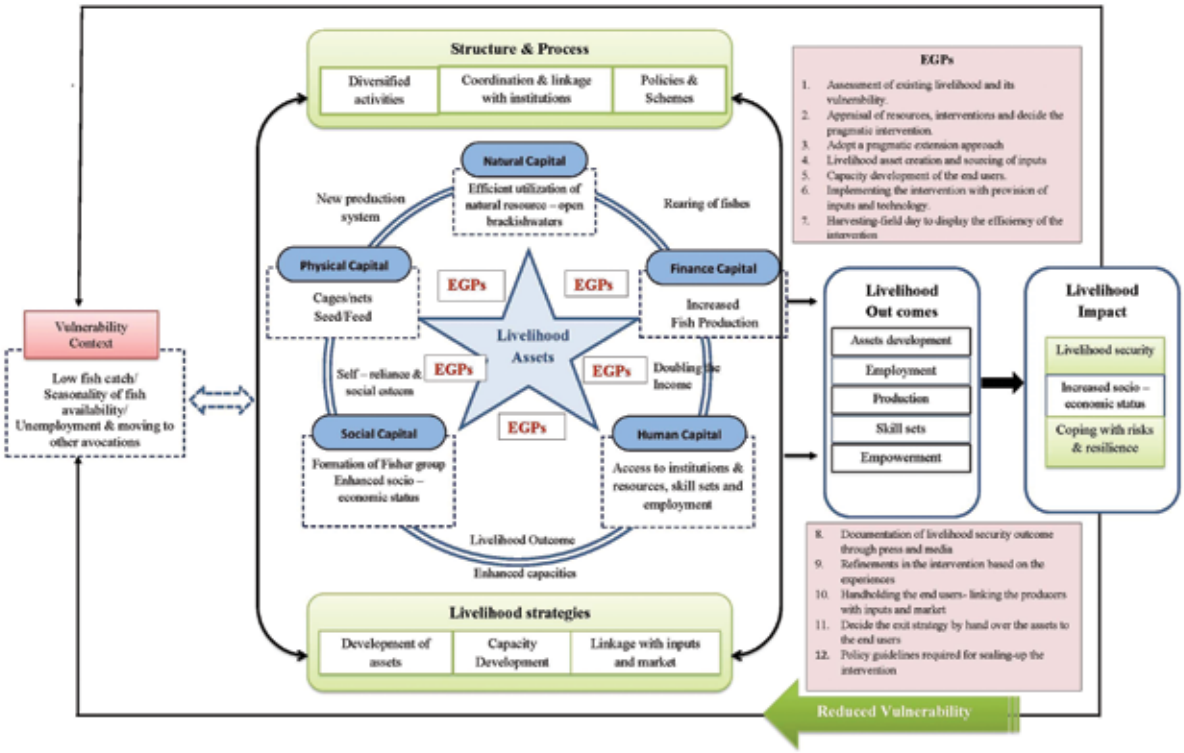
TECHNOLOGY TRANSFER MECHANISMS FOR IMPROVING THE LIVELIHOOD SECURITY OF COASTAL FAMILIES

Brackishwater aquaculture initiative by ICAR-CIBA in the open brackishwater bodies with the participation of SC/ ST families has revealed the potential of the open brackishwater bodies as a livelihood and income generation in Keelarkollai village of Kuvathur Panchayat. This initiative develops a model for a two stage rearing (nursery and grow-out) of Seabass in open brackishwater bodies. After 60 days of the nursery phase, the sea bass fry attained 30g/10-12 cm size, 200 nos were stocked along with mullets, Pearl spot, Siganus sp and catfish in pen enclosures (10ft x10ft) in open brackishwater bodies and reared for 9 months with natural feed. The estimated production of Seabass is expected to be 150 Kg and other fishes around 300 Kg.

The Hausman test ratio of USA and Japan suggest that random effects model is better than fixed-effects model for this study

EXTENSION GOOD PRACTICES (EGP) FOR IMPLEMENTING AQUACULTURE BASED LIVELIHOOD DEVELOPMENT PROGRAMMES:

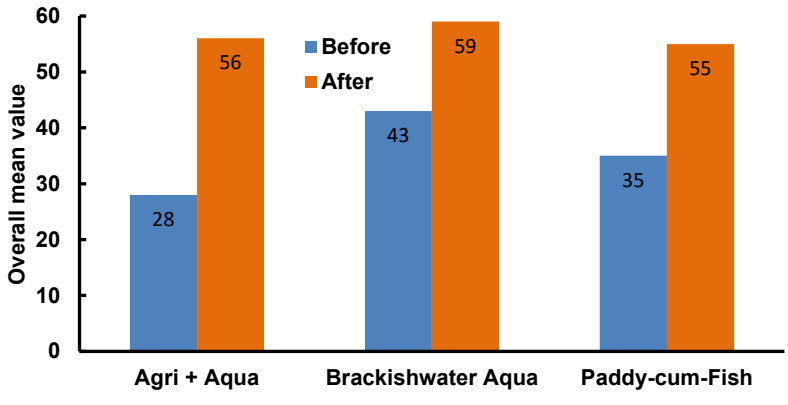
Extension good practices were evaluated as part of the ongoing livelihood initiatives undertaken



Modified Livelihood Development Framework (Adopted from DFID)

by the institute for their relevance and reliability. The sustainable livelihood framework proposed by the DFID was modified suitably and EGPs were incorporated. These EGPs would facilitate the asset creation and strategies to be adopted in the development of aquaculture based sustainable livelihoods. Three aquaculture based farming system: land shaping for aqua-agri integration, brackishwater pond based polyculture and paddy-cum-fish farming implemented in the South 24 Parganas district of West Bengal were assessed. All the interventions taken up have contributed significantly towards the enhanced livelihood security of the farm families. It is seen that farm pond based aqua-agri integration had better economic returns followed by the paddy-cum-fish and brackishwater aquaculture interventions respectively.

The findings substantially indicated that all the three farming models have contributed for enhancing the livelihood security levels of the farm families in terms of creation of livelihood asset mainly the farm pond, conservation of natural water for multiple cropping and aquaculture, enhanced capabilities, employment generation, improved production from the land/pond, enhanced income from farming, access to better market price, access to development institutions, minimization of migration during off-season, enhanced self-reliant, and social status of the farm families.



Impact of aquaculture based livelihood security models

CAGE AQUACULTURE IN PUDUCHERRY - A FEASIBILITY STUDY

The coastal fishers of Murungambakkm village in Puducherry and Mathagadi in Karaikal were trained in nursery rearing of Asian Seabass fry using net cages (Hapas). They have completed respectively three cycles and one cycle of nursery rearing. Floating frames for nursery rearing, increased feeding frequency and in-situ pre-grow out rearing along with nursery were taken up. Floating frames enhanced the life of the nursery setup, increased feeding frequency reduced the cannibalism and increased the overall survival by 20%. Further, it was observed that nursery rearing in low saline waters (up to 5 ppt) yielded better survival vis-a-vis brackishwaters. The nursery earing was found to be economically viable.

SMART AQUACULTURE MODEL (SAM): APPLICATION OF ICT AND DATA ANALYTICS FOR SUSTAINABLE SHRIMP AQUACULTURE

'Production system information need analysis' for shrimp farming was developed with a sample of 180 shrimp farmers. Fifteen aspects covering the total cropping cycle of the Pacific white shrimp (*Penaeus vannamei*) farming were shortlisted to assess the information needs based on the relevance rating and content judgment of subject matter specialists. The primary data on the information needs of farmers were ascertained on a dichotomous mode (needed vs not needed). The data show that majority of the shrimp farmers needed information on diseases diagnosis, prevention and management (75%), water quality parameters and their management (67.9), probiotics and water quality kits (63%), pond bottom metabolites management (62%) and aeration, aerators and

Table.6.1. Economics of Seabass nursery rearing

Sl.No	Module details	Expenditure in Rs.
A	**Fixed investments:**	0.818***±0.108
A.1.	10 Hapa's (2x1x1m) @ Rs.1500/hapa.	Rs. 15,000
A.2.	Floating frame, Predator net, poles and ropes	Rs. 25,000
A.3.	Sampling & grading devices, transport, etc.	Rs. 10,000
	Fixed cost	**Rs. 50,000**
i)	Depreciation @ 20% of the fixed cost	Rs.10,000
ii)	Interest on fixed cost @ 8%	Rs.4,000
iii)	Insurance on the fixed investments @ 2%	Rs.1,000
	Total Fixed cost per crop **(A)**	**Rs.15,000**
B	**Operational Expenses**	-0.005±2.570
B.1	Seed cost including logistics - Seed (2.5 cm fry @ 1000 per hapa = 10,000); cost @ Rs.10/fry.	Rs. 1,00,000
B.2	Feed @ Rs.100/kg (approx. 80 kgs)	Rs.8,000
B.3	Other miscellaneous expenses	Rs.2,000
	Total operational expenditure (B)	**Rs.1,10,000**
C	**Total expenditure (A + B)**	**Rs.1,25,000**
D	**Income and Profitability**	
D.1.	Productivity (Survival 50-60%) (AL 7 cm, ABW 8 g size)	5000- 6,000 fingerlings
D.2.	Cost of production per fingerling (C / D.1)	Rs.21 - 25
D.3.	Sale price @ Rs.35 per fingerling	Rs. 1,75,000 - 2,10,000
D.4.	Net income per cycle (60 days) **(D.3 - C)**	**Rs.50,000-85,000**
	Benefit Cost Ratio **(D.3 /C)**	1.4 - 1.68
E	**Monthly income per group** (D.4/2 = 42,500) (Three youths can be a group/team-with the effort of 200 working hours)	Rs.25,000-42,500

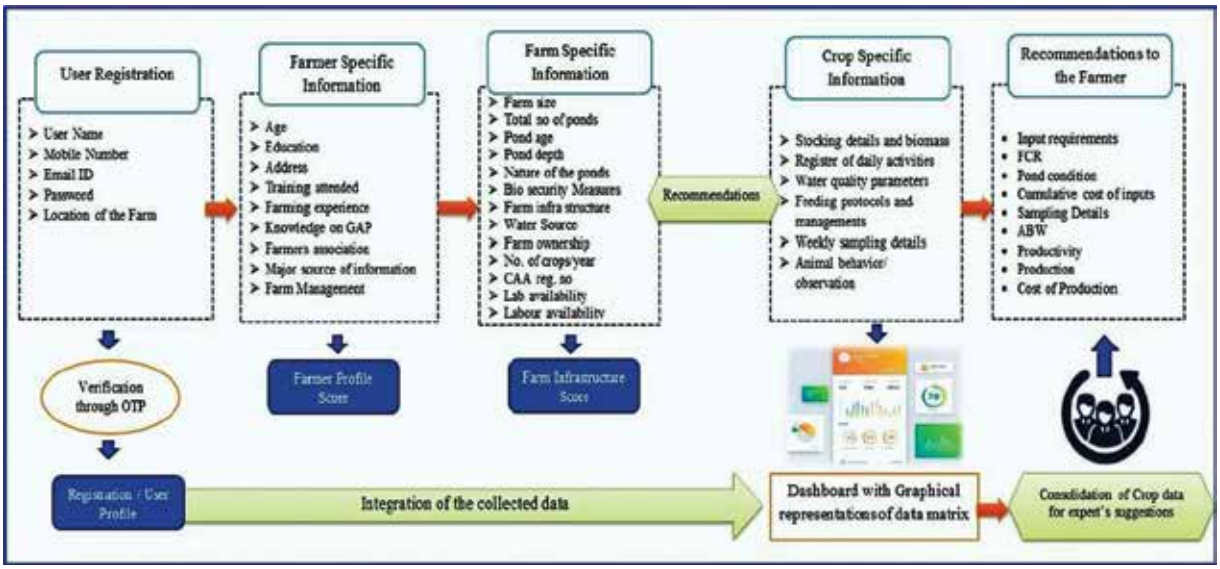
***significance at 1%; **significance at 5%; * significance at 10%; Mean±standard error are given in the Table

their efficiency (61%). Most of them (87%) had networks other than BSNL and 91% of farmers preferred English as the language of interaction. Shrimp farmers were relatively better educated and afford to have advanced mobile phones, therefore, mobile phone based information exchange could be a viable rategy to provide informatirvices and interact with shrimp farmers.

