CIBA

ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

भा.कृ.अनु.प. - केन्द्रीय खारा जलजीव अनुसंधान संस्थान

ANNUAL REPORT 2017-18

Indian white shrimp, *Penaeus indicus*: potential candidate species for domestication and genetic improvement; farming of this shrimp has been widely demonstrated nationwide by CIBA as alternate for exotic *Penaeus* vannamei.

Dr. Trilochan Mohapatra, Director General, ICAR releasing the disease diagnostic kit developed by CIBA during his visit to CIBA headquarters.

Indian white shrimp, *Penaeus indicus*: potential candidate species for domestication and genetic improvement; farming of this shrimp has been widely demonstrated nation wide by CIBA as alternate for exotic *Penaeus vannamei*.

Brackishwaters are home for an amazingly diverse and unique group of fishes to keep in the home aquarium. CIBA is involved in research on potential ornamental fishes in brackishwater such as scats, mono angel, chromides and tiger perch, and achieved success in technologies for seed and feed production.

भाकृअनुप
ICAR

CIBA

वार्षिक प्रतिवेदन

ANNUAL REPORT
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भा.कृ.अनु.प.–केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
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ANNUAL REPORT
2017-18

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For mainstreaming the brackishwater aquaculture at the broader context of social development, landless and underemployed fishers should be brought to the aquaculture sector. CIBA has successfully demonstrated cage farming of Asian seabass in the open brackishwater ecosystem with the active participation of coastal fisher.

Preface

The year 2017-18 was a momentous year for ICAR-Central Institute of Brackishwater Aquaculture as it marked thirty years of substantial research and development in brackishwater aquaculture sector. Our research focuses on crucial questions about how to develop strategies for sustainable aquaculture, aquatic food security and how to support rural livelihood. After the introduction of specific pathogen-free stock of exotic shrimp *Penaeus vannamei*, India had an ever time high production of 600000 tons during the current year. This high production masks the several crucial weakness and challenges of the industry, for example, low survival, emerging disease problems, the high cost of production, and issues in marketing. ICAR-CIBA has an enormous task, therefore, to steering the brackishwater aquaculture industry towards sustainability, food security and livelihood. We continued to work with our stakeholders to translate our mission into reality.

Development of a native *Penaeus* species, which has the potential for selective breeding and genetic improvement, has been one of the high priority areas of brackishwater aquaculture in India. Thus, *Penaeus indicus* has been identified as a national priority species for specific pathogen free and genetically improved stock. To generate real-world farm level performance of this species, twenty one culture trials were carried out at identified stations all along the Indian coast with the participation of farmers. The production performance of the undomesticated stock of native species indicates that it is similar or even better to the exotic vannamei of pre-genetic selection phase. It is clear evidence of this species for its potential for domestication and selective breeding. The most importantly, the absence of emerging diseases such as EHP and running mortality syndrome during this demonstration trials, is found to be paramount for this species.

Kuruma shrimp, *Penaeus japonicus, is* reportedly the highest valued penaeid shrimp, because of its outrageously high price in Japan. The previous studies conducted by us suggested the differences in the aquaculture traits and biology concerning *P. japonicus* reported from other countries, although organoleptic studies conducted by us proved no taste difference between native *P. japonicus* and Indian species. Molecular signature of this species, using specimens obtained all along its distributional range in India, was evaluated using 16S rRNA gene and CO1 gene.

Molecular phylogenetic analysis of 16S and CO1 demonstrated that the species reported in India is a cryptic species of *Penaeus japonicus* group. The genetic distance between Indian species and *P, japonicus* and *P. pulchircaudatus* confirms a new species status for Indian taxa.

For mainstreaming the brackishwater aquaculture at the broader context of social development, landless and underemployed fishers should be brought to the aquaculture sector. Aquaculture of brackishwater fishes, in locally crafted cages suitable for estuaries, creeks, are an emerging innovative and viable technology. CIBA has successfully demonstrated cage farming of Asian seabass fish (*Lates calcarifer*) in the Buckingham canal waters at Vennangupattu coastal village (Kancheepuram District, Tamil Nadu). This is a novel three-tier model comprising nursery rearing, pre-grow out and grow out cages were taken up in a phased manner.

Aquaculture feed and nutrition has been the major thrust area of the Institute since its establishment. Asian seabass, *Lates calcarifer*, has been the focus of diversification of brackishwater aquaculture in India. Low volume cage culture in coastal waters, particularly in estuaries and open brackishwater bodies is emerging aquaculture in many coastal states of India. The feed is the critical input for the success of aquaculture. The institute has developed, tested and successfully demonstrated a grow-out feed for seabass, *Lates calcarifer*, under the brand name seebass^{Plus}.

To achieve maximum efficiency and profitability, it is required to formulate holistic research in aquaculture practices with inter and intradisciplinary cooperation. A research program with the proper merging of basic and applied research is needed to resolve the current research issues and planning for future. We are developing our research program with interdisciplinary cooperation. The white spot syndrome virus, WSSV, is the major pathogen of shrimp aquaculture, which has been devastating the shrimp farming industry since its emergence. For the first time, the complete de novo genome of an Indian isolate of this virus has been deciphered using Illumina and Nanopore sequencing technologies. The genome has 280,591 bp with 442 predicted coding genes. The availability of this genome provides valuable information for developing novel strategies for management of this pathogen in shrimp aquaculture industry.

A model organism is crucial in biological studies, particularly for developmental biology, animal health and genetic research. Studies using the model organism revolutionized the scientific application of basic research, for example, studies on Zebrafish provided reproductive biological methods for breeding of aquaculture species. During the current year, we have developed the breeding technology of a potential brackishwater model fish, *Oryzias*, sp.

High-quality research work carried out by our scientists enhanced our reputation. During the current year, the Institute released 209 publications with 79 papers published in high-quality peer-reviewed journals, an increase of 41% over the last year. Generating new knowledge and developing new product and process are crucial for achieving our mission. During the current year, we have generated ₹ 2.5 million, and have made 18 commercial agreement with various public and private stakeholders.

I am honoured to present the annual report of ICAR-CIBA that reports the research and development output during the period 2017-18. I am incredibly grateful to our all funding agencies and stakeholders for their valuable support. Newly emerging challenges and possibilities keep research organizations such as ICAR-CIBA at the central position; we are expected to deliver the needs and aspirations of a vibrant farming sector. I do not doubt that CIBA is ready to meet these challenges.

As I complete my fourth year as Director of this prestigious institute, I place on record my personnel gratefulness to all our stakeholders who supported us, and their faith in our mission enables our effort. We are immensely grateful to Dr Trilochan Mohapatra, the Director General ICAR, without his professional support 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. I thank all my colleagues for their commitment and support for the fulfilment of the mandate of the Institute.