DEVELOPMENT OF A MOBILE APPLICATION FOR SHRIMP FARM MANAGEMENT

The farmer respondents were of the perception that a mobile application in which the farmer or the farm operator could enter his/her data on water quality parameters, feed requirements, feed rationing, feeding behavior and feed management, biomass estimation, animal behavior, pond conditions, average growth, body weight and economics of inputs. The application could include blocks of farmer specific details, farm specific information, crop specific information and day-to-day data entry register. The application should integrate the data from these components, process them and show inferences in

Technical information needs of *Penaeus vannamei* farmers



the form of graphs or data matrices using that the farmer can visualize the status of his farming and might take decisions appropriately. It is intended that by using this application the farmer can forecast his inputs requirements and productivity. Such that we can pool the data from several farms and forecast the requirements and identify the shortfalls in every aspect monitored and alert the farmer to rectify the issue and take an appropriate decision. A frame work for the mobile application is developed for implementing a mobile application for shrimp farm management.

KNOWLEDGE AND ECONOMIC EMPOWERMENT OF TRIBAL WOMEN

Involvement of rural women, particularly from tribal communities, in modern brackishwater aquaculture were extremely less during the initial phase of development of brackishwater aquaculture. In order to bring forward these marginalized society to involve brackishwater aquaculture, and to develop brackishwater aquaculture as a more inclusive and equitable sector, tribal women (villages of Kannavanthurai and Senjiamman tribal village of Tiruvallur and in Chengalpattu districts,Tamil Nadu) were trained the practical aspects of fish and shell fish aquaculture. They were provided *in situe* training in brackishwater aquaculture technologies such as milk fish farming, seabass nursery rearing (in hapas) in open waters and pond, seabass farming (in FRP cages) in open waters and pond, crab farming (in pond), *Penaeus indicus* farming (in pond), *Etroplus suratensis* (Pearlspot) farming. These brackishwater aquaculture interventions were integrated with other allied technologies: poultry, mushroom farming, kitchen gardening and community / societal development like distribution of diesel engine, solar lights and farm implements to the beneficiaries to create sustainable livelihoods opportunities even during the lean fishing season. The profit earned from the sale of produce facilitated them to avail bank loans for their interventions at the end of the project.

In another intervention, a homestead pearl spot (*Etroplus suratensis*) fish breeding unit was developed at Kovalam village (Chengalpattu dt., Tamil Nadu). A shed was created for this purpose, and six concrete tanks (800 L) were built. Pearlspot brooders 4 pairs were stocked in each tank. Pearl spot fingerlings were produced, and Rs.7,000 was realized from this sales.

SUSTAINABLE LIVELIHOOD MODELS FOR RESOURCE POOR AQUAFARMERS FOR DOUBLING THEIR INCOME

In order to diversifiy the livelihood opportunities of rural people of coastal Tamil Nadu, a study was carried out in Nagappatinam district. These coastal rural population is severely constrained due to low income or unstable income, limited access to the natural resources and lack of knowledge on alternative livelihood. Brackishwater aquaculture interventions integrated with horticulture was found to be an effective tool to income generation. Farmers were trained in nusery rearing and grow out rearing of seabass. Addtionally they were provided practical training on horticulture. Initially, two stage model Seabass nursery rearing (67 days) followed by the polyculture of Asian seabass and tilapia, as forage fish model, was demonstrated in a grow out pond (8000 m^2). Tilapia broods (~ 270 Kg) was stocked in two acres, 70 days prior to stocking of seabass fingerling. The seabass fingerling (35-40g/ 12-14 cm) was stocked at a density of 800 fish/ acre. The estimated production of 800 kg of Seabass (Rs 2, 20,000) and 300 Kg of Tilapia (Rs 21000) is expected with the survival of 50%. Initial harvest performance realized a sale for Rs 50000 including the sale of horticulture crop.

RECYCLING OF FISH WASTE TO A VALUE ADDED PRODUCT: A CONCEPT OF THE CIRCULAR ECONOMY

ICAR-CIBA has developed cost effective indigenous eco-friendly products: branded as CIBA-Plankton^{Plus} and Horti^{Plus}, from fish-waste of fish markets and Fish trimming from fish processing units, to boost and maintain the healthy plankton bloom in aquaculture systems and as an organic manure for agriculture/horticulture. The products are developed under the concept "waste to wealth" in Swachh Bharat initiatives of Govt. of India. Plankton^{Plus} has proven its efficiency in various aquaculture systems for different species. This technology has been transferred to 'Nambikkai Fish Farmers Group', Nambikkai Nagar, Chennai, through start-up India programme, Agri-business incubator. CIBA provides the necessary hand-holding and training to the Nambikkai Fish Farmers Group on production and marketing of PlanktonPlus and Horti^{Plus}.

The institute has "Fish Waste Processing Unit" at Chennai for the production of Plankton^{Plus} and Horti^{Plus} from fish waste sourced from fish markets. Production capacity of the small scale Fish-Waste to Wealth unit is 2000 L/ month. Annual turnover of one unit is Rs.16.80 lakhs with net profit of Rs.4.56 lakhs. Nambikkai Fish Farmers Group, Nambikkai Nagar, Chennai is producing Plankton^{Plus} and Horti^{Plus} using Fish-waste sourced from locals, and Processed at the Start-up Unit established by CIBA. Impact of this initiative, the group has produced 6499 Kg of Plankton^{plus} and 850 Horti^{plus} and received Rs. 4,23,892. The group is processing the fish waste persistently and producing Plantonplus and Horti^{plus} as an alternative livelihoods activity.

INTEGRATED BRACKISHWATER FISH FARMING MODEL FOR TRIBAL COMMUNITIES OF GUJARAT

Integrated brackishwater Fish Farming model was developed at Matwad village, Navsari, Gujarat, for providing employment and livelihood opportunities to tribal communities through different brackishwater aquaculture technologies. The model comprising of (1) nursery rearing of Asian seabass, *Lates calcarifer* and Scat, *Scatophagus argus* in hapas, (2) polyculture of Milkfish, *Chanos chanos* and Pearl spot, *Etroplus suratensis* in pond (2000 sq.m), and (3) goat and poultry farming shed (16x12 ft) on pond dyke. Training was given to the tribal group comprising of 6 women and 2 men on polyculture of fishes, nursery rearing of seabass, milkfish culture, health issues in brackishwater aquaculture and basics of goat farming etc.,

A total of 11000 nos. of seabass fry (1.2-2.0cm) were stocked in 22 hapas @ nearly 500/hapa. During the 45 days of nursery rearing, the animals were fed twice daily with farm made ball shaped feed @ 8% of body weight. Periodically grading was done every 5 days and cleaned to avoid clogging of hapas. After 75 days of nursery rearing, seabass fingerlings of size of 3-4 inch and 10-12 g (45% survival) were harvested and sold to interested aqua farmers @ Rs.40-20/piece depending on the size of the fingerlings. An amount of 2.4 lakhs was realized from seabass fingerlings sales. During nursery rearing of milkfish, around 13000 nos seed were stocked in happas and fed with feed at 8-10% body weight two times a day. After culture of 90 days the 12260 fingerlings were sold at the rate of Rs 10- 15/- and the group generated total revenue of Rs 1.75 lakhs.

CIBA hatchery produced pearlspot seed (2-3 inch) and milkfish

seed (2-3 inch) were stocked at density of 1400 seeds and 800 seeds respectively in the pond for polyculture. Both the fishes were fed with poly^{plus} feed @3-10% two times a day. After the culture of four months, the pearlspot were grown to size of 200-250 g with 98% survival and milkfish to 200-400g with 95% survival. After harvest, 275 kg pearlspot fish were sold at rate of 250/- Kg and 190 kg milkfish @Rs 100/- kg. From the culture, the group generated revenue of Rs. 0.88 lakhs. As a part of the integrated farming, 3 nos of Surati goat (8 kg Average body weight) were given to the group. The goat was fed with grass and artificial feed two times in a day. Totally from this model the tribal group generated revenue of Rs. 5.03 lakhs.

This initiative is not only cleaning and hygienic disposal of fish market waste which is abundantly available in the village cluster but also will help to produce wealth from waste as a concept of circular economy. This user-friendly technology will help in improving the environment in addition to enhancing their livelihood.

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

TRAINING PROGRAMS ATTENDED

SCIENTISTS

S.No	Name of the Person	Programme Name	Venue	Duration	Organized by
1	Dr. S.K. Otta, Principal Scientist	Training Programme on Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projects	Hyderabad	18 - 23rd July 2019	ICAR-NAARM
2	Dr. M. Muralidhar, Principal Scientist	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
3	Dr. J. Syama Dayal, Principal Scientist	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
4	Dr. M. Poornima, Principal Scientist	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
5	Dr. P. Ezhil Praveena, Senior Scientist	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
6	Dr. R. Anandaraja, Senior Scientist	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
7	Dr. Bhuvaneswari, Scientist	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
8	Dr. P. Kumararaja, Scientist	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
9	Dr. S. Kannappan, Principal Scientist	Training Programme on Science, technology & Emerging Trends	New Delhi	14-18th October 2019	IIPA
10	Dr. T.N. Vinay, Scientist	Hands –on Training course in Proteomics	Bengaluru	22-29th November 2019	Cellular and Molecular Platforms

TECHNICAL STAFF

S.No	Name of the Person	Programme Name	Venue	Duration	Organized by
1	Dr. Joseph Sahayarajan-Asst. Chief Technical Officer	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL
2	Dr. A. Nagavel, Asst. Chief Technical Officer	NABL assessor Training Programme	ICAR -CIBA, Chennai.	16 – 20th September 2019	NABL

ADMINISTRATIVE STAFF

S.No	Name of the Person	Programme Name	Venue	Duration	Organized by
1	Shri. Raghavendra, Assistant (Store Section)	Training Programme on Assets Management	New Delhi	6-8th November 2019	ICAR-IARI
2	Shri. K. C. Gopala Krishna Moorthy, Personal Assistant	Improving skills of administrative staff of ICAR dealing with Court Cases	Jodhpur	25-27th November 2019	ICAR–AZRI

TRAININGS CONDUCTED 2019

Sl. No	Name of the Training /FGD	Duration	No. of participants
HEADQUARTERS			
1	Training programme on 'Recent advances in soil and water management in brackishwater aquaculture'	24 – 29 June, 2019	6
2	Skill development program on seed production and farming practices of Asian sea bass (*Lates calcarifer*)	July 15-19, 2019	22
3	'Hands on Training on Shrimp and Mud Crab Aquaculture'	22nd to 27th July 2019	14
4	Recent advances in captive breeding and farming of potential brackishwater finfishes	August 9 to 15, 2019	9
5	Hands-on Training Programme on 'Biofloc based nursery and grow-out culture technology and its application in aquaculture'	24-28 September 2019	22
6	Hands on training programme on 'Application of Recent Advances in Genetics and Biotechnological tools in Aquaculture'	14-19 October 2019	5
7	Customized training program on pelleted feed preparation	November 25-26, 2019	2
8	Dedicated Hands-on training programme on "Aquatic Animal Health Management in Brackishwater Aquaculture"	30 November – 5 December 2015	10
9	Training on 'Better management practices in shrimp seed production and grow out farming'	2-6 December 2019	17
KAKDWIP RESEARCH CENTRE			
	Advances in Brackishwater Aquaculture Practices"	01-06 July, 2019	6
NAVSARI GUJARAT RESEARCH CENTRE			
	Training on "Brackishwater Aquaculture and Allied Technologies for Alternative Livelihoods"	26th to 28th June, 2019	76

PH.D STUDENT AWARD LIST APRIL 2019 TO FEBRUARY 2020

	Name of the Student	Thesis Title	Date
	Ms. D. Thulasi	Studies on sulfate - reducing bacteria sulfide toxicity and bioremediation in shrimp culture pond sediment. **Supervisor:** Dr. R. Saraswathy, Principal Scientist ICAR- CIBA Chennai	02nd April 2019
	Shri. M. Vasanth	Studies on Greenhouse Gases Emission from Coastal Aquaculture Systems **Supervisor:** M. Muralidhar, Principal Scientist ICAR- CIBA Chennai	18th September 2019
	Ms. V. Chitra	Role of pond soil fertility and water salinity on essential mineral availability in coastal shrimp farming. **Supervisor:** M. Muralidhar, Principal Scientist ICAR- CIBA Chennai	19th September 2019
	Shri. Prudhvi madhu babu	Comparative Study in Relation to Dietary Formulations on Digestive Enzymes in Brackishwater Fishes With Different Food Habits. **Supervisor:** Dr.J.Syama Dayal, Principal Scientist ICAR- CIBA Chennai	24th September 2019
	Shri. S. Nandakumar	Replacement of fishmeal with alternate protein sources in the diet of Asian Seabass, *Lates calcarifer* **Supervisor:** Dr. K. Ambasankar, Principal Scientist, ICAR- CIBA Chennai	30th January 2020
	Shri. S. Satheesh Kumar	Viability and Transmission of White Spot Syndrome Virus (WSSV) in shrimp Aquaculture **Supervisor:** Dr. S. V. Alavandi, Principal Scientist ICAR- CIBA Chennai	06th February 2020

Workshops, Seminars and Meetings

NABL Accreditation awareness program in collaboration with Food Safety Standards Authority of India (FSSAI) on 24th April, 2019

ICAR-CIBA organized accreditation awareness program in association with The Food Safety and Standards Authority of India (FSSAI) on April 24, 2019. Dr. K. K. Vijayan, Director, emphasised the need for collaborative network with stakeholders to strengthen the activities in achieving issues such as food safety management and competence of testing laboratories to ensure quality standards. Mr. N. Venkateswaran, Director, NABL, briefed the activities of NABL Accreditation, and Ms. Rini Narayan, Deputy Director, NABL, New Delhi presented in depth procedures for NABL Accreditation.

Interaction meeting with Bangladesh delegates on shrimp farming development and technological backup of ICAR-CIBA on April 25, 2019

An interaction meeting was jointly coordinated by ICAR-CIBA, Bay Of Bengal Programme (BOBP) along with Department of Fisheries, Coastal Aquaculture Authority of India (CAA) with the visiting scientist, officials of Govt of Bangladesh on April 25, 2019. The main purpose of this meeting was to provide a background knowledge on vannamei introduction in India and post vannamei aquaculture scenario in India to Bangladesh delegates. The team comprised 10 officials representing the Government of Bangladesh and 04 representatives of the private sector. Director CIBA, Dr K.K. Vijayan while welcoming the gathering briefed about the brackishwater aquaculture sector and the milestones over the period.
Dr C. Gopal, Member Secretary, CAA, presented the part of CAA as a national regulatory agency on coastal aquaculture activities.

World Environment Day was celebrated to emphasize the need to protect the environment. The theme of the World Environment Day, 2019 was "Beat the Air Pollution".

World Environment Day was celebrated at ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai to emphasize the need to protect the environment. The theme of the World Environment Day, 2019 was "Beat the Air Pollution". In his presidential address, Dr. K.K. Vijayan, Director, ICAR-CIBA, underlined the initiative taken by ICAR-CIBA on banning of plastic use in the institute premises, greening of campus with planting trees and converting fish waste into wealth with community participation. Dr. P. Saiprasad, Assistant Director of Tamil Nadu Pollution Control Board, Chennai was the chief guest and he spoke about the ill-effects of air pollution on human health and the measures taken by the government to combat it and the influence of environment on animal health. Dr. S. Suvana, Scientist, Environment Section proposed the vote of thanks.

The interaction meeting with self-help group of Sindhudurg district Maharashtra under the project on Livelihood security of coastal fisher community

ICAR-CIBA, Chennai in collaboration with Mangrove Foundation, Govt. of Maharashtra is implementing the project on "Brackishwater cage culture with multi-trophic candidate species in diverse rearing systems for alternate communities living near the mangroves. The first harvest of farmed seabass from one of the cages was carried out on June 15, 2019, at the cage farming site, Malvan, About 526 kg of Seabass fish harvested, each weighing about 500g was sold to a domestic fish trader at the site itself. A sum of Rs.2.0 Lakh was realised and handed over to the beneficiary fishers. During the interaction session, Dr. K.K Vijayan Director, CIBA and Chief Guest of the programme, highlighted the scope of brackishwater cage farming as a model for the production of healthy food, employment generation and increasing the income of the coastal folks. Shri.N.Vasudevan, Additional Principal Chief Conservator of Forests (APCCF), and Executive director, Mangrove Foundation, Govt. of Maharashtra said that the cage farming is the first step towards Blue-Green Revolution in brackishwater,

Fifth International Yoga Day celebrations

ICAR – Central Institute of Brackishwater Aquaculture (CIBA, Chennai) celebrated fifth international day of Yoga on June 21, 2019. As a prelude to International Yoga Day, a practical demonstration cum training programme on simplified yoga protocols was organized during June 17-21, 2019 at CIBA. Dr. K. Ambasankar, Principal Scientist and Nodal officer for yoga day, welcomed the gathering and briefed about the importance of yoga. Dr. K.K. Vijayan, Director, CIBA highlighted the significance of this yoga day and emphasized its relevance in today's lifestyle. It was followed by a theory cum practical session of yoga by Yoga trainer from Government Yoga and Naturopathy Medical College, Ms. Janani Subburaj.

Shrimp health and aquatic environment camp at Kaikaluru, Krishna District, Andhra Pradesh

The institute organized shrimp health and aquatic environment camp at Kaikaluru, Krishna District in Andhra Pradesh under the "**National Surveillance Programme for Aquatic Animal Health Diseases (NSPAAD)**" project to sensitize the shrimp farmers on emerging diseases and their prevention by adopting better management practices (BMPs). A total of 150 farmers and stakeholders from Kaikaluru attended the programme. The unique feature of shrimp health and aquatic environment camp was 'on-farm' testing of shrimp samples for important diseases such as white spot disease (WSD) and Enterocytozoon hepatopenaei (EHP) using real time PCR test at free of cost for the farmers.

Celebration of National Fish Farmers Day with the Coastal Fishers of Tamil Nadu and West Bengal

The institute celebrated the 'National Fish Farmers Day' on July 10, 2019 with a group of fishers and fish farmers at Thargas village Sirkazhi Taluk, Nagapattinam District, Tamil Nadu, to commemorate the epoch-making innovation in the field of induced breeding of Indian major carps by the renowned scientists Dr. K.H. Alikunhi and Dr. H.L Chaudhury on this day in 1957. The participants were sensitized about the cost-effective, sustainable fish farming models of CIBA for the livelihood security of coastal fishers. Dr. C.V. Sairam Principal Scientist and Scientist-In-Charge, Social Sciences Division, Dr. D. Deboral Vimala, and Dr. P. Mahalakshmi, Principal Scientists, Social Sciences Division of CIBA, coordinated the programme.

National Fisheries day Celebration in Kakdwip Research Centre of CIBA

Kakdwip Research Centre (KRC) of ICAR-CIBA observed the National Fish Farmers' Day on 10th July 2019 with the tribal fish farmers at village Mundapara, Manmathapur, Sundarban. Integrated farming of fish farming with livestock and horticulture was highlighted in the discussion with tribal farmers which is environment friendly and generates additional revenue. Tribal Women shared their experiences with integrated poultry and pig-cum- fish farming and desired to expand the culture interventions in the coming days with the technical support of ICAR-CIBA.

ICAR-CIBA conducted interface meeting with tribal fishers of Tiruvallur and Kancheepuram districts of Tamil Nadu under the CSR scheme

The institute conducted an interface meeting on July 24, 2019 as part of a Corporate Social Responsibility (CSR) project on "Knowledge and Economic Empowerment of women, tribal and their families in coastal villages of Tamil Nadu through adoption of brackishwater aquaculture and allied technologies integrated with societal development programmes" funded by *Chennai Petroleum Corporation Limited (CPCL)* a Group company of Indian Oil Corporation. About 30 tribal fishers from the coastal villages of Tiruvallur and Kanchipuram districts participated and interacted with subject matter scientists of CIBA and progressive aqua-farmer. Dr.K.K.Vijayan, Director, CIBA inaugurated the interaction and expressed that CIBA along with CPCL is striving for improving the livelihood opportunities of the resource poor tribal fishers through brackishwater aquaculture technologies and allied enterprises. Project along with Dr. C.V.Sairam, Head i/c, Social Sciences Division, CIBA.

Dr.Trilochan Mohapatra, Director General, ICAR & Secretary, DARE, Govt. of India visited CIBA on 7th August, 2019.

Dr.Trilochan Mohapatra, Director General, ICAR & Secretary, DARE, Govt. of India visited ICAR-CIBA, and had a discussion with the Scientists of CIBA and CMFRI, Chennai Centre Chennai on 7th August, 2019. While complimenting the work of the scientists he emphasized that scientists should increase their visibility and quality in their research output on par with international level. Dr.K.K.Vijayan, Director, CIBA briefed the DG about the salient research achievements of the institute and gratefully acknowledged the continued support from the ICAR and DARE for the research and development programme of the CIBA, Chennai.

Seventy-third Indian Independence day celebration

ICAR-CIBA celebrated its 73rd Independence Day on 15th August 2019 with pride and remembered the great sacrifices made by freedom fighters, to win freedom for India. Dr K K Vijayan, Director, CIBA hoisted the tricolour flag and delivered the independent day speech. In his address, he remembered the great sacrifices made by the great leaders and all those fought for Indian Independence. He highlighted that it is the duty of every Indian citizen to protect the idea of nation and to strive hard for sustainable growth and prosperity of the country.

Aqua Aquaria -2019 held at Hyderabad

ICAR-Central Institute of Brackishwater Aquaculture, Chennai partnered in the **Aqua Aquaria India 2019-Blue Revolution to India's hinterland** organized by the MPEDA, during August 30 to September 1, 2019 The ICAR-CIBA stall in the international aquaculture exhibition showcased the scientific accomplishments, technical know-hows developed and transferred by CIBA for the development of brackishwater aquaculture in the country. Honourable Vice President of India **Shri M. Venkaiah Naidu** visited the CIBA stall.

Jal Shakti Abhyan: ICAR-CIBA organized outreach activities for the school students to create awareness on water conservation

ICAR-CIBA organised outreach activities for high school students on September 5 and 10, 2019 in collaboration with the Krishi Vigyan Kendra, Kanchipuram, Tamil Nadu to inculcate the importance of water conservation, rain water harvesting and efficient utilization water. More than 1500 school students participated in the campaign and it is tantamount to communicating about 2000 families. The Govt. of India through the Jal Shakti Abhiyan envisages a time bound, mission mode water conservation and water security campaign aims at making water conservation a Jan Andolan through asset creation and extensive communication.

Secretary-level interactive meeting with stakeholders and coastal state governments

Interaction meeting was organized at MES CIBA on September 2019 to review the available infrastructure facilities for initiating a national level programme on selective breeding of *Penaeus indicus*, involving the Research Institutions, Developmental Departments and private sector and farmers on consortium mode. The meeting was chaired by Smt. Rajni Sekhri Sibal, IAS, Secretary, Department of Fisheries, Ministry of Fisheries, Animal husbandry and dairying.

Hindi week celebrations in ICAR-CIBA

ICAR-CIBA celebrated Hindi Week during 14th – 20th September 2019 to promote use of Hindi as official language. During the week, Hindi noting and drafting, translation, poem, Singing, Hindi prashnothri and extempore competitions were organized which were attended by scientists, staff and research scholars of CIBA. The valedictory function was organized on 20th September, 2019. On this occasion, Dr. K.K. Vijayan Director CIBA, released the 5th issue of annual Hindi magazine "Jal Tarang" and in his address Dr. K.K. Vijayan Director CIBA, remarked the linguistic diversity of India and importance of Hindi in communicating across Nation. Dr. Sujeet Kumar, Scientist and member of Hindi Cell presented the work carried out by Hindi cell during the year 2018-19. The program was coordinated by Dr. Krishna Sukumaran.

Bhatnagar awardee in Fishery biology Prof. T. J. Pandian delivered SCAFI Lecture series edition on Fish breeding and Genetics, 1st October 2019 at ICAR-CIBA Chennai

The Society of the Coastal Aquaculture and Fisheries (SCAFi) lecture series at ICAR-CIBA is intended to provide understanding and scientific discussions topics of importance in fisheries and aquaculture, and to give futuristic perspectives on research and role of science in day to day life. Prof. (Dr). T. J. Pandian opened up his talk on 'Fish Breeding and Genetics' with philosophy of science, starting from logistics, abstract and experimental studies. The lecture highlighted the importance of fish breeding in aquaculture through a series of anecdotes starting from Mendelian law of genetics, and even connecting how the genetics of haemophilia affected the Queen Victoria kingdom.

Harvest mela cum farmers interaction meet in Gujarat

NGRC of CIBA along with Department of Fisheries, Govt. of Gujarat, jointly organised a harvest mela cum farmer's interaction meet on October 19, 2019 in connection with the harvest of *Penaeus indicus* farming carried out at the BARD farm, Matwad village, Navsari. The interaction was inaugurated by Dr. C. G. Dangaria, Vice Chancellor, Navsari Agriculture University (NAU), Navsari in the presence of Dr. K. K. Vijayan, Director, ICAR-CIBA, Chennai. Around 120 participants including village panchayat president, progressive fish and shrimp farmers attended the program.