Thank you all for joining with us on this journey, the achievements provided here are only highlights, and I invite readers to go through this detailed report

Dr K.K.Vijayan
Director

कार्यकारी सारांश

कार्यकारी सारांश

जलजीव पालन एक आशाजनक क्षेत्र बन गया है जो विश्वन के खाद्य उत्पा दन क्षेत्र में महत्वनपूर्ण भूमिका निभाता है। खारा जलजीव पालन जिस पर झींगा पालन का वर्चस्वक है, भारतीय जलजीव पालन का प्रमुख आधार है। आईसीएआर-सीबा सम्पूर्ण मूल्यर श्रृंखला में पालन प्रणाली से अंतमि उपज अवस्था : जीवन चक्र की सभी अवस्थाओं, पशु पोषण, स्वा स्यृत एवं आनुवंशिकी तक अनुसंधान एवं विकास कार्य करता है। हमारा ध्योन निरंतर प्रजातियों में सुधार एवं परिष्कृत करने में योगदान देने की ओर है, जो प्रजातियों उत्पा दन अवस्था में है और नई प्रजातियों के विकास में अनुसंधान अंतराल कम करना है।

हिलिसा तेनुलूलोसा इलीशा का बंद स्थितियों में संवर्धन एवं प्रजनन

तेनुलूलिसा इलीशा जिसे सामान्य त: हिलिसा कहा जाता है, दक्षिण एशिया विशेषकर पश्चमि बंगाल में एक अति महत्वैपूर्ण मत्स्य प्रजाति है। बाजार की उच्च, मांग के कारण विवेकहीन शोषण तथा अन्य मानवजनित दबावों के कारण जलीय परितंत्रों में इस प्रजाति की उपज घटने लगी है। यद्यपि बंद प्रजनन का प्रयास वर्ष 1990 से किया गया है परन्तुक जीवन चक्र का सफल समापन अभी भी गूढ़ रहा है। काकद्वीप अनुसंधान केन्द्रक के वैज्ञानिकों ने वन्या रूप से प्राप्ता प्रजनकों के उपयोग से हिलिसा मछली का बंध नषिचन का मानकीकरण किया। प्रजनकों के विकास के लिए मुरीगंगा, पश्चमि बंगाल से प्राप्त हिलिसां पोनों का संवर्धन काकद्वीप अनुसंधान केन्द्रर में मिट्टी के खाराजलीय तालाब में किया गया। हिलिसाक मछली की पोने (1.37 ग्रा., 52.97 मि.मी.) 32 माह के संवर्धन काल में बढ़कर 383.80 ग्रा/339.33 (शारीरिक भार एवं कुल लम्बाई) की हो गई है। भारी संख्याप में परिपक्वा नर मछलियों (139.35 ग्रा./260 मि.मी.) के साथ अंडाणु परिपक्वपता की 5वीं अवस्था की अंडाणुओं (570 मैक्रोमीटर) वाली परिपक्वम मादा मछलियां (358.18 ग्रा.-425.2 ग्रा./352 मि.मी.-370 मि.मी.) प्राप्ता हुई है। नवम्ब3र से फरवरी के दौरान परिपक्वब नर एवं मादा मछलियों का अध्ययन किया गया जिससे बंद स्थितियों में परिपक्व.ता और बीज उत्पामदन के लिए प्रजनन की संभावना स्पथष्ट हुई है। खाराजलीय तालाब की बंद स्थितियों में प्रजनकों की यह पहली सूचना है।

आईसीएआर-सीबा बंद स्थितियों में मिल्कभफिश प्रजनन की सफलता से आगे बढ़कर मिल्कआफिश हैचरी हेतु प्रौद्योगिकी परिशोधन की ओर

बंद स्थितियों में मिल्कौफिश प्रजनन प्रौद्योगिकी के परिशोधन से वर्ष 2016-17 के दौरान 2,12,500 लार्वा अंडों का उत्पादिन हुआ। कुल उत्पाकदति जीरे 54% निषेचन की दर से 1,15,000 है। लार्वा अतिजीविता दर 45.5% प्राप्तत किया गया है। बीजों को देश के विभिन्नि खारा जलीय पालन प्रणालियों में जलजीव पालन हेतु पश्चमि बंगाल, केरल और तमिलिनाडु के किसानों में वितरित किया गया। संभावित उद्यमियों के लिए घेरलूकृत मत्स्ये संपदा के सृजन के लिए 200 मछलियों का एक ब्रूडबैंक का रखरखाव किया जा रहा है। पश्चमि बंगाल में बंद स्थितियों में मिल्कोफिश के प्रजनन के प्रथम बैच को 'डेकन हिलिसा ' के नाम से प्राप्तब किया गया। श्री अमलेश चटर्जी, एसी फिश एण्डा प्रोन फार्मस से भागीदारी के अंतर्गत किए गए पालन परीक्षणों में उत्पाचदन लागत 90-100 रुपए प्रति किलोग्राम और स्थानीय बाजार दर 150-170 रुपए प्रति किलोग्राम पाया गया।

देश के खाराजलीय किसानों के लिए आईसीएआर-सीबा के पश्चमीन हेचरी का एशियिन सीबास बीज उत्पालदन में दो दशक

पिछले दो दशकों की कटिबद्धता को जारी रखते हुए चालू वर्ष में भी आईसीएआर-सीबा देशभर के किसानों के लिए वीएनएन फ्री सप्लाई के माध्यसम से लगभग 0.9 मिलियिन एशियिन सीबास बीजों की आपूर्ति की गई। संस्थान ने आंध्र प्रदेश के मछलीपट्टनम जिले में अल्पनकालिक सीबास नर्सरी उत्पा दन प्रणाली के उभरने में महत्व पूर्ण भूमिका निभाई। संवर्धन गतिविधि वाली यह एक मॉडल सेटेलाइट नर्सरी बन गई है जो देश के विभिन्नि भागों में मछली पालन के लिए अंगुलिकाओं की आपूर्ति करती है। यह नर्सरी सीमांत ग्रामीण युवाओं के लिए आजीविका सृजन तथा खुले जल संसाधनों के उपयोग में भी एक मॉडल जैसा कार्य कर रही है।

फार्म आधारित प्रजनन प्रणाली में प्रेरित प्रजनन द्वारा ग्रे मुल्लेट का लार्वा उत्पाकदन

एक निजी उद्यमी के प्रक्षेत्रित्र

स्थगल पर ग्रे मुल्लेट प्रजनन के लिए प्रक्षेत्र आधारित लो-वॉल्यूनम सिस्टिकम का विकास किया गया। इस प्रणाली के उपयोग से किए गए 8 एवं 5 प्रजनन परीक्षण के परिणामों में अंतिम अंडाणु परिपक्वता तथा अंडोत्सर्जन देखा गया एवं क्रमश: 750-850 µm प्राप्तथ किया गया। प्रेरित प्रजनन के माध्यनम से प्रति मादा से लगभग 0.5 मिलियिन अंडे प्राप्तम हुए। तथापि, निषेचन दर सापेक्ष रूप से कम रही। इस प्रणाली से लार्वा उत्पायदन इस मॉडल की संभाव्यतता सूचित करता है।

ग्रे मुल्लेट की बंद स्थतियों में परिपक्वता एवं निषेचन

चालू वर्ष में ग्रे मुल्लेट का प्रेरित निषेचन सफलतापूर्वक किया गया। तीन मछलियों में प्रेरित निषेचन देखा गया जिनसे इंट्रा ऑवारियन अंडाणु व्यास 520, 525 तथा 535 µm प्राप्ते हुआ। LHRHa तथा डोपामाइन इनहेबिटर के संयोजन की प्रतिक्रिया स्व5रूप मछलियों में निषेचन संपन्न हुआ। 2 मिलियिन से अधिक अंडे प्राप्त हुए जिनका व्यावस 800 µm है। तथापि, निषेचन दर कम देखी गई। उष्मा यन टैंक से एकत्रित लार्वा का औसत आमाप 2.4 मि.मी. (टीएल) है।

लिजा पार्सिया में लैंगिक परिपक्वता तथा प्रेरित प्रजनन के लिए पीयूष ग्रंथी सार अनुकूलतम पाया गया