World Fisheries Day advocating aquaculture in brackishwater for the livelihood security of fishers

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) observed the World Fisheries Day on 21st November 2019 along with fishers of neighbouring villages at Muttukkadu Experimental Station, Chennai to sensitize them on adoption of aquaculture in the brackishwaters for fish production, alternative livelihood development and doubling their income. During the interaction Dr.K.K.Vijayan, Director, CIBA emphasized that aquaculture in brackishwaters is an economically viable activity for the coastal fishers to provide alternative employment and income generation to the fishers.

ICAR-CIBA, Chennai observed the Constitution Day on 26th November, 2019

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA), Chennai observed the Constitution Day on 26, November, 2019. During this occasion the Director, Scientists, Officers, Staff and research scholars took the pledge by reading out the Preamble of the constitution of India. A banner indicating the constitution day (Samvidhan Divas) was also put up during the occasion.

Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE and DG-ICAR, visited ICAR-CIBA and interacted with scientists 1st December 2019

Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR visited ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) on 1st December and interacted with Heads of Division and unit in-charges of various sections about the newer developments in research areas in CIBA Chennai, and its impact on the sector. Scientists explained the highlights of research outputs and technology transfer in the areas of species diversification, feed biotechnology, disease management, genetics & genomics and societal interventions.

ICAR-CIBA Celebrated World Soil Day along with aqua farmers of North Kerala on 5th December 2019 and distributed soil and water health cards to aqua farmers

ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) celebrated the World Soil Day in consort with the aquafarmers of Kannur in Kerala State on December 5, 2019 under the Guidance of Dr.K.K.Vijayan, Director of CIBA. CIBA in collaboration with Kerala Aqua Farmers Federation (KAFF) conducted a workshop on "Better Management Practices in Brackishwater Aquaculture" to sensitize the farmers on sustaining ecosystems and the importance of soil and water fertility in aquaculture on this occasion. Soil and water health cards (SWHC) were issued to 60 which were prepared based on their soil and water investigations in the programme. Dr. Devika Pillai Professor, Aquatic Animal Health Management, Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, who inaugurated the workshop explained the importance of soil and water quality parameters in aquaculture.

Waste to wealth product from ICAR-CIBA 'PlanktonPlus' helped to increase the shrimp production and income of farmers in Sundarban area

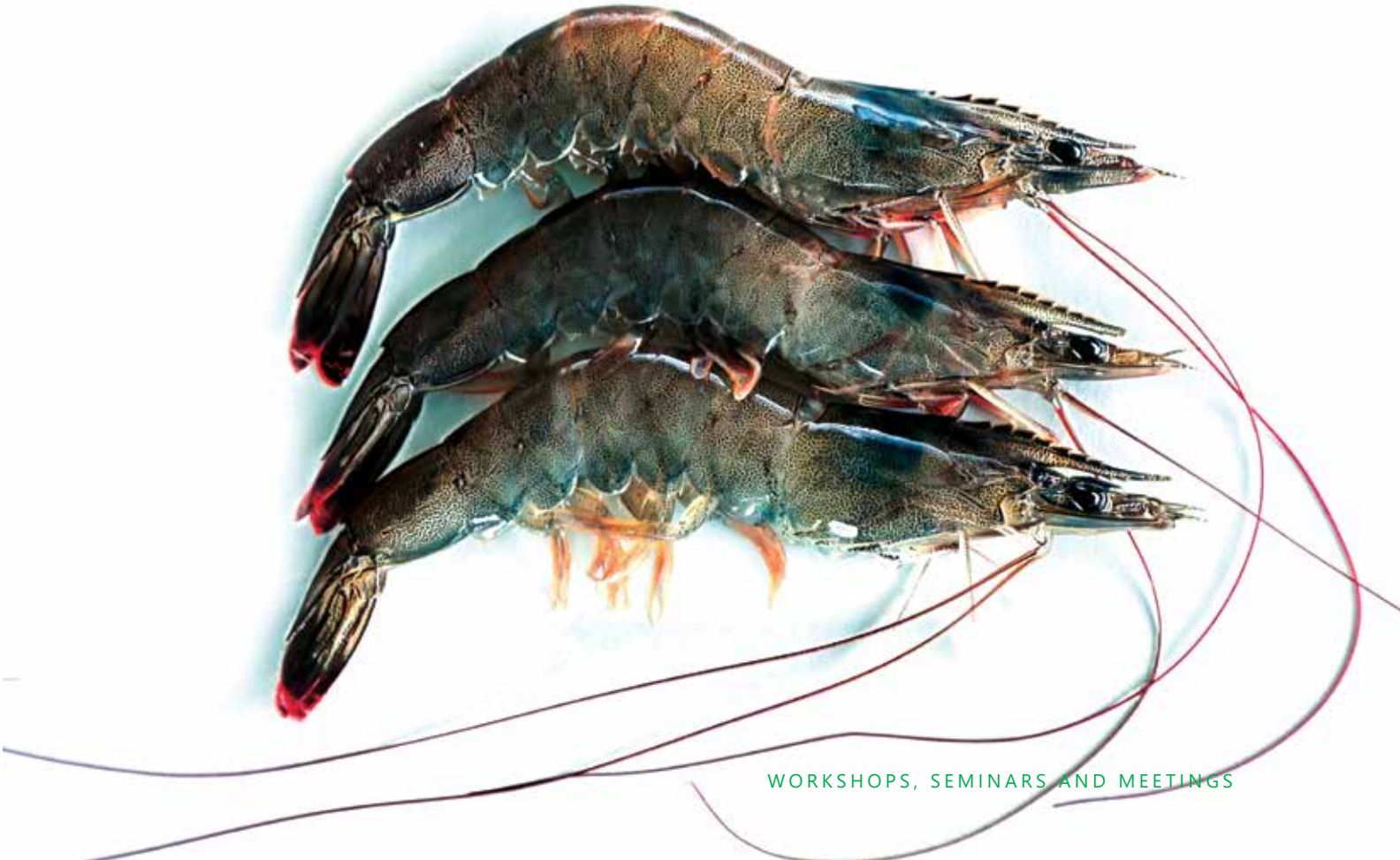
ICAR-CIBA developed Plankton^{Plus}, a plankton booster and growth promoter from fish waste and demonstrated its potential use for *P. vannamei* culture among the farmers of West Bengal. Kakdwip Research centre of CIBA organized a Farmers' Meet-cum-Harvest Mela at Dwariknagar, Namkhana on December 7, 2019, where the shrimp produced using Plankton^{Plus} technology was harvested and witnessed by 150 shrimp farmers, representatives from local Gram Panchayat, Officials from the Dept. of Fisheries.

Haryana Senior Cabinet Minister Shri. J.P Dalal visited the shrimp feed mill established at Bhiwani with ICAR- CIBA Technology

Haryana senior cabinet minister Shri J.P Dalal visited 'Dr. Attar Aqua feed mill' established on Public Private Partnership (PPP) mode by ICAR-CIBA, through non-exclusive technology transfer, at Bhiwani, Haryana. Honourable Minister interacted with feed mill entrepreneur and shrimp farmers and assured his support of aquaculture development in Haryana. He has seen the operation of feed mill and the total process involved in the shrimp feed preparation. He acknowledged the efforts of CIBA in establishing the feed mill in Haryana using the indigenous and cost effective feed technology developed by CIBA benefiting the farmers in the northern India.

ICAR-CIBA observed Kisan Diwas at Ganeshnagar village, Sundarban, West Bengal on 23rd December 2019

Kakdwip Research Centre of ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Kakdwip, West Bengal organised the Kisan Diwas in connection with National Farmers Day as an activity of Swachhta Pakhwada at Ganeshnagar village, in South 24 Parganas district, West Bengal.



Awards & Recognition

ICAR-CIBA WON "BEST STALL AWARD" IN THE SWASRAYA BHARAT-KERALA SCIENCE FEST 2019

For displaying the scientific achievements and technologies developed and transferred by CIBA for the development of brackishwater aquaculture in the country, the institute bagged the "**Best Stall Award**" and the award was presented by Hon'ble Governor of Kerala, Shri. Arif Mohammad Khan during the valedictory function held during the concluding day on November 26th 2019.

Linkages & Colloborations

THE INSTITUTE MAINTAINED LINKAGES WITH THE FOLLOWING NATIONAL AND INTERNATIONAL ORGANIZATIONS

NATIONAL ICAR INSTITUTES

CMFRI	**ICAR - Central Marine Fisheries Research Institute, Kochi, Kerala** **Photo gallery**
	ICAR - Central Inland Fisheries Research Institute, Barrackpore, West Bengal **Photo gallery**
	ICAR - Central Institute of Fisheries Technology, Kochi, Kerala **Photo gallery**
	ICAR – Central Institute of Fisheries Education, Mumbai, Maharashtra **Photo gallery**
NBFGR	**ICAR – National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh** **Photo gallery** **Ganga Aquarium**
CIFA	**ICAR - Central Institute of Freshwater Aquaculture, Bhubaneshwar, Odisha** **Photo gallery**
	ICAR – Directorate of Coldwater Fisheries Research, Bhimtal, Uttarakhand **Photo gallery**
CIARI	**Central Island Agricultural Research Institute Port Blair**
	Central Research Institute for Dry land Agriculture, Hyderbad
	Directorate of Seed Research, MaU
Directorate of Research on Women in Agriculture	**Directorate of Research on Women in Agriculture**
naarm	**National Academy of Agricultural Research Managmentt, Hyderbad**

OTHER INSTITUTES/SAUS/STATE AGRICULTURAL DEPARTMENTS

Agricultural and processed food products Export development authority, New Delhi
Centre for Advanced studies in Marine Biology, Annamalai University, Parangi Pettai
Coastal Aquaculture Authority, Chennai
College of Fisheries, University of Agricultural science, Mangalore
College of Fisheries, Sri Venkateswara Veterinary University, Muthukur
Department of Horticulture, Government of Tamil Nadu, Chennai
Department of Animal Husbandary, Govt of Tamil Nadu, Chennai
Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, New Delhi
Depatment of Biotechnology, New Delhi
Fisheries College and Research Insttitute, Tamil Nadu Veterinary and Animal Science University, Thoothukudi
Indian Institute of Technology, Chennai
Mangrove Cell, Government of Maharashtra, Mumbai
Ministry of Science and Technology, New Delhi
Ministry of Water Resoruces, New Delhi
Marine Product Development Authority , Cochin
Navsari Agricultural Universiy, Navasari, Gujrat
National Fishereis Development Board, Hyderbad
National Institute of Ocean Technology, Chennai
Sundarban Development Board,
Govt of West Bengal
Tanil Nadu Agricultural University, Chennai
Tamil Nadu Veterinary and Animal Science University, Chennai
Tamil Nadu Agricultural University, Coimbatore
Tamil Nadu Dr J. Jayalalithaa Fisheries University
University of Madras, Chennai
West Bengal University of Animal And Fisheries Science, Kolkata

STATE FISHERE DEPARTMENTS/BFDAS

The institute has well established linkate with state Fishereis and Dept./BFDAs mainly for transfer of technologies

Consultancies, Technology Development & Transfer

INSTITUTE TECHNOLOGY MANAGEMENT AND AGRI BUSINESS INCUBATION UNIT (ITMU) & (ABI)

Transfer of Plankton^{Plus}, and Horti^{Plus} production technology and product marketing to Nambikkai Fish Farmers Group, Chennai and Coastra Biosolutions Pvt Ltd., Chennai

MoU was signed with the Coastra Biosolutions for production and marketing of Plankton booster, Plankton^{Plus} and manure for horticulture, Horti^{Plus} from fish waste on April 5, 2019. Under the agreement, the ICAR-CIBA will provide the necessary training to the Nambikkai Fish Farmers Group on production technology of Plankton^{Plus} and Horti^{Plus} from fish waste. Nambikkai Fish Farmers Group, Nambikkai Nagar, Chennai., and Coastra Biosolutions Pvt Ltd., will be marketing the products produced by the Nambikkai Fish Farmers Group under intimation to ICAR-CIBA.

Ornamental fish entrepreneur from Kerala, signed MoU for taking up brackishwater ornamental fish rearing technology and trade

ICAR-CIBA has identified the brackishwater ornamental aquariculture as a sector with greater growth prospects in the country. As a part of this, Central Institute of Brackishwater Aquaculture (CIBA), Chennai signed a MoU with Mr. Joshy Paul, 'Ornamental Fish Entrepreneur', a progressive ornamental fish breeder and trader from Thrissur, Kerala.

MoU with Academy of Maritime Education and Training (AMET), Deemed University, Chennai for Research Collaboration on the Frontiers of Live Feed Production for aquaculture

MoU was signed with Academy of Maritime Education and Training, (AMET, Deemed to be University), on the 15th May 2019 for technical collaboration on the frontiers of live feed production. Under the agreement, CIBA and AMET will collaborate on the research aspects of copepod biology and scaling up the production of selected species of copepod for larviculture of economically important brackishwater fish species.

MoU for the technology transfer of 'Colourfishfeed', indigenous formulated feed for ornamental fishes, with Techno feeder, Pvt, Ltd, Chennai on 11th June 2019

The institute has carried out detailed research program on feed development for the emerging ornamental fish rearing and developed a novel "Colourfish *feed*", an import substitute, for aquarium fish rearing. This feed is scientifically formulated to maintain good health and colour of the ornamental fish. The technology transfer on a non-exclusive basis is for the customized feed mill and scaling up of ornamental fish feed production. Techno Feeder Private limited, Chennai signed MoU with CIBA on 11th June 2019, through the MoU, the company envisaged to produce the ornamental feed with CIBA's technical guidance.

Maharashtra government signed MoU for the seabass hatchery technology

Maharashtra government has signed an agreement with the ICAR-CIBA to boost its farmed fish production in the State. The MoU involves setting up of a state-of-the-art seabass hatchery with the state government's funding and continuing the partnership of CIBA with Mangrove Foundation of Maharashtra in the promotion of brackishwater cage farming, which has evolved as a successful model in providing alternative livelihood for the coastal villagers.

M/s. Raj Hatcheries, Pvt Ltd. West Bengal signed MoU for the technology alliance on milkfish hatchery

MoU was signed with Raj Hatcheries (Bengal) Pvt. Ltd., East Midnapur district, West Bengal on 17th Sep, 2019 for transfer of milkfish (*Chanos chanos*) hatchery technology and to set up a state of the art finfish hatchery in West Bengal.

CMR Feed and Bio Supplements signed an MoU for acquiring shrimp feed technology

The CMR Feed and Bio Supplements, Chennai, signed a Memorandum of Understanding (MoU) with ICAR-CIBA on 1st Nov 2019 for the transfer of shrimp feed (VanamiPlus) technology on a non-exclusive basis.

Farmer entrepreneur of Pulicat, Tamil Nadu signed MoU for marketing PlanktonPlus on non-exclusive basis

Fisher Self Help Group, Nambikkai fish farmers group, produces PlanktonPlus with a technical support of CIBA. A farmer entrepreneur Shri. A. John Britto, Pulicat, Thiruvallur district, Tamil Nadu came forward to take up the marketing rights of the product. A Memorandum of Understanding (MoU) was signed in this regard on 4th November, 2019 at CIBA and supply the product to Shri John Britto for marketing the product among the aquaculturists in the region.

PATENTS GRANTED

Sl. No.	Date of filing	App. No.	Title of the Invention	Inventors	Application Status
1.	11/02/2011	347/DEL/2011	Development of an assay and kit for molecular screening of Betanodavirus by nested reverse transcription polymerase chain reaction (nested RT-PCR).	Dr.K.P. Jithendran and Sh.CP. Binesh	Granted Application, Patent Number : 315677 on 09/07/2019

REVENUE GENERATED

Sl.No.	Name of the client	Consultancy/Technology transfer	Received (*in Rs.*)
1	Nambikkai Fish Farmers group, Patinapakkam, Chennai	Partnership in Establishing Fish Waste Processing unit and Recycling of Fishwaste	31,706
2	Sri.Nagakishore Mudela & Sri. Syamala Rao Maradani, Krishna Dist, AP.	Transfer of Technology on Plankton^{plus}	3,54,000
3	NRG Feeds, West Bengal	Polyculture feed processing and Production	1,18,000
4	Dr.Attar aqua feed, Haryana	Shrimp feed processing and production	1,26,000
5	M/s. Pranita Marines, West Godavari, AP	Shrimp feed processing and production	59,000
6	Techno Feeder Pvt. Ltd, Chennai-600042.	Color fish^{plus}-CIBA ornamental Fish Feed	2,36,000
7	Freshto home foods private limited, Bangalore	Fish Feed Production	1,08,000
8	Kailash Hatcheries, Odisha	Knowledge partnership for eco-friendly biofloc based technology	70,800
9	Raj Hatcheries (Bengal) Pvt.Ltd., West Bengal	Milkfish (*Chanos Chanos*) Seed Rearing and Captive Broodstock Development	2,36,000
10	CMR feeds, Chennai	Shrimp feed processing and production	7,08,000
11	Eccogen feeds, Ernakulam, Kerala	Seabass feed processing and production	59,000
12	John Britto, Chennai	Marketing rights of CIBA-Plankton^{Plus}	5,000
		Total	**21,11,506**

Official Language Implementation Program

HINDI WEEK CELEBRATIONS IN ICAR-CIBA

In order to promote use of Hindi as official language, ICAR-CIBA celebrated Hindi Week during September 14 – 20, 2019. During the week, Hindi noting and drafting, translation, poem, Singing, Hindi prashnotri and extempore competitions were organized which were attended by scientists, staff and research scholars of CIBA. The valedictory function was organized on September 20, 2019. On this occasion, Dr. K.K. Vijayan, Director, CIBA, released the 5 th issue of annual Hindi magazine "Jal Tarang" and distributed the award to winners of Hindi competition and under Hindi incentive scheme. In his address, he remarked the linguistic diversity of India and importance of Hindi in communicating across Nation. Dr. Sujeet Kumar, Scientist and member of Hindi Cell presented the work carried out by Hindi cell during the year 2018-19. The program was coordinated by Dr. Krishna Sukumaran.

भा.कृ.अनु.प. - सीबा में हिंदी सप्ताह का आयोजन

सीबा ने हिंदी के आधिकारिक भाषा के रूप में उपयोग को बढ़ावा देने के लिए 14 - 20 सितंबर 2019 के दौरान हिंदी सप्ताह मनाया। सप्ताह के दौरान, हिंदी नोटिंग और प्रारूपण, अनुवाद, कविता, गायन, हिंदी प्रश्नोट्री और एक्सपेम्पोर प्रतियोगिताओं का आयोजन किया गया, जिसमे सीबा के वैज्ञानिक, कर्मचारी और शोध छात्र उपस्थित थे। 20 सितंबर, 2019 को समापन समरोह का आयोजन किया गया । इस अवसर पर, सीबा निदेशक , डॉ। के.के. विजयन ने वार्षिक हिंदी पत्रिका "जल तरंग" का 5 वां अंक जारी किया और हिंदी प्रतियोगिता के विजेता और हिंदी प्रोत्साहन योजना के तहत पुरस्कार वितरित किया। अपने अध्यक्षीय भाषण में, उन्होंने भारत की भाषाई विविधता और विशेष रूप से हिंदी के महत्व पर टिप्पणी की। डॉ। सुजीत कुमार ने वर्ष 2018-19 के दौरान हिंदी सेल द्वारा किए गए कार्यों को प्रस्तुत किया। कार्यक्रम का समन्वय डॉ। कृष्ण सुकुमारन ने किया।


CIBA
ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE, CHENNAI
हिंदी सप्ताह समारोह
14th - 20th सितंबर, 2019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CIBA


ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE, CHE
हिंदी सप्ताह समारोह
14th - 20th सितंबर, 2019

Research & Administrative Meetings

INSTITUTE RESEARCH COUNCIL

Chairman	**Dr. K.K.Vijayan, Director**
Members	Assistant Director General (M.Fy.), ICAR, New Delhi Dr. S.V. Alavandi, Principal Scientist Dr. C. P. Balasubramanian, Principal Scientist Dr. M. Kailasam, Principal Scientist Dr. M. S. Shekhar, Principal Scientist Dr. C. V. Sairam, Principal Scientist Dr. M. Muralidhar, Principal Scientist Dr. K. Ambasankar, Principal Scientist Principal Investigators of all the projects
Member Secretary	Dr. Subhendu Kumar Otta, Principal Scientist

The 36th IRC Meeting was held on 2-3rd April 2019 and the progress of research work was reviewed.

INSTITUTE MANAGEMENT COMMITTEE (IMC)

The Institute Management Committee has been constituted as follows:

Chairman	**Dr. K.K.Vijayan, Director**
Members	Dr. Pravin Puthra, ADG (M.Fy.), ICAR Dr. Sudhansu Sekhar Mishra, Principal Scientist, ICAR- CIFA, Bhubaneswar Dr. V.R. Suresh, Principal Scientist, ICAR-CIFRI, Barrackpore, West Bengal Dr. Vindhya Mahendra, Principal Scientist, ICAR-NBFGR, Lucknow Dr. Shekarnath Ojha, Principal Scientist, ICAR-CIFE, Mumbai Commissioner of Fisheries, Govt. of Tamil Nadu, Chennai Commissioner of Fisheries, Govt. of Gujarat, Gandhi Nagar The Dean, FCRI, TANUVAS, Thoothukudi FAO, IIHR, Bangalore
Member Secretary	Dr. M. Kumaran, Principal Scientist & Head of Office
Co-opted Members	Dr. S. K.Otta, Principal Scientist, OIC, PME Cell Dr. M. Jayanthi, Principal Scientist & OIC Engg. Cell Dr. K.P. Kumaraguru vasagam Shri R.K.Babu, Finance & Accounts Officer Shri. R. Kandamani, AAO (Stores) Smt. V. Usharani, AAO (Estt.) Shri S. Pari, AAO & DDO Shri. P. Srikanth, Junior Accounts Officer
Non-Official Members	Sh. S. Satish Kumar, Farmers' Representative Sh. R.P. Venkatachalam, Farmers' Representative The 51st IMC meeting held on 19th July 2019.

HINDI CELL

The Hindi Cell has been constituted as follows:

Chairman	**Dr. M. Shashi Shekhar, Principal Scientist**
Members	Dr. Krishna Sukumaran, Scientist Dr. Sujeet Kumar, Scientist Ms. Babita Mandal, Scientist Dr. Suvana Sukumaran, Scientist

INSTITUTE JOINT STAFF COUNCIL (IJSC)

The composition of the Institute Joint Staff Council (reconstituted by CIBA for a period of three years w.e.f 03.08.2019 to 02.08.2022 vide Office Order F.No.13-1/2012-Admn. Dated 14.08.2019) is as follows:

Official Side	
Chairman	**Dr. K.K.Vijayan, Director**
Members Secretary	Dr. T. Ravisankar, Principal Scientist
Members	Dr. K. Ambasankar, Principal Scientist Dr. M. Kailasam, Principal Scientist Dr. P. Mahalakshmi, Principal Scientist Shri R. Elankovan, Chief Technical Officer Shri R. K. Babu, Finance & Accounts Officer
Staff Side	
Secretary	Shri N. Jagan Mohan Raj, Sr. Technical Asst.
Members	Shri S. Saminathan, Technical Officer Shri P. Srikanth, JAO Smt. E. Mary Desouza, Assistant Shri C. Raghu, Skilled Support Staff Shri R. Mathivanan, Skilled Support Staff

GRIEVANCE COMMITTEE

The composition of the Institute Grievance Committee (reconstituted by CIBA vide Office Order F.No.48-16/2010-Admn. dated 02.07.2019) is as follows:

Chairman	**Dr. K.K.Vijayan, Director**
Elected Members	
Scientific Members	Dr. K. Ambasankar, Principal Scientist Dr. Nila Rekha, Principal Scientist
Technical Member	Dr. Joseph Sahaya Rajan, Senior Technical Officer
Administrative Members	Mrs. Usha Rani, A.A.O Shri P. Srikanth, J.A.O
Staff Member	Shri. R.Mathivanan, Skilled Support Staff

WOMEN COMPLAINT COMMITTEE

Women Complaint Committee has been constituted as follows:

Chairman	**Dr. R. Saraswathy, Principal Scientist**
Members	Dr. Prasanna Kumar Patil, Principal Scientist Dr. P. Nila Rekha, Principal Scientist Shri N. Jagan Mohan Raj, Sr. Technical Asst Smt. E. Mary Desouza, Assistant

External Member Dr. A. Sumathi, Asst. Prof. & Head–in-Charge, Dept. of Biomedical Sciences , Sri Ramachandra Medical College, Porur, Chennai

WOMEN CELL

Women Cell has been constituted as follows:

Chairman	**Dr. D. Deboral Vimala, Principal Scientist**
Members	Dr. R. Saraswathy, Principal Scientist Smt. B. Amudavalli, Assistant Smt. K. Hemalatha, Stenographer Smt. K. Subhashini, PA
Members Secretary	Shri R. Kandamani, AAO

LIAISONING COMMITTEE

Liaisoning Committee has been constituted as follows:

Chairman	**Dr.S.Kannappan, Principal Scientist**
Members	Dr. K. Ambasankar, Principal Scientist Dr. R. Saraswathy, Principal Scientist Dr. Akshaya Panigrahi, Principal Scientist Dr. M. Kumaran, Principal Scientist Dr. P.K. Patil, Principal Scientist

Services & Assignments

SERVICES IN COMMITTEES

Dr.K.K.Vijayan, Director

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

• Member -ICAR Regional Committee No.VIII

• Executive Committee Member - National Centre for Sustainable Aquaculture (NaCSA)

• Member - Coastal Aquaculture Authority

• Member - Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur.