लिजा पार्सिया के लिए केवल पीयूष ग्रंथी सार या hCG के संयोजन आशाजनक खुराक पाई गई और इससे अंडाणु व्या स, अंडोत्सर्जन का प्रेरण तथा निषेचन में उल्लेखनीय वृद्धि हुई है। लिजा पार्सिया में हार्मोन आपूर्ति के लिए ऑस्मोटिक पंपों का उपयोग पर किए गए अध्ययन में पाया गया कि लिजा पार्सिया की लैंगिक परिपक्वता के लिए पीयूष ग्रंथी सार काफी प्रभावकारी है।

माइस्टस गुलियो के लिए छोटे पैमाने पर हैचरी प्रणाली के विकास के लिए प्रोटोकोल का अनुकूलन

माइस्टस गुलियों के हैचरी उत्पाटदन के लिए लागत प्रभावी सरल प्रोटोकोल का विकास किया गया। प्रेरित निषेचन के लिए आपूर्ति की जाने वाली hCG खुराक का अनुकूलन किया गया। इसके अलावा, यह पाया गया कि नर पक्षपाती लिंगानुपात प्रजनन उपज को बढ़ाता है। सफल निषेचन के लिए अंडाणु का व्यागस 750- 850 µm होने पर hCG का प्राइमरी एवं सेकेण्डेरी डोज की आवश्यकता होती है जबकि अंडाणु का व्यामस 850 µm होने पर hCG का एक डोज आवश्यक होता है।

बंद स्थतियों में प्रजनक संपदा के विकास के माध्यहम से रेड स्नैपर के बंद प्रजनन हेतु ठोस नींव

घरेलूकृत तालाब तथा आरसीसी टैंक आधारित प्रजनन संपदा के विकास के माध्यडम से रेड स्नै पर तुटजानस अर्जेंटमैक्यू लेटर के बंद प्रजनन हेतु ठोस नींव रखी गई है। तालाब आधारित पालन परीक्षणों से सूचित होता है कि तालाब आधारित प्रणाली में ट्रैश फिश तथा गोलीनुमा आहार के उपयोग द्वारा आहार रणनीति अपनाने पर बेहतर वृद्धि देखी गई। परिणामों से यह भी सूचित हुआ है कि 10 माह की पालन अवधि में औसत शारीरिक भार में 865 ग्राम की वृद्धि की संभावना है।

जड़ खाद्य पदार्थों को प्रारंभिक आहार के रूप में उपयोग से पर्ल स्पॉधट लार्वा संवर्धन की संभावनाओं का निरूपण

पर्ल स्पॉ ट के लार्वा संवर्धन प्रोटोकोल के परिशोधन हेतु किए गए प्रयोगों में प्रारंभिक आहार के रूप में जड़ खाद्य पदार्थों पर पर्ल स्पॉ ट के संवर्धन की क्षमता देखी गई है। 100 माइक्रोन की एक प्रारंभिक आहार से 200 और 300 माइक्रोन की अपेक्षा काफी अधिक वृद्धि दर प्राप्ती हुई। 15 दिनों के संवर्धन काल केवल जड़ आहारों के उपयोग की तुलना में जड़ आहार के उपयोग के दौरान सूक्ष्म शैवाल पृष्ठभूमि में उपयोग करने पर बेहतर वृद्धि दर (अंतिम औसत शारीरिक भार 13.48±1.47 मि.ग्रा.) देखी गई। पर्ल स्पॉमट के टैंक आधारित नर्सरी संवर्धन प्रयोगों से स्प ष्ट4 हुआ है कि पर्ल स्पौट नर्सरी सवंर्धन के लिए संग्रहण घनत्वh 1.5 नग प्रति लीटर तथा 15 पीपीटी लवणीयता अनुकूल है।

वित्तिपूतसप्राय प्रजाति किनारा पर्ल स्पॉषट इट्रोप्ललस कनारेंससि के संरक्षण में एक उल्लेघखनीय कदम है : आईसीएआर-सीबा द्वारा बंद प्रजनन का मानकीकरण

कर्नाटक से प्राप्त् कनारा पर्ल स्पॉ ट (100 नग औसत लंबाई 88.9± 8.9 मि.मी.; औसत भार 18.26±6.79 ग्रा.) मछलियों को हैचरी स्थतियों (लवणीयता : 5-8 पीपीटी, तापमान 26-280से., पीएच-7.5-8.2) के अनुकूलन से पांच परीक्षणों में सफलतापूर्वक प्रजनन करवाया गया। लार्वा की औसत संख्या 75-100 प्रति निषेचन दर्ज किया गया। घरेलूकृत प्रजनक संपदा के विकास के लिए मत्स्यॉ हैचरी में एफ-1 पीढ़ी के 300 जीरों का रखरखाव किया जा रहा है।

खाराजलीय परितंत्र में जलजीव पालन के व्यतवहार्य विकल्पह के रूप में इंटीग्रेटेड मल्टीक-ट्रॉफिक एक्वालकल्चमर (आईएमटीए) का परीक्षण

चार भिन्नि प्रजाति संयोजनों : टायगर श्रिम्प (पीनीयस मोनोडॉन) + मुल्लेकट्स (मुगिल सेफालस तथा लिजा टेड) – (सी), टायगर श्रिम्प + मुल्लेट्स + वाटर स्पै नेक (इपोमोइया एक्वाफटिका) (टी-1), टायगर श्रिम्पग + मुल्लेरट + आयस्टनर (क्रासोस्ट्रिया कटकेनसिस) – (टी-2), टायगर श्रिम्पा + मुल्लेशट + वाटर स्पैनेक + आयस्टोर – (टी-3) का 150 दिनों तक 12 तालाबों (500 वर्गमीटर) में आईएमटीए मुल्यांकन किया गया। अन्य उपचारों की अपेक्षा

दोनों पौधों का मछली एवं झींगे के संयोजन में नकिासी फसलों के रूप में उपयोग सं उल्ले खनीय उच्चछ उत्पा दन (1510±36 कि.ग्रा./हे.), बेहतर जल गुणवत्ता , उच्च– लाभ:लागत अनुपात के साथ उच्चछ आय (रू 2.24 लाख/हे.) प्राप्तक किया गया।

इंडियन व्हांइट श्रम्पि पीनयिस इंडकिस के पालन का नरि्पण

वभिन्निव कृषि जलवायु क्षेत्रों में इंडयिन व्हाकइट श्रम्पिक पीनयिस इंडकिस की उत्पादन क्षमता के मूल्यां कन हेतु भारत के 6 भन्निा तटीय राज्यों में पायलेट स्केाल पर पालन कर नरि्पण कार्य किया गया। इन परीक्षणों में 2 से 12 पीपीटी लवणीयता एवं 35 पीएल/ वर्ग मीटर के संग्रहण घनत्व। पर औसत उत्पा दन 4.4 ± 0.8 मट्रिकि टन/ हे. तथा 10 पीएल/वर्ग मीटर संग्रहण घनत्वत पर 1.142 ± 0.20 टन/हे. प्राप्त किया गया। 135 दनिों की पालन अवधि के पश्चा त नम्निउ एवं उच्च1 संग्रहण घनत्वी पर अंतमि शारीरकि भार क्रमश: 28-30 ग्रा. तथा 17-20 ग्रा. पाया गया।

टाइगर श्रम्पिक पी. मोनोडोन, पेसफिकि व्हाइट श्रम्पिर पी. वन्नाउमई तथा इंडयिन व्हाग्इट श्रम्पि पी. इंडकिस के उत्पा.दन गुण