• Member - Scientific Advisory Committee for Dr. Perumal Krishi Vigyan Kendra

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

• Member - Board of Management of Tamil Nadu Fisheries University, Nagapattinam.

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

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

• Member - Board of Management of Central Institute of Fisheries Education, Mumbai.

• Member - National Committee on Introduction of Exotic Aquatic Organisms into Indian waters, constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi.

• Member - Advisory Committee on Hilsa Conservation and Research

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

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

• Member - Society of Coastal Aquaculture and Fisheries

• Member - Society for Fisheries Technologists

• Member - Marine Biological Association of India

• Member of Faculty in the Board of Studies of Cochin University of Science and Technology (CUSAT), Kochi.

• Member – Tamil Nadu State Council for Science and Technology, Chennai

• Selection Committee Member – Tamil Nadu Scientist Award (TANSA) constituted by Tamil Nadu State Council for Science and Technology.

• Member - High Power Society "Society for Promotion of Shrimp Farming in Punjab", headed by Additional Chief Secretary, Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, constituted by Department of Fisheries, Punjab.

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

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

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

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

• Member - Steering Committee for the Asian Pacific

Aquaculture 2019 (APA 2019) event to be held on 18-21 June 2019 in Chennai.

• Member - Sub-Committee to work out modalities for engaging Consultants in Coastal Aquaculture Authority.

• Member - Central Standing Committee (CSC) on Pradhan Mantri Matsya Sampada Yojana (PMMSY) for formulation of unit cost norms, unit costs and guidelines in respect of all the components and sub-components of the PMMSY

• Member - National Advisory Committee of the National Symposium on "Coldwater fisheries development in India : Innovative approaches and way forward for enhancing hill farmers income", organized during 24-25 September 2019.

• Member - National Advisory Board of the International Symposium on Coastal Agriculture (ISCA) organized by Indian Society of Coastal Agricultural Research during 5-8 November 2019 at Kolkata

• Member - Committee for reviewing financial elements of programmes under the Deep Ocean Mission Proposal, constituted by NIOT, Chennai.

Scientists

• Delivered lecture as a Guest lecturer on "Cost effective feed development for farming of brackishwater finfish and shellfishes" in ICAR-Sponsored 21-days Winter School organized by Department of Animal Nutrition, WBUAFS on 17th September, 2019 – Dr.Debasis De

• Participated as resource person in the Farmers' Day celebrations organized by ICAR-CSSRI, Regional Research Station, Canning Town on 27th November, 2019 – Dr. Debasis De

• Acted as expert member for sustainable development of Jharkhali Fish Farm of Sundarban Development Board, Govt. of West Bengal on 6th May, 2019 – Dr.T.K.Ghoshal

• Delivered a a guest lecturer at training programme of progressive farmers at Kakdwip organized by Sundarban Development Board during September 18-27, 2019 – Dr. Sanjoy Das

• Delivered a lecture as a Guest lecturer on Brackishwater Fish Farming in a training programme organized by Sundarban Development Board, Govt. of West Bengal on 20 September 2019 at Kakdwip, South 24 Parganas Dr. Gouranga Biswas.

Arya

Implementation of ARYA (Attracting and retaining Youth in Agriculture, i.e., Aquaculture)

Under the ARYA **(Attracting and retaining Youth in Agriculture, i.e., Aquaculture)** initiatives, orientation was given to the school students at Govt. Higher Secondary School, Pakkam, Tiruvallur dt. on 8.1.19. Twenty five school students were made aware of ornamental fish culture and simple techniques to be followed in ornamental fish aquarium tank maintenance. In line with this and interest shown by this school students. It was decided to donate an ornamental fish aquarium tank to Govt. Higher Secondary School, Pakkam, Tiruvallur dt. So, under the CIBA/CPCL CSR Project No. 519 project funds an ornamental fish aquarium tank was installed in this school on 25.2.19 The school students actively participated in ornamental fish aquarium tank maintenance along with their teachers.

Swachhta Pakhwada

Swachhta Pakhwada was conducted at Kanavanthurai and Senjiamman tribal villages, Tiruvallur district Tamil Nadu. Students from Loyola college, Chennai and Govt. Higher Secondary School , Pakkam, Tiruvallur dt. around 75 numbers participated in this programme and conducted street play and cultural programme to create awareness on cleanliness among the villagers. Village heads, Villagers, beneficiaries of project participated in this programme. 7 Poster titled "Save nation", Say no to rubbish in the brackishwater resources", "Keep your village clean", "Keep environment clean", "Need more oxygen. Ask a tree", " Keep our nation clean" and " Cleanliness is first law of health" was released and distributed to the students. A short film on this programme was also developed. Initiatives were taken to clean the community pond in the village, fish ponds and streets within the village. Cleaning materials, T.shirts and caps with slogan was printed and distributed to the beneficiaries and participants.

Jal Shakti Abhyan

Under Attracting and Retaining Youth in Aquaculture (ARYA), ICAR-CIBA organised outreach activities for high school students on 5th and 10th September 2019 in collaboration with the Krishi Vigyan Kendra, Kanchipuram, Tamil Nadu to inculcate the importance of water conservation, rain water harvesting and efficient utilization water. More than 1500 school students participated in the campaign and it is tantamount to communicating about 2000 families. The Govt. of India through the Jal Shakti Abhiyan envisages a time bound, mission mode water conservation and water security campaign aims at making water conservation a Jan Andolan through asset creation and extensive communication. As part of the campaign the scientists of CIBA and KVK conducted essay writing, elocution competitions and audio-visual presentations for the students of Chennai High School Mylapore on 5th September, 2019 and Muruga Dhanuskodi Girls Higher Secondary School at Tondiarpet, Chennai on 10th September, 2019. Further, the students were given exposure on the gravity of water resources depletion, water pollution and its impact and the importance of afforestation, rain water harvesting, conservation and efficient usage of water. During the occasion, water conservation pledge was administered to the students.

Mera Gaon-
Mera Gaurav

Mera Gaon-Mera Gaurav, a program which is launched by ICAR in order to realize Prime Minister's lab to land program, has been successfully implementing by ICAR-CIBA since its inception. Scientists were grouped in to 12 teams to work on each selected village, and these groups regularly interacted with the farmers in order to provide scientific and technological helps. During this year, front line demonstrations were conducted on nursery rearing of Seabass in hapas, Seabass grow-out culture, milkfish culture, Pear spot larval rearing techniques and mud crab culture. ICAR-CIBA inaugurated a Fish Waste Processing Unit at Pattinapakkam, Chennai which is operated by a Self Help Group (SHG) for recycling of fish waste to high-value products. The institute has sensitized farm women/fisherfolk in earning their livelihood as a group and was mobilized in adopting brackishwater aquaculture technologies. The sizable portions of farm women/ fisherfolk were provided access to the brackishwater aquaculture technologies and skill development to acquire empowerment to improve their standard of living economically. A total of 246 activities was conducted and 1688 farmers and farm women were benefitted out of it.

Swachh Bharat Mission

ICAR-CIBA URGED STUDENTS AND FARMERS TO SHUN SINGLE USE PLASTICS IN WORKSPACE, MARKETS THROUGH THE SWACHH BHARAT ACTIVITIES

"Swachh Bharat Abhiyan (SBA)", or Clean Indian Mission" a campaign launched by Prime Minister of India, Shri Narendra Modi, on October 2, 2014 towards the goal of clean up the streets, roads and infrastructure of cities, towns, and rural areas. Since then ICAR-CIBA has been taking sincere efforts to fulfil this major goal. During the current year, The Prime Minister of India has called upon the nation to begin a campaign to shun single use plastic, from September 11, 2019 to October 2, 2019, Gandhi Jayanti and Swachhta Pakhwada from 16– 31 December 2019. The main aim of the campaign was to highlight the importance of avoiding the single use plastics and how to control the plastic pollution around the globe.

As a part of the campaign, CIBA scientists has organized 'swachhata' activities at Institute headquarters, Research centres and field stations at West Bengal, Gujarat, and Muttukadu (KRC of CIBA, Kakdwip, West Bengal, MES of CIBA, Muttukadu and NGRC of CIBA, Navsari, Gujarat). Several programs were organized involving villagers and school children: Awareness programmes on plastic pollution, reduction, reuse and recycling of plastics, essay writing; elocution, drawing competition to school children. More than 600 participants, scientists, staff, farmers and school students participated in the various activities.

Awareness programmes at Santhome, Chennai - ICAR-CIBA, Chennai

Rallies of students and staff of CIBA at Santhome Public pathway, Chennai, Tamil Nadu

Rallies, Chennai High School, Mylapore, Chennai – ICAR-CIBA, Chennai

Rally on the Highway Road followed by an awareness programme, Muttukadu, Kancheepuram, Tamil Nadu- ICAR-CIBA, Chennai

Celebrated "150th Birth Anniversary of Mahatma Gandhi: In relation with agriculture and its allied sector" among school students at Mylapore, Chennai, Tamil Nadu and Matwad Primary School, Matwad, Navsari, Gujarat. Scientists of CIBA explained various means to shun single-use plastic and to sensitize the children on swatch bharat mission and minimizing the use of single usage plastics and a pledge in this regard was administered to the participants. Essay, drawing and elocution competition were conducted among students and prizes were distributed.

Pledge on shun single-use plastic by ICAR-CIBA, Chennai Staff, school students and teachers

Speech competition for primary school students of Matwad Primary School, Matwad, Navsari, Gujarat

CIBA campus is maintaining as “Plastic Free Zone” since 31st December 2018, and replaced plastic cups, plastic bags, and plastic water bottles with ceramic tea cups, cloth and jute bags and stainless steel water bottles respectively. Institute has distributed stainless steel water bottles to 25 beneficiaries from adopted village, Nammbikkai Nager and Srinivasapuram, Chennai, Tamil Nadu and plastic collection bin to Chennai High School, Mylapore, as a symbol of implementation of plastic free environment in the coastal areas. Through the various Swachh activities the participants understood the importance on the call on shun Single Use Plastics and affirmed solemnly on avoidance of Single Use Plastics to make our country greener and plastic free.

Distinguished Visitors

DISTINGUISHED VISITORS 2019

Sl. No	Details of visitors	Date of visit
HEADQUARTERS		
1	Ms. Pallavi Gautham, Technical officer, FSSAI, New Delhi	24.04.2019
2	Ms. Rini Narayan, Deputy Director, NABL, New Delhi	24.04.2019
3	Mr. N. Venkateswaran, Director, NABL, New Delhi	24.04.2019
4	Ms Mahbooba Panna, Joint Secretary, Ministry of Fisheries and Livestock, New Delhi	25.04.2019
5	Dr. Y. S. Yadava, Director, BOBP, Chennai	25.04.2019
6	Dr C. Gopal, Member Secretary, Coastal Aquaculture Authority, Chennai	25.04.2019
7	Mr. Joshy Paul, 'Ornamental Fish Entrepreneur', a progressive ornamental fish breeder and trader from Thrissur, Kerala	08.05.2019
8	Dr. P. Saravanan, Registrar, AMET Academy of Maritime Education and Training,	15.05.2019
9	Sri Nagakishore Mudedla and Sri Syamala Rao Maradani, Aqua-entrepreneurs, Gudivada, Krishna district, Andhra Pradesh,	16.05.2019
10	Dr. P. Saiprasad, Assistant Director of Tamil Nadu Pollution Control Board, Chennai	05.06.2019
11	Mr. Ranjith Manivannan, Director, Techno Feeder Private limited, India	11.06.2019
12	Shri Kaushikbhar, Senior Manager, CPCL Chennai	24.07. 2019
13	Shri Eraniyappan, a progressive aqua-farmer	24.07. 2019
14	Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE and DG, ICAR, New Delhi	07.08. 2019
15	Mr. Arokiaswamy, Managing Director, Raj hatchery.	17.09.2019
16	Smt. Rajni Sekhri Sibal, IAS, SecretarySecretary, Department of Fisheries, Ministry of Fisheries, Animal husbandry and Dairying, Government of India	25.09.2019
17	Shri K.S.Srinivas, IAS, Chairman, MPEDA	25.09.2019
18	Dr. Pravin Puthra, ADG (Marine Fishery), ICAR, New Delhi	25.09.2019

19	Ms.I.Rani Kumudhini, IAS, Chief Executive, NFDB	25.09.2019
20	Prof. (Dr). T. J. Pandian, Bhatnagar awardee in Fishery biology	01.10.2019
21	Ms. C. Mohana Rekka, Managing Director, CMR Feeds, and Bio Supplements, Chennai	01.11.2019
22	Shri John Britto, a farmer entrepreneur	04.11.2019
23	Shri E.T. Mohan Kumar, Assistant Director of Fisheries, Department of Fisheries, Government of Tamil Nadu	21.11.2019
24	Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE and DG-ICAR, New Delhi	01.12.2019
KAKDWIP RESEARCH CENTRE		
25	Dr. P. Puthra, ADG (Marine Fisheries), ICAR	31.05.2019
26	Mr. S. K. Sahu, Fishery Extension Officer of State Fisheries Department, West Bengal	05.07.2019
27	Mr. Vaibhav Tiwari, IPS, Superintendent of Police, Sundarban Police District	07.12.2019
28	Swami Adhyatmananda Maharaj, Secretary, Bharat Sevashram Sangha, South 24 Parganas	07.12.2019
29	Mr. Choudhury Mojammel Haque, Assistant Director of Fisheries (Brackishwater), Govt. of West Bengal	07.12.2019
NAVSARI GUJARAT RESEARCH CENTRE		
30	Shri N. Vasudevan, Additional Principal Chief Conservator of Forests (APCCF), and Executive Director, Mangrove Foundation, Govt. of Maharashtra	15.06.2019
31	Dr. R. Borichangar, Associate Professor and Nodal officer, College of Fisheries (COF), Navsari Agriculture University (NAU)	26.06.2019
32	Dr. Naveen Patel, Research Scientist, Livestock production unit, NAU, Navsari	26.06.2019
33	Dr. H. Solanki, Assistant Professor, COF, NAU, Navsari	26.06.2019
34	Mrs. Neelamben Patel, Gram Sarpanch, Matwad, Gujarat	26.06.2019
35	Shri Anoop Kumar, Secretary, Animal husbandry, Dairying and Fisheries, Govt. of Maharashtra	22.08.2019
36	Shri N. Vasudevan, Executive Director, Mangrove Foundation, Maharashtra	22.08.2019
37	Shri R.R. Jadhav, Commissioner of Fisheries, Govt. of Maharashtra	22.08.2019
38	Shri Jawaharbhai P Chavda, Honourable Minister of Fisheries and Tourism, Govt. of Gujarat	01.12.2019

Personnel

STAFF POSITION		
Sl.No.	**NAME**	**DESIGNATION**
1	Dr.K.K.Vijayan	Director
2	Dr. S.V.Alavandi	Principal Scientist, HOD(I/c) , AAHED
3	Dr. K. P. Jithendran	Principal Scientist
4	Dr.C.V.Sairam	Principal Scientist
5	Dr.T. Ravisankar	Principal Scientist
6	Dr. M. Muralidhar	Principal Scientist
7	Dr. (Smt) M. Jayanthi	Principal Scientist
8	Dr. (Smt) B. Shanthi	Principal Scientist
9	Dr. C. P. Balasubramanian	Principal Scientist
10	Dr. M. Kailasam	Principal Scientist
11	Dr. (Smt) D. Deboral Vimala	Principal Scientist
12	Dr. M. Shashi Shekhar	Principal Scientist
13	Dr. (Smt) P. Nila Rekha	Principal Scientist
14	Dr. K. Ambasankar	Principal Scientist
15	Dr. J. Syama Dayal	Principal Scientist
16	Dr. Akshya Panigrahi	Principal Scientist
17	Dr. M. Kumaran	Principal Scientist
18	Dr. S. Kannappan	Principal Scientist
19	Dr. (Smt) M.Poornima	Principal Scientist
20	Dr. (Smt) R. Saraswathy	Principal Scientist
21	Dr. M.Makesh	Principal Scientist
22	Dr. (Smt) Sherly Tomy	Principal Scientist
23	Dr. Prasanna Kumar Patil	Principal Scientist
24	Dr. Subhendu Kumar Otta	Principal Scientist
25	Dr. (Smt) P. Mahalakshmi	Principal scientist

26	Dr.K.P.Kumaraguru vasagam	Principal Scientist
27	Shri. Ashok Kumar Jangam	Scientist (SS)
28	Dr. R. Ananda Raja	Senior Scientist
29	Dr.(Smt)P. Ezhil Praveena	Senior Scientist
30	Dr.(Smt) Krishna Sukumaran	Senior Scientist
31	Dr. (Smt).Shyne Anand	Senior Scientist
32	Dr.B.Sivamani	Senior Scientist
33	Dr.(Smt)R.Geetha	Senior Scientist
34	Dr.T.Senthil Murugan	Senior Scientist
35	Dr. Vinaya Kumar Katneni	Scientist
36	Dr. Sujeet Kumar	Scientist
37	Dr. P. Kumararaja	Scientist
38	Dr. (Smt) N. Lalitha	Scientist
39	Dr. (Smt) T. Bhuvaneswari	Scientist
40	Dr. (Smt) Vidya Rajendran	Scientist
41	Dr. Satheesha Avunje	Scientist
42	Shri. K.P.Sandeep	Scientist
43	Dr. Aritra Bera	Scientist
44	Shri. T.Sathish Kumar	Scientist
45	Smt.M.U.Rekha	Scientist
46	Dr.N.S.Sudheer	Scientist
47	Dr. Suvana Sukumaran	Scientist
48	Dr.(Smt)Neethu.K.C.	Scientist
49	Shri.Dani Thomas	Scientist
50	Shri.R. Aravind	Scientist
51	Shri.Biju.I.F.	Scientist
52	Ms. Misha Soman	Scientist
53	Smt.Mary Lini	Scientist
54	Dr.J.Raymond Jani Angel	Scientist
55	Shri.T.Sivaramakrishnan	Scientist
56	Dr.Vinay Tharabenahalli Nagaraju	Scientist

TECHNICAL		
Sl.No.	**NAME**	**DESIGNATION**
1	Shri R. Elankovan	Chief Tech. Officer
2	Dr. S. Sivagnanam	Chief Tech. Officer
3	Shri D. Raja Babu	Chief Tech. Officer
4	Shri M. Shenbagakumar	Chief Tech. Officer
5	Shri R. Puthiavan	Assistant Chief Tech. Officer
6	Smt. K. Jacquline	Assistant Chief Tech. Officer
7	Shri Joseph Sahayarajan	Assistant Chief Tech. Officer
8	Shri S. Rajamanickam	Assistant Chief Tech. Officer
9	Shri S. Nagarajan	Assistant Chief Tech. Officer
10	Dr. A. Nagavel	Assistant Chief Tech. Officer
11	Shri R. Subburaj	Assistant Chief Tech. Officer
12	Shri N. Ramesh	Tech. Officer
13	Shri S. Saminathan	Tech. Officer
14	Shri N. Jagan Mohan Raj	Tech. Officer
15	Shri D. M. Ramesh Babu	Tech. Officer
16	Shri G. Thiagarajan	Tech. Officer
17	Shri K. Paranthaman	Senior Tech. Asst.
18	Shri K. Karaian	Senior Tech. Asst.
19	Shri.S.Prabhu	Technical Asst.
20	Shri. K.V. Delli Rao	Senior Technician

ADMINISTRATION		
Sl.No.	**NAME**	**DESIGNATION**
1	Shri Babu R.K	Finance & Accounts Officer
2	Shri R. Kandamani	Asst. Admn. Officer
3	Smt. V. Usharani	Asst. Admn. Officer
4	Shri S. Pari	Asst. Admn. Officer
5	Shri P. Srikanth	Junior Accounts Officer
6	Smt. S. Nalini	P.S
7	Shri. K.G. Gopala Krishna Murthy	P.A.

8	Smt. K. Subhashini	P.A.
9	Shri A. Manoharan	Assistant
10	Smt. E. Amudhavalli	Assistant
11	Shri A. Sekar	Assistant
12	Smt. E. Mary Desouza	Assistant
13	Shri. Raghavendra.K	Assistant
14	Smt. K. Hemalatha	Stenographer, Grade – III
15	Smt. R. Vetrichelvi	Upper Division Clerk
16	Smt. M. Mathuramuthu Bala	Upper Division Clerk
17	Smt. B. Prasanna Devi	Upper Division Clerk
18	Shri. R. Kumerasen	LDC
19	Shri A. Paul Peter	LDC

SKILLED SUPPORT STAFF

Sl.No.	NAME	DESIGNATION
1	Shri K. Nithyanandam	Skilled Support Staff
2	Shri V. M. Dhanapal	Skilled Support Staff
3	Shri V. Kumar	Skilled Support Staff
4	Shri E. Manoharan	Skilled Support Staff
5	Shri C. Saravanan	Skilled Support Staff
6	Shri S. Selvababu	Skilled Support Staff
7	Shri C. Ragu	Skilled Support Staff
8	Shri P.G. Samuvel	Skilled Support Staff
9	Shri M. Sakthivel	Skilled Support Staff
10	Shri R. Mathivanan	Skilled Support Staff
11	Shri R. Indra Kumar	Skilled Support Staff
12	Shri G. Dayalan	Skilled Support Staff
13	Shri Kanaka Prasad	Skilled Support Staff
14	Smt. S. Premavathy	Skilled Support Staff
15	Shri. J. Murugan	Skilled Support Staff
16	Shri.V.Kishorkumar	Skilled Support Staff
17	Shri. S. Solin Igneshus	Skilled Support Staff

KAKDWIP RESEARCH CENTRE OF CIBA SCIENTISTS		
Sl.No.	**NAME**	**DESIGNATION**
1	Dr.T.K.Ghosal	Principal Scientist
2	Dr.Sanjoy Das	Principal Scientist
3	Dr.G.Biswas	Senior Scientist
4	Dr. Prem Kumar	Senior Scientist
5	Ms.Christina Lalramchhani	Scientist
6	Mrs. Babita	Scientist
7	Ms. Leesa Priyadarsani	Scientist

TECHNICAL		
Sl.No.	**NAME**	**DESIGNATION**
1	Smt. Chhanda Mazumder	Senior Tech. Asst.

ADMINISTRATION		
Sl.No.	**NAME**	**DESIGNATION**
1	Shri. S.K Bindu	Assistant

SKILLED SUPPORT STAFF		
Sl.No.	**NAME**	**DESIGNATION**
1	Shri N..N.Jana	Skilled Support Staff
2	Shri K.P.Naskar	Skilled Support Staff
3	Smt L.R. Bhuiya	Skilled Support Staff
4	Shri U.K. Santra	Skilled Support Staff
5	Shri P.C. Das	Skilled Support Staff
6	Shri.Sanjoy Some	Skilled Support Staff

NAVSARI-GUJARAT RESEARCH CENTRE OF CIBA, GUJARAT		
Sl.No.	**NAME**	**DESIGNATION**
1	Shri.Pankaj Amrut Patil	Scientist
2	Shri.Tanveer Hussain	Scientist
3	Shri.Jose Antony	Scientist

Infrastructure Development

INFRASTRUCTURE DEVELOPMENT FOR THE YEAR 2019

Sl.No.	NAME
1.	Expansion of laboratory building at CIBA Headquarters.
2.	Construction of Arch with gate in the main entrance of CIBA Headquarters
3.	Replacement of AC units in the main building at CIBA Headquarters
4.	Wooden cupboard for account section record room (Storage Unit) at CIBA Headquarters
5.	Providing MS gate in the eastern side of the compound wall at CIBA Headquarters
6.	Facility for collection the rainwater from main building terrace to existing well at CIBA Headquarters
7.	Barbed wire fencing over the existing western side compound wall & abut to the southern side compound wall for garden purpose at CIBA Headquarters
8.	False ceiling in Aquaculture lab at CIBA Headquarters
9.	Supply and fixing of polycarbonate sunshade in the Atrium space outside area at CIBA Headquarters
10.	Renovation of sewage line from front side of the main building to main sewage line at CIBA Headquarters
11.	Construction of semi-permanent shed for housing the incinerator at CIBA Headquarters.
12.	Making and fixing of CIBA sign board in the main entrance arch at CIBA Headquarter
13.	Conversion of existing Electricity Low Tension (LT) into High Tension (HT) power supply at Muttukadu Experimental Station , Muttukadu
14.	Renovation of Electrical room and Portico in the main building at Muttukadu Experimental Station of CIBA, Muttukadu
15.	Providing concrete pillars around the MES boundary line at Muttukadu
16.	Replacement of Air conditioners with buy back at MES of CIBA, Muttukadu Experimental Station of CIBA, Muttukadu
17.	Renovation of existing building utilized as trainees' hostel and rest room in the main building at MES of CIBA, Muttukadu
18.	Supply and installation of additional 3 Nos of air conditioners in Fish hatchery at MES of CIBA, Muttukadu
19.	Renovation of Electrical wiring and electricals appliances/fixtures in the existing building utilized as trainees hostel at MES of CIBA, Muttukadu
20.	Brick pitching/polythene lining of B sector of pond at KRC of CIBA, Kakdwip

Guest house - MES

Guest house - KRC

Laboratory building- HQRS

Mullet culture pond at MES

Library & Documentation

LIBRARY AND DOCUMENTATION

Library holdings

CIBA library currently holds 3000 books including 24 newly procured books. In addition to the e-subscription through Consortium for e-Resources in Agriculture (CeRA), CIBA library has been subscribing print volumes of national and International journals. Regional research centers at Kakdwip, West Bengal and Navasari, Gujart also maintain Library facilities. The details of Library holdings are provided in the diagram below.