टाइगर श्रम्पिक पी. मोनोडोन, पेसफिकि व्हाइइट श्रम्पि पी. वन्नामिई तथा इंडयिन व्हाइट श्रम्पि- पी. इंडकिस के उत्पाइदन गुणों की तुलना के लिए काकद्वीप अनुसंधान केन्द्र के प्रक्षेत्र स्टे्शन में 120 दनिों का प्रयोगात्मक परीक्षण किया गया। 14 सप्ताह की पालन अवधि के दौरान पी. इंडकिस की वृद्धि का स्वयरूप पी. वेन्नाामई के समान ही रहा और इससे यह सूचति होता है कि इस प्रजाति को घरेलूकृत फसल के रूप में वकिास की संभावनाएं हैं।

आहार की उच्चइ बारंबारता के दौर में पीनयिस इंडकिस के लिए उच्चण घनत्वत एवं सूचीच्छय जल वाले नर्सरी सवंर्धन

हैचरी उत्पादन एवं पालन अवस्था के बीच नर्सरी सवंर्धन के अनेक लाभ जैसे बढ़ती वृद्धि, नम्निस एफसीआर, पालन की छोटी अवधि तथा रोगाणुओं के संक्रमण का कम प्रकोप आदि हैं। इस संदर्भ में पीनयिस इंडकिस के लिए उच्ची घनत्व वाले नर्सरी संवर्धन प्रोटोकोल का वकिास किया गया। इस अध्ययन से यह नरि्पति किया गया कि लार्वा के बाद की अवस्थाा के झींगों को 1000 नग/घन मीटर की दर से 45 दनिों तक नम्निस प्रोटीन वाले आहार (30%) तथा अंतमि शारीरकि भार एवं अतजीविता से समझौता कि बनिा संवर्धन किया जा सकता है।

भारत के आंध्र प्रदेश चरिाला में कुरुमा श्रम्पिप पीनयिस जापोनकिस के पालन का नरि्पण

कुरुमा श्रम्पिप पी. जापोनकिस अधकितम मूल्या का पालति झींगा है और इसे जापान में समुद्री स्वाद्य उत्पारदन का राजा कहा जाता है। चूंकि झींगा लंबी दूरी के परविहन को सह सकता है, अत: इस प्रजाति को जीवति अवस्था में वक्रिय किया जा सकता है जसिसे अधकि मूल्यी प्राप्तल होता है। इस पृष्ठीभूमि के वपिरीत इस प्रजाति को वविधिकृत फसल के रूप में वकिास करने की संभावनाओं को नरि्पति करने हेतु कसिान के तालाब में पालन प्रयोग कि गए। नीचे की रेतीली सतह वाले 600 वर्ग मीटर वाले तालाब में 50 नग प्रति वर्ग मीटर के संग्रहण घनत्वी से कि गए पालन से 150 दनिों में 5000 कि.ग्रा./हे. तथा 50 प्रतशित अतजीविता दर प्राप्त हुई।

कुरुमा झींगा पीनयिस जापोनकिस का नम्निन लवणीय नष्पिादन

समुद्री जल तथा समुद्री जल के समान लवणीयता सूत्र में पी. जापोनकिस पालन का सफल प्रलेखन किया गया। पूर्व में कि गए अनुसंधान परणिामों के वपिरीत 60 दनिों के इंडोर प्रयोग से नरि्पति होता है कि पी. जापोनकिस को नम्निज लवणीयता दर 5-10 पीपीटी पर, वृद्धि एवं अतजीविता दर से समझौता कि बनिा पालन किया जा सकता है।

तरुण झींगों की बेहतर अतजीविता तथा आमाप में सुधार के लिए मड क्रैब नर्सरी में आवधकि आकार का ग्रेडगि

नर्सरी संवर्धन के दौरान मड क्रैब का सामाजकि पदानुक्रम एवं आक्रामकता, पशु के आमाप से संबंधति एक गुण है जो नरभक्षति, क्षेत्रीय व्यसवहार तथा प्रतबिंधति आहार का कारण बनता है और इसके परणिामस्वोरूप उपज के दौरान आमाप की वविधिता तथा नम्निंस्तरीय अतजीविता प्राप्तर होती है। मड क्रैब की आक्रामकता के आमाप ग्रेडगि का वृद्धि एवं तरूण झींगों की अतजीविता पर प्रभाव के अध्यबयन के लिए नर्सरी संवर्धन प्रयोग किया गया। अध्योयन से यह नष्किर्ष नकिलता है कि आवधकि आमाप ग्रेडगि के अंतर्गत संवर्धति केकड़ों में उच्च अतजीविता दर होती है, तथापि औसत में कोई उल्ले खनीय अंतर नहीं पाया गया।

स्काउइला सर्राटा की अतजीविता एवं वृद्धि पर लवणीयता का प्रभाव

मड क्रैब एस. सर्राटा की वृद्धि एवं अतजीविता के लिए अनुकूलतम लवणता स्तउर का नरि्धारण किया गया। लवणीयता के चार स्तकरों, 5, 15, 25 और 35%, का मूल्यां कन किया गया और मूल्यांकति चार लवणीयताओं में उच्च तम अतजीविता (93.3%) 35% में पायी गयी और इसके बाद का स्थानि 25% (63%), 15% (46.7%) तथा 5% (40%) रहा है। तथापि नम्निे लवणीयता स्तार में अंतमि शारीरकि भार तथा पृष्ठ5वर्म (कारापेस) की चौड़ाई परीक्षति उच्चतम लवणीयता से तुलना योग्य है। यद्यपि 35% पर अतजीविता अधकि है, इस लवणीयता में वशिष्टि वृद्धि अधकि

नहीं है, अत: बेहतर वृद्धि एवं अतजीविता के लिए 15 से 25% लवणीयता की संस्तुति दी जा सकती है।

वाणज्यिकि परीक्षणों में पीनयिस इंडीकस की प्रजनन क्षमता

घरेलूकरण एवं अनुवांशकि सुधार के लिए स्थासनीय देशज सम्पादाओं को प्रमोट करने में वन्य इंडयिन व्हाइट श्रम्पि के प्रजनन तथा बीज उत्पोदन की अंतर्नहिति क्षमता/अवरोधों का प्रलेखन महत्वपूर्ण कार्य है। इस तथ्य को ध्यापन में रखते हुए, वभिन्निह स्थावनों से प्राप्त% वन्य् प्रजनकों का प्रजनन क्षमता एवं हैचरी उत्पोदन का परीक्षण कयि गया। इसके अतरिक्ति डब्यूक एसएसवी प्रकोप का भी मूल्यांरकन कयि गया। बंद स्थतियिों में संसर्ग की असफलता तथा मैचुरेशन टैकों में नर मछलियों का नमि्न् संख्याल से नषिचन पर प्रतकिूल पड़ता है। औसत सफल चक्र में नौप्लीियस से माइससि अतजीविता 60% (50%-70%) जब कि माइससि से पीएल 25% प्राप्त की गई। डब्यू स एसएसवी संक्रमण से सूपकषट् हुआ है कि पी. इंडकिस प्रजनकों में मासकि औसत प्रकोप 72% है और अत्य(धकि प्रकोप अगस्तर से नवम्बइर के दौरान (87.5-100%) है।

पीनयिस इंडीकस के लिए बीज परविहन प्रोटोकॉल का मानकीकरण

लम्बीस दूरी तक पीएल के परविहन से जुड़ी बड़ी समस्या) दबाव के कारण मार्त्यकता है। फार्म में पहुंचने तक पी. इंडकिस के बीज परविहन का मानकीकरण पीएल की उच्च् अतजीविता दर सुनश्चिति करने के लिए महत्व पूर्ण है। अध्यायन से सूचति होता है कि पीएल 9 अवस्थास वाली पी. इंडकिस लम्बीी दूरी के परविहन के लिए उपयुक्तप है तथा उन्नकत पीएल के मामले में सग्रहण घनत्व 250 नग/ली. से कम रखा जा सकता है।

पीनयिस जपोनीकस का बीज उत्पादन एवं लार्वा संवर्धन

भारत में पेनेयड झींगा पालन में ववििधिता लाने की दशि में प्रथम कदम के रूप में पीनयिस जपोनीकस के बीज उत्पाादन का परीक्षण कयि गया। वन्यप रूप से प्राप्त पी. जपोनीकस के प्रजनकों के उपयोग से नषिचन और लार्वा संवर्धन परीक्षण कए गए। लार्वा अवस्थास पूर्ण होने के पश्चोत उपरोक्ता लार्वा संवर्धन पद्धति से औसत अतजीविता 50% और उच्चतम अतजीविता 90 प्राप्ता की गई। दो साइकल से कुल 2 लाख लार्वा का उत्पाटदन कयि गया और पीएल 20 की अवस्थाा में कसिानों के तालाबों तक पालन संबंधी अध्यलयनों को लिए भेजा गया।

मड क्रैब सूका इला सरराटा की तरूण मछलियों को बड़े पैमाने पर उत्पांदन हेतु द्वविरणीय प्रणाली

इस प्रजाति के हैचरी उत्पारदन को बढ़ाने के लिए सूका इला सरराटा के संवर्धन तथा बड़े पैमाने पर उत्पौदन संबंधी प्रयोग कए गए। द्वविरणीय प्रणाली में इनडोर एफआरपी टैक में जेड1 लार्वा को मेघालोपा अवस्थ् तक तथा मेघालोपा अवस्था से आगे मट्टिी के तालाबों में स्थानपति आउटडोर नेट केज में पालन कयि गया। इसके बाद बड़े टैकों में उच्च् घनत्व (> 150 नग/ली.) तथा छोटे टैक में नमि्नो संग्रहण घनत्वं (10 नग/ली.) का मूल्यांईकन कयि गया। यह पाया गया कि इन्डोीर हैचरी में मेघालोपा अवस्थ् तक हैचरी उत्पाद्न के बाद बंद कर देना उत्पागदन को अनुकूलतम बनाने के दशि में कुशल पद्धति है। यद्यपि छोटे टैको का उत्पानदन अधकि है, बड़े टैकों में उच्च घनत्वं अपनाना आर्थकि रूप से व्यदवहार्य है।

मेघालोपा अवस्थान से बाहरी संवर्धन के माध्यमम से मड क्रैब बीज उत्पावदन में हैचरी फेज को घटाना

केकड़ा लार्वा जीवन चक्र में मेघालोपा अवस्थो मड क्रैब बीज उत्पाद्न में संवेदनशील अवस्था है चूंकि इसके मांसभक्षी आचरण, आहार पद्धति में बदलाव तथा क्रमकि अवस्थावपन के कारण इन्डोार टैकों में उच्चआ मार्त्यहता दर होती है। मेघालोपा को वैकल्पकि रूप से खाराजलीय तालाबों में स्थौपति नेट केज में संवर्धन कयि जा सकता है और यह मड क्रैब की हैचरी अवस्थां की अवधि को उल्लेखनीय रूप से कम कर देता है। इन्डोऔर हैचरी से मेघालोपा को नकिालने की आयु का मूल्यांलकन एक 15 दविसीय प्रयोग में कयि गया। 3 और 4 दनि आयु वाले मेघालोपा के उपयोग से मेघालोपा से केकड़े में बदलने का बेहतर बदलाव दर क्रमश: 62.33 ± 3.08% तथा 69.66 ± 2.35% प्राप्त कयि गया। वर्तमान परीक्षणों से यह नष्कि र्ष नकिलता है कि 3 से 4 दनि आयु वाले मेघालोपा को आउटडोर सस्टिम में संग्रहति करना बेहतर परणिाम देता है और इस जीवन अवस्थाि में मत्य् कपालकों को केकड़ा पालन हेतु आपूर्त की जा सकती है।

झींगा प्रक्षेत्रों में रोग नगिरानी

वर्ष 2016-17 के दौरा 155 झींगा प्रक्षेत्रों का अध्ययन कयि गया। वर्ष 2016-17 के दौरान भी माइक्रोस्पो।रोडयिन परजीवी एन्टे रोसाइटोजून हेपाटोपेनेय (ईएचपी) खारा जलजीव पालन के लिए बार बार संक्रमण उत्पडन्न। कयि। सफेद धब्बो रोग 8.9%, हेपाटोपैनक्रयिाटकि माइक्रोस्पो रडिोसस 23.6% तथा संक्रमक हाइपोडर्मल एवं हेमाटोपोएटकि नेक्रोससि (आईएचएचएन) 1.3%, मौजूद रहा है। प्रक्षेत्र के खराब प्रबंधन के कारण अन्य रोगों के लक्षण जैसे वृद्धि अवरोध, सफेद मल सड्रिोम (डब्यू प् एफएस), व्हायइट मसल सड्रिोम (डब्यू व एमएस), क्रोनकि मोर्टालटी सड्रिोम तथा ब्लैएक गलि सड्रिोम क्रमश: 15.17%, 16.5%, 3.4%, 2.7%, 7.5% प्रक्षेत्रों में देखा गया है। अध्ययिन से यह पुष्ट हुई है कि भारतीय खारा

जलजीव पालन ओआईई सूचीबद्ध रोगों से मुक्त. है जैसे टौरासड्रिोम (टीएस), येल्लो हेड रोग (वाईएचडी), एक्यूट हेपाटोपैनक्रयिाटकि नेक्रोसिस रोग (एएचपीएनडी) तथा नेक्रोटैजगि हेपाटोपैनक्रयिाटाइटसि (एनएचपी)। फरवरी-मार्च, 2017 के दौरान पूर्व गोदावरी, आन्ध्रप्रदेश में ओआईई प्रोटोकॉल के उपयोग से पी. वन्नायमेय के दो प्रक्षेत्रों 55 एवं 70 डीओसी के संक्रामक मयोनेक्रोसिस रोग की पहचान की गई। प्रभावति तालाबों में मार्त्यता दर लगभग 15% रही है। प्रभावति झींगों में व्हातटश्नि एब्डोमनिल मसल के साथ सुस्ती, मांसपेशयिों में स्वचिाव तथा आंतड़ियों में कमजोर एफसीआर 2.2, धीमी वृद्धा (70 डीओसी पर 4-5 ग्रा.) होतीहै। जलजीव पालन की वविधिकिरण योजना के एक भाग के रूप में तमलिनाडु और ओडशिा के वभिन्नि स्थातनों से प्राप्तव पीनयिस इंडकिस प्रजनकों के रोगाणुओं का प्रोफाइलगि कयिा गया ताकि सीबा हैचरी में प्रजनन कार्यक्रम में इनकी उपयुक्तनता परखा जा सके। पीनयिस इंडकिस प्रजनकों 284 में से 72% डब्यूता एसएसवी से, 3.87% आईएचएचएनवी से प्रभावति है जसिसे सूचति होता है कि हमारे खारा जलीय परतिंत्रों में इन रोगाणुओं की उच्चव स्थानिकिता है। पखमीन रोगों में से आईरोडोसे दोहरा संक्रमण (आरएसआईवीडी) तथा वायरल नर्वस नेक्रोसिस (वीएनएन) प्रक्षेत्र एवं वन्यज पखमीनों जैसे सीबास, मल्ले ट, रेड स्नेसपर तथा तलिापयिा में आम है।

ईएचपी का प्रसार

ईएचपी के प्रसार पर कयिे गए अन्वे षणों से सूचति हुआ है कि संक्रमति झींगों के साथ दो सप्तासह के सहजीवन और ईएचपी से प्रभावति झींगों से हेपाटोपैनक्रयिास के साथ सात दनिों तक आहार ग्रहण करने पर स्वरस्थ एसपीएफ वन्नोमेय झींगों में भी संक्रमण फैल सकता है। एक और रोचक तथ्यक यह है कि ईएचपी मृदा के माध्यएम से भी फैल सकता है जसिकी पुष्टि पीसीआर द्वारा सूय स्थाए झींगों को तालाब की मृदा पर 15 दनिों तक एक्पोएज करने पर हुई। अन्यच प्राणजिातों जैसे पॉलीकीट वार्म, ग्रीन मसल और क्ला5म्सि की जांच से ज्ञात हुआ है कि इन जीवजातों की ईएचपी फैलाव में कोई भूमकिा नहीं हो सकती है जो पीसीआर परीक्षणों से स्पाष्ट है।

सफेद मल के अणुजीव ववििधिता की जांच

सफेद मल के अणुजीव ववििधिता सड्रिोम (डब्यू भ एफएस) से प्रभावति झींगा तालाब में नेक्श्ट जेनरेशन सीकवेंसगि (एनजीएस) से सूचति हुआ है कि स्वहस्थव तालाब की तुलना में जीनस स्तेर पर कवकीय ववििधिता में में उल्ले खनीय भन्नि ता है। केवल डब्यू त एफएस प्रभावति तालाब में फंगल जेनेरा जैसे मलाससेजयिा, गानोडेर्मा मौजूद हैं। माना जाता है कि मलाससेजयिा से मानव एवं पशुओं में त्वेचा संक्रमण होता है। डब्यू है एफएस प्रभावति तालाब में कैनडडिा प्रजाति प्रमुख जेनेरा है। इसकी अनेक प्रजातयिां प्राकृतकि रूप से रोगजनक हैं।

उन्नत डब्यूँ नडएसएसवी नैदानकि कटि

वन स्टेहप डब्यूडाम एसएसवी पीसीआर एस्सेस से 5 गुना अधकि संवेदनशील फस्टए स्टेप पीसीआर बीइंग 200 कॉपीस/µएल वाले उन्नएत डब्यूसे जएसएसवी नेस्टे ड पीसीआर डायग्नोस्टिकि एस्सेर का वकिास कयिा गया। अन्यए नेस्टेड पीसीआर एस्से स की तुलना में 10 से 50 गुना अधकि संवेदनशील नेस्टेड डब्यू। एसएसवी पीसीआर की संवेदनशीलता 2 कॉपीस/ µएल है। डब्यूसंव एसएसवी, ईएचपी तथा आईएचएचएनवी के लिए हाई सेंसटवि वज्युिअल लूप मीडएिटेड आइसोथरमल एम्ली न फकिेशन एस्सेच का भी वकिास कयिा गया और इन नैदानकिों को पाइन्टम ऑफ केर तक ले जाने का प्रयास कयिा जा रहा है।

वाइब्रयिोसिस का जैवकि नयिंत्रण

झींगा हैचरयिों में फेज थेरेपी के उपयोग से वाइब्रयिोस का जैवनयिंत्रण कार्य जारी रखा गया। फेज प्रॉडक्शजन प्रोटोकोल का अनुकूलन कयिा गया। झींगा हैचरयिों में ल्यूनमनिीसेंट बैक्टीरयिल डसिीस (एलबीडी) आउटब्रेक के दौरान फेज थेरेपी परीक्षण कए गए। चार फेजेस के कंसोर्टयिम का उपयोग कयिा गया। फेज थेरेपी से उपचारति टैंको में लार्वा का औसत अतजिीवति पीएल 5 अवस्थो तक 36% है जो पीएल 3 अवस्थाि में अनुपचारति टैंकों में 100% है। इसके अतरिक्तिव, वाइब्रयिो काउंट में एक लॉग रडिक्शपन तथा ल्यूमनिीसेंट बैक्टीरियिल काउंट में दो लॉग रडिक्श न थे।

डब्ल्यूएसएसवी की प्रभावकारी नष्कि्रयिता

जलजीव पालन जैव सुरक्षा में कीटाणु शोधन एक महत्वउपूर्ण उपाय है। कृत्रमि झींगा पालन पर्यावरण में डब्यूटाण एसएसवी की प्रभावकारी नष्कि्रयिता के लिए क्लो रीन उपयोग की अनुकूल मात्रा एवं अवधि प्रभावति झींगा के ऊतकों में दो दनिों में वायरस की नष्कि्रयिता के लिए 10 पीपीएम, जबकि मृदा में डब्यू एसएसवी की नष्कि्रयिता 20 पीपीएम क्लोपरीन की आवश्यलकता है। 42 झींगा प्रक्षेत्रों में पालति झींगों का वश्लिेकषण एंटबियोटकि्स के लिए कयिा गया जैसे, क्लो,रमफेनकिोल, नाइट्रोफ्यूरान्स तथा इसकी व्युयत्पत्तयिां, नाइट्रोफ्यूरान मेटाबोलाइट, सल्फो नेमाइड्स तथा इसकी व्युनत्पनत्तयिां तथा टेट्रासाइक्लनि अवशेषों से स्परष्ट् हुआ है कि केवल चार मृदा नमूने ही सेमकिार्बाजाइड के प्रति सकारात्मरक हैं।

जलीय पशु रोगों की पीसीआर

नैदानिकी का क्षमता निर्माण एवं सामंजस्यल दर

इस कार्य का मुख्यर उद्देश्यी देश के पूर्वी तट एवं पश्चिमी तट के जलीय किसानों के हित के लिए कुशल एवं विश्वसनीय पीसीआर परीक्षण सेवाएं उपलब्धक कराने हेतु है, जहां वे अपने नमूनों को विश्लेषणीयता के साथ परीक्षण करा सकें ताकि प्रमाणीकरण प्रक्रिया के माध्यनम से उपयुक्त निर्णय ले सकें। प्रथम चरण में प्रयोगशालाओं में उपलब्धय पीसीआर सुविधाओं का सीबा एवं आरजीसीए के एक दल द्वारा निरीक्षण के माध्यम से निर्धारण किया गया। इसके बाद सीबा में प्रयोगशाला तकनीशीयनों के लिए 03 से 05 अक्तूंबर, 2016 के दौरान तीन दिवसीय व्यदवहारिक प्रशिक्षण का आयोजन किया गया जिसमें न्यू क्लिक एसिड, डब्यू मे एसएसवी, ईएचपी तथा आरएनए वायरस, संक्रामक मायोनेक्रोसिस वायरस के लिए पीसीआर के सिद्धांत एवं व्यबवहार का सैद्धांतिक एवं अभ्यायसात्मरक कक्षाएं सम्मिलित की गई। झींगा रोग न्यूतक्लिक एसिड एवं पीसीआर के मौलिक तथ्यभ, झींगा नमूनाकरण के प्रोटोकोल, न्यूलक्लिक एसिड के निष्कर्षण, पीसीआर पर कार्य, इलेक्ट्रो फोरेसिस तथा पीसीआर परिणामों की सूचना के अलावा ट्रबल शूटिंग पर एक अध्योय वाले प्रशिक्षण मैनुअल प्रशिक्षणार्थियों को उपलब्धा कराया गया। वर्ष 2016-17 के दौरान आंध्र प्रदेश (11), तमिलनाडु (8), कर्नाटक (3) तथा गुजरात (3) की कुल 25 प्रयोगशालाओं ने इस पीसीआर रिंग परीक्षण कार्यक्रम में भाग लिया। रिंग परीक्षण में भाग लेने वाली 25 प्रयोगशालाओं मंप से 24 प्रयोगशालाओं ने परिणामों को प्रस्तुात किया जिनमें से 17 प्रयोगशालाएं रिंग परीक्षण में सफल हुईं।

जलजीव पालन स्वास्यशा शिविर

तमिलनाडु के नागपट्टनम जिले के चिन्ना थुम्बूर में 19 अगस्तग, 2016 तथा तमिलनाडु के रामनाथपुरम जिले में 28 सितंबर, 2016 को जलजीव पालन स्वास्य20 शिविरि का आयोजन किया गया। इस प्रदेश के झींगा पालकों के हित में पीसीआर-डीएनए परीक्षण के उपयोग से डब्यू इ एसडी तथा ईएचपी के लिए नि:शुल्क ऑन-फार्म परीक्षण सेवा उपलब्ध कराई गई। तालाब की मृदा की अवस्थास तथा जल गुणवत्ता प्राचल जैसे रडिॉक्स् पोटेंशियल, पीएच, लवणीयता, क्षारीयता, कठोरता आदि जिनमें बैक्टीरियल लोड भी सम्मिलित है, जो जलजीव पालन तालाब परितंत्र के स्वास्यष्ा को सूचित करता है। सूचित करने संबंधी परीक्षण किए गए तथा किसानों को उनकी रिपोर्ट दी गई उपचारात्मकक सुझाव दिए गए। डब्यूएसडी, ईएचपी, एक्यूकट हेपाटोपेंक्रियाटिक निक्रोसिस डिसीस (एएचपीएनडी) तथा जलजीव पालन के निवेशों के उचित उपयोग जैसे रोग प्रबंधन विषयों पर मातृभाषा में तैयार किए गए विस्तावर पत्रकों को झींगा पालकों में वितरित किया गया। तालाब की मृदा एवं जल गुणवत्ता के बेहतर प्रबंधन के लिए मृदा एवं जल गुणवत्ता प्रबंधन, रडिॉक्स। पोटेंशियल तथा झींगा पालन में खनिजों के उपयोग विषयों पर पत्रक वितरित किए गए।

पीनीयस वन्नालमेय के लिए लागत प्रभावी आहार

केरल के त्रिसूर जिले के वोडंगलार गांव के एक किसान के तालाब में सीबा का देशज लागत प्रभावी आहार वन्ना मीप्लेस का परीक्षण किया गया। हम ने यह निरूपित किया है कि वन्नामीप्ल स के उपयोग से एक कि.ग्रा. झींगा उत्पादिन के खर्च को 91 से 98 रुपए तक सीमित किया जा सकता है, जो वाणिज्यिक आहार के उपयोग में 140 रुपए तक जा सकता है। यह निरूपित किया गया है कि कि.ग्रा. झींगा उत्पा दन में आहार खर्च को 91 से 98 रु. तक सीमित किया जा सकता है, जो वाणिज्यिक आहार के उपयोग में 140 रुपए तक जा सकता है।

आहार में एक घटक के रूप में राइस ड्राइड डिस्टिलरी ग्रेन

पी. वन्नाममेयी, पी. मोनोडॉन तथा मुगिल सेफालस के आहार में घटक के रूप में राइस ड्राइड डिस्टिनलरी ग्रेन सोल्यूइबल (डीडीजीएस) की संभावना का परीक्षण किया गया। परिणामों से स्पष्ट हुआ है कि पी. मोनोडॉन तथा मुगिल सिफिालिस के आहार में निष्पाडदन से समझौता किए बिना डीडीजीएस को 10% तक सम्मिलित किया जा सकता है। पी. वन्नाझमेयी के आहार में सोयाबीन मील के स्था न पर डीडीजीएस को 10% तक उपयोग किया जा सकता है।

कुरूमा झींगा, पी. जापोनीकस के लिए विशेष आहार

निम्ना प्रोटीन (42%) वाले आहार की तुलना में पी. जापोनीकस को दिए गए उच्च प्रोटीन (48%) का निष्पा2दन बेहतर देखा गया है, अधिकतम लागत:लाभ अनुपात को प्राप्तस करने में निम्न8 प्रोटीन आहार लागत प्रभावी है।

कवकीय (एस्पनरगिल्लिलस नायगर) किण्वशन का प्रभाव

झींगों के दो तैलीय आहार (सूरजमुखी और मूँगफली) में पोषक तत्वों के उपयोग से सूचित हुआ है कि पी. इंडकिस के कच्चे) आहार में 2.5% सम्मिलिन सीमा के विरुिद्ध तैलीय आहारों को क्रमश: 7.5% तथा 10% तक बढ़ाया जा सकता है।

केकड़ों का आहार

केकड़ों के पालन में सूत्रबद्ध सूखे आहार के उपयोग का खेत परीक्षण किया गया, जिसके परिणामों से यह स्परष्टह हुआ है कि परंपरागत ट्रैश फिश आधारित एकल पालन तथा बहु-प्रजातीय पालन की तुलना में इससे लागत:लाभ आशाजनक पाया गया।

ग्रे मुल्लेट में फैटी एसडि की गतविधि

मल्कि फशि के मांसपेशयिों तथा यकृत में आयु एवं लगि के संदर्भ में फैटी एसडि की भन्नि ताओं पर कए गए अध्ययनों से स्प ष्ट हुआ है क मादा मछलयिों की तुलना में नर मछलयिों में प्रारंभकि अवस्थाओ में प्रजनन के लए महत्वपूर्ण फैटी एसडि अधकि होते हैं जसिसे यह सूचति होता है क नर मछलयिों में परपिक्वनता शीघ्र होती है। यह भी स्प ष्ट है क आयु के संदर्भ में ऊतक आधारति भन्नि मताएं होती हैं। यह सूचना मुल्लेयट्स की वभिन्नि जीवन अवस्थांओं में आवश्यतक आहार की रूपरेखा के लए उपयोगी है।

पी. वन्नाममेय में आवश्यपक आहारीय फैटी एसडि का स्तर

हाइपर और हाइपो लवणता तनावपूर्ण पर्यावरण में पी. वन्नामेयी की अतजीवति एवं वृद्धि नष्पिादन में आवश्यणक फैटी एसडि के स्त रों में बदलाव से आहारीय संशोधनों के कारण वृद्धि देखी गई है।

हरति जल स्थतियिों में उच्चद घनत्व में मल्किआफशि के पोनों का नर्सरी संवर्धन

मल्किजफशि के पोनों के लए वशिेष नर्सरी आहार का वकिास कयिा गया जो मल्किजफशि के अधकितम वृद्धि संभावनाओं को प्राप्तव करने में प्रभावकारी पाया गया। 40 दनिों के संवर्धन काल में लार्वा का शारीरकि भार 2.6 ग्रा. प्राप्तग हुआ।

पर्ल स्पॉसट के लए सूक्ष्म आधारति नर्सरी आहार

सूक्ष्मप जगत के टैकों में सूक्ष्मध आधारति नर्सरी के आहार के उपयोग से पर्ल स्पॉआट की तरुण मछलयिों के गहन नर्सरी संवर्धन में सुधार कयिा गया। 20 दनिों के डीपीएच पर प्रारंभकि 80 से 100 मि.ग्रा. पोनों के उपयोग से 40 दनिों के संवर्धन काल में 95% अतजीवति तथा 0.8 से 1.0 एफसीआर से 1 ग्रा. (900 मि.ग्रा. से 1200 मि.ग्रा.) तरुण मछलयिों का उत्पादन 1000 पोना/घन मीटर के घनत्वआ से उत्पा दन कयिा गया।

संग्रहण घनत्व् में समृद्ध सूक्ष्मम जगत आधारति प्राकृतकि आहार का प्रभाव

सूक्ष्म जगत आधारति प्राकृतकि आहार स्थतियिों में वन्नारमेयी झींगों के संग्रहण घनत्व् का वृद्धि नष्पिादन पर कए गए अध्ययन से स्पकष्ट हुआ है क बेहतर आहार उपयोग के लए अनुकूलतम घनत्वा 50 झींगा प्रति वर्ग मीटर है।

बायोफ्लॉक मील में न्यू ट्रएिंट प्रोफाइलगि

सी:एन अनुपात के संदर्भ में उत्पोदति बायोफ्लॉक मील में पोषक तत्वों के प्रोफाइलगि से स्पंष्टउ हुआ है क बायोफ्लॉक एमनिो एसडि मेथयिोनाइन का समृद्ध स्रोत है जसिे जलीय आहार सूत्रणों में एमनिो एसडि को सीमति करने वाला माना जाता है।

माइस्ट्स गुलयिो के लए आवश्यकि आहारीय प्रोटीन

माइस्ट्स गुलयिो के लए आवश्यकि आहारीय प्रोटीन के अध्ययैन से स्पष्ट हुआ है क अधकितम नष्पिोदन के लए 25% क्रूड प्रोटीन अनुकूलतम होगा। बैकयार्ड पालन प्रकार में उच्चम मूल्य के इस मछली के गहन पालन के लए कम लागत वाले व्य वहारकि आहार जसिमें 25% प्रोटीन तथा 6% लपिडि मौजूद हो, सफिारशि की जाती है।

सूक्ष्मच शैवाल की जैववविधिता

मुत्तुकाडू पश्च जल में सूक्ष्मह शैवाल के वश्लिे षण में पाया गया क पश्च जल जलीय कृषि में महत्वचपूर्ण सूक्ष्मक शैवालों के नस्लों व से समृद्ध है। इन पश्चमजलों से पहली बार संभावति नस्ल् जैसे, आर्थ्रोस्पीरा मैक्समिा तथा स्पीरुलिना सबसालसा को पृथक कयिा गया और इन संपदाओं का रखरखाव कयिा गया। प्रत्यआक्ष आहार के लए लाइव फीड को समृद्ध करने के लए इन संसाधनों को लाइव फीड के रूप में बेहतर उपयोग करने हेतु न्यू ट्रएिंट प्रोफाइलगि तथा मॉलक्यिूकलार टेक्सोनोमी अध्य यनों का प्रयास कयिा गया।

पर्ल स्पॉट का आनुवांशकि गुणवत्रिण

वभिन्नि प्रथा नों (पुलकिट झील : तमलिनाडु; वेल्लार्यनी, वेम्बाकनड तथा अस्था मुडी : केरल) के पर्ल स्पॉथट समष्टयिों इट्रोप्ल:स सुराटेंसस का माइटोकोंड्रयिल डीएनए ATPase 6/8 के उपयोग से आनुवांशकि गुणवत्रिण कयिा गया। वेल्लोयनी, वेम्बायनड तथा अस्थाडमुडी झीलों से पुलकिट झील की समष्टि पूरणत: भन्नि पाई गई।

पीनीयस इंडकिस की आनुवांशकि संपदा

इंडयिन व्हाकइट श्रंपि पीनीयस इंडकिस : 1) पश्चमि बंगाल, 2) ओडशिा, तमलिनाडु एवं केरल तथा 3) महाराष्ट्र्य के तीन भन्नि। आनुवांशकि संपदाओं को माइटोकोंड्रयिल डीएनए जीन, 16S rRNA के आधार पर प्रलेखति कयिा गया।

पीनीयस वन्ना मेय का ट्रांसक्रप्टिोमि प्रोफाइलगि

तापमान दबाव वाले पी. वन्नाकमेय तरुण झींगों के ट्रांसक्रप्टिोम प्रोफाइलगि के आधार पर यह अनुमान लगाया जा सकता है क 29o से. पर रखरखाव कए गए झींगों की तुलना में उच्च तापमान (31 एवं 33o से.) वाली झींगों की तुरुण मछलयिों ने फैटी एसडि बायोसथिेसस में सम्मलिति ट्रांसक्रप्टिोम की उच्च अभव्यिसक्ति दर्शाई है।

पीनीयस जीनस का मॉल्यूट्लर फाइलोजेनेटकि वश्लिेषण

संपूर्ण माइटोकोंड्रयिल जीनोम के

उपयोग से पीनीयस सेंसुलाटो जीनस की झींगा प्रजातियों में आकलति फाइलोजेनेटकि संबंध, पेरेज फरफेंटे तथा केनसेली (1997) द्वारा प्रस्तायवति इस जीनस के 6 अलग जेनेराओं में वभिाजन की आवश्यनकता नहीं है।

सीबा की प्रौद्योगकियिों तथा नीतगित हस्तेक्षेपों के आर्थकि प्रभाव का वश्लिेषण

तीन चयनति जलजीव पालन प्रौद्योगकियिों, नामत: डब्ल्यूएसएसवी कटि (2002-2009), पीनीयस वन्नोमेय का परविेयन (2009-2016) तथा सीबास्टमि उत्पालद (2012-2016) के आर्थकि प्रभाव का मूल्यांकन कयिा गया। इन प्रौद्योगकियिों से 2002 से 2016 के दौरान राष्ट्री य राजकोष को प्राप्तक कुल आर्थकि लाभ 34,413 करोड़ रुपए का आकलन कयिा गया है।

मेरा गांव मेरा गौरव (एमजीएमजी) कार्यक्रम

सनजीयाममन, तरिूपलायनम तथा कनवनतुराइ, अवूरीवक्क्म, तरिुवल्लूर जलिों के जनजातीय तथा तटीय क्षेत्रों में कुल 10 बैठकों तथा जागरुकता अभयिानों का आयोजन कयिा गया। कचिन गार्डन, पोषणकिता एवं स्वोच्छकता, समूह गठन, प्रौद्योगकियिों का नरिूपण एवं अपनाना, कौशल वकिास तथा प्रौद्योगकियिों को अपनाने के दौरान समस्यानओं का समाधान जैसे हस्त क्षेपों पर लाभार्थयिों के हति के लिए प्रशक्षिण दयिा गया।

झींगा पालन प्रणालयिों की सततता का अध्ययन

केरल, तमलिनाडु और पश्चमि बंगाल राज्यों में झींगा पालन की सततता का अध्ययन कयिा गया। झींगा पालन प्रणालयिों की सततता के आकलन के लिए वस्तिृात मेथडोलॉजी के आधार पर कुल 28 सूचकों की पहचान की गई। अध्य यनों के परणिामों से स्पडष्टर हुआ है कि झींगा पालन का औसत सततता सूचकांक 0.74 है। जबकि अर्द्ध-गहन तथा परंपरागत झींगा पालन का सततता सूचकांक क्रमश: 0.79 तथा 0.65 है। परणिामों से सूचति हुआ है कि परंपरागत प्रणालयिों की तुलना में अर्द्ध-गहन पालन