Library and e-Resource Centre

The CIBA library has been upgraded as Library and e-Resource Centre with six workstations having the facility to access e-books, online journals, Institute publications and scientists' publications for easy retrieval and use by scientists and scholars. This facility is now open to students, scholars and academia from other Universities, Colleges and Institutes. The e-Resource Centre is kept open till 6 p.m. for effective use by students.

Data Repository

Under the digitalization initiative, all institute publications and individual scientist's publications have been digitized and uploaded in the ICAR-KRISHI Portal. ICAR-CIBA has uploaded all the publications and technologies developed in the past six years. The Institute was felicitated with a Certificate of Appreciation for proactively implementing ICAR-Research Data Management Guidelines and uploading the publications and technologies.

Online access to the CIBA Subscribed & CeRA journals and Document delivery services

CIBA has access to e-books and journals published by Springer, John Wiley and Elsevier through ICAR- CeRA resource sharing platform. CIBA library has listed all the full content accessible online journals along with their access links in the CIBA web portal for easy retrieval by scientists and scholars. The library section supplied photocopies of journal articles requested from various ICAR institutes, scientists and research scholars under CeRA-Document Delivery Request (DDR).

Exchange services

CIBA library maintained exchange relationship with various national and international organizations working on fisheries and aquaculture on mutual interest. The library maintained free mailing of institute's annual report and other Institute publications to various research organizations, universities and other agencies to provide updates on the institute research and development programmes.

Information services to the stakeholders

CIBA library acted as a reference library by providing access to the reference books & journals available in the library to the scientific personnel of other research organizations, academia, university/ college students, research scholars, stakeholders and other related visitors. The library provided photocopying service to users on nominal payment basis.

Utilization of funds

The funds available to the tune of Rs. 8.00 lakhs were effectively utilized towards the procurement of new books, Journals, Anti-plagiarism and Grammarly software for the library users, Scientists and Staff of Headquarters, KRC and NGRC.

ISBN Numbers

CIBA has obtained 50 ISBNs for five years from the Ministry of Human Resources Development for its publications. 21 books have been allotted ISBN numbers as of December 2019.

भारतीय कृषि अनुसंधान परिषद

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

भा.कृ.अनु.प. में ज्ञान संवर्धन के लिए अनुसंधान आंकड़ों का कोष

ICAR Research Data Repository for Knowledge Management

CERTIFICATE OF APPRECIATION

प्रशंसा पत्र

यह प्रशंसा पत्र भा.कृ.अनु.प.–केन्द्रीय खारा जल जीवपालन अनुसंधान संस्थान, चेन्नई को भा.कृ.अनु.प. अनुसंधानिक आंकड़ों के प्रबंधन दिशानिर्देशों के सक्रिय क्रियान्वयन एवं कृषि पोर्टल में पिछले 6 वर्षों के सभी **प्रकाशन एवं प्रौद्योगिकियां** अपलोड करने में योगदान के लिए प्रदान किया जाता है।

This certificate of appreciation is awarded to **ICAR-Central Institute of Brackiswater Aquaculture, Chennai** for proactively implementing ICAR Research Data Management Guidelines and uploading of all its **Publications and Technologies** for the last 6 years in KRISHI Portal.

(आर. सी. अग्रवाल)
उपमहानिदेशक (कृषि शिक्षा)
(R.C. Agrawal)
DDG (Agricultural Education)

(के. अलगुसुन्दरम)
उपमहानिदेशक (प्राकृतिक संसाधन प्रबंधन)
(K. Alagusundaram)
DDG (Natural Resource Management)

दिनांक : 10 दिसंबर 2019

Date: 10 December 2019

ICAR - CIBA Library Holdings

1. Books 3700
2. Journal Back Volumes (Bounded) 1610
3. Journal Loose issues 6700
4. Abstracts, Bulletins, Reports & Others 1500
5. Miscellaneous Publications 650

Publication, Participation in Conferences & Meetings

INSTITUTE PUBLICATION LIST

Annual Report 2018-19
Training Calendar 2019-20
Jal Tarang Vol. 5 (Hindi Magazine)

CIBA EXTENSION SERIES

- Mud crab aquaculture: A Gujarat perspective. CIBA Extension Series No.67
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Sairam, C.V., Palaniswami, C., Subramanian, P., Bosco, S.J.D., Arunachalam, V., Ravisankar, T., Vijayan, K.K., 2019. Disaster management in coastal agro-eco-systems. Workshop on Disaster Management in Agriculture organized, MANAGE, Hyderabad, 11-12, Dec., 2019, pp.1-7

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Sivamani, B., Gopikrishna, G., Kumar, K.V., Shekhar, M.S., Vijayan, K.K., 2019. Population genetic structure of *Penaeus indicus* across Indian coasts. International conference on Aquatic Resources and Blue Economy (AQUABE 2019) organized by Kerala University of Fishereis and Ocean Studies (KUFOS), Kochin, Kerala, 28-30, Nov. 2019.

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Participations In Conference Meetings Workshop And Symposia

DIRECTOR

Project Meeting/Workshop of DBT funded Project entitled "Poverty alleviation through prevention and future control of the two major socio-economically important diseases in Aquaculture" at Bangladesh Agricultural Univeristy, Bangladesh during 6-10 April 2019.

Advisory Committee Meeting of ADCOS, constituted to impart updated scientific and technical guidance and advice on fish culture at Payyanur on 4th May 2019.

Harvest Mela of cage cultured Asian seabass at Talashil, Taluka-Malvan, Sindhudurg on 15th June 2019.

Meeting with the Hon'ble Minister, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India at Indian Council of Agricultural Research (ICAR), New Delhi on 25th June 2019.

27th Research Council meeting of Science Research Scheme (RC-SRS) of Kerala State Council for Science, Technology and Environment (KSCSTE) as a Member of the RC Committee at Sasthra Bhavan, Pattom, Thiruvananthapuram during 27-28 June 2019

91st Foundation Day Celebration of ICAR at NASC Complex, New Delhi on 16th July 2019.

Divisional Meeting with the Directors of Fisheries and Animal Science Research Institutes at SMD (Fisheries), ICAR, New Delhi on 17th July 2019.

Aqua Aquaria 2019 organized by MPEDA, Kochi on 30th August 2019.

XXVI Meeting of the Regional Committee No.VIII at IIHR, Bangalore during 6-7 September 2019

Harvest Mela cum Interaction Meet on Indian White Shrimp, Penaeus indicus at NGRC – BARD farm of CIBA at Matwad, Navsari on 19th October 2019

Swasraya Bharat 2019, organized by Swadeshi Science Movement (SSM) at Marine Drive Helipad Grounds, Kochi on 29 November 2019

International Conference on "Aquatic Resources & Blue Economy" (AQUABE 2019) organized by Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi at Le Meridian, Kochi on 29 November 2019

Sixth Biennial Conference of Ocean Society of India – OSICON 2019, organised by Centre for Marine Living Resources and Ecology (CMLRE), Kochi on 14 December 2019

International Conference on Frontiers in Marine Science Challenges and Prospects – MARICON 2019, organized by School of Marine Sciences, Cochin University of Science and Technology, Kochi on 19 December 2019

SCIENTISTS

Attended 6th meeting of Scientific Advisory committee of Sasya Shyamala Krishi Vigyan Kendra, Ramkrishna Mission Vivekananda Educational and Research Institute on on 26th September, 2019 – Dr. Debasis De

International Conference on Animal Nutrition 2019 (INCAN2019), during 17-19 December, 2019 in Kolkata, West Bengal – Dr. Debasis De, Dr.T.K.Ghoshal, Dr. Gouranga Biswas

Practitioners' Conference on Integrated Mangrove Aquaculture organized by Nature environment & wildlife society, Kolkata on 26th November, 2019 in Kolkata, West Bengal – Dr. Debasis De

Attended ICAR regional committee II review meeting at ICAR-Central Inland Fisheries Research Institute, Barrackpore on 12th June 2019 – Dr.T.K.Ghoshal

4th Regional Science and Technology Congress- 2019 (Southern Region) during 23-24 December, 2019 at Mulana Abul Kalam Azad University of

Technology, Haringhata, Nadia, West Bengal - Dr. Gouranga Biswas, Dr. Prem Kumar

International Conference on Frontiers in Marine Science Challenges and Prospects (MARICON 2019) during 16-20 December 2019 at Cochin, Kerala, India - Dr. Prem Kumar

AQUA AQUARIA INDIA 2019 held at HITEX exhibition center Hyderabad from 30th August to 1st September 2019- Dr K. P. Jithendran

National Seminar on recent trends in parasitology on March 22, 2019 at Kannur University, Mananthavadi campus- Dr K P Jithendran

Co-chaired the session "Biotechnology and Nanotechnology" at Asian Pacific Aquaculture 2019, World Aquaculture Society, June 19-21, Chennai Trade Centre, Chennai- Dr S K Otta

Finalization of BMC of Govt of Andhra Pradesh, 8th April 2019 - Dr S K Otta

"Metabolomics Research in ICAR" at NASC complex, Delhi on 8th July 2019- Dr S K Otta

Second annual review meeting on AMR conducted by ICAR and FAO at Kolkata on 19th September 2019- Dr S K Otta

Brainstorming session on Fish genomics for undertaking network programme for whole genome sequencing and transcriptomics for commercially important fish species of India. 5.4.2019, CIBA, Chennai- Dr Sujeet Kumar

Asian Pacific Aquaculture 2019 (APA 2019) June 19 -21, 2019, Chennai- Dr Sujeet Kumar

International Conference on Frontiers in Marine Science Challenges and Prospects (MARICON 2019) during 16-20 December 2019 at Cochin, Kerala, India Dr Ezhil Praveena

International Conference on Frontiers in Marine Science Challenges and Prospects (MARICON 2019) during 16-20 December 2019 at Cochin, Kerala, India Dr Bhuvaneswari

International Conference on Frontiers in Marine Science Challenges and Prospects (MARICON 2019) during 16-20 December 2019 at Cochin, Kerala, India Mr Satheesh Kumar

"International conference on current immunological tools for biodiversity and status of environment health" organized by the Centre of Advanced Study in Marine Biology at Parangipettai, India during 21 to 23rd August, 2019 and presented as an invited speaker on "Mortality among farmed mud crab, Scylla serrata due to white spot syndrome virus (WSSV) in Andhra Pradesh, India". Dr Anandaraja


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Headquarters

ICAR-Central Institute of Brackishwater Aquaculture
75 Santhome High Road, MRC Nagar
Chennai - 600 028, Tamil Nadu,
Telephone: +91 44 24616948, 24618817, 24610565, 24611062
Fax: +91 44 24610311
E-mail: director.ciba@icar.gov.in

Muthukadu Experimental Station of CIBA
Kovalam Post, Muttukadu - 603 112
Tamil Nadu. Telephone: +91 44 27472344, 27472061

Kakdwip Research Centre of CIBA
24 Parganas District (South)
Kakdwip - 743 347, West Bengal.
Telephone: +91 3210255072, Fax: +91 3210255072
E-mail: krckakdwip@yahoo.co.in

Navsari Gujarat Research Centre
1st Floor, Animal Husbandry Polytechnic,
Navsari Agricultural University Campus,
Eru Char Rasta, Dandi Road,
Navsari - 396 450, (Gujarat) INDIA.
Phone : +91 7977078509; 9421717537

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Brackishwater Aquaculture for Food, Employment and Prosperity

ICAR-Central Institute of Brackishwater Aquaculture
ISO 9001:2015
(Indian Council of Agricultural Research)
#75, Santhome High Road, MRC Nagar, RA Puram,
Chennai, Tamil Nadu - 600 028.

Phone : +91 44 24618817, 24616948, 24610565
Fax : +91 44 24610311
Web : www .ciba.res.in
Email : dir ector.ciba@icar.gov.in /director@ciba.res.in

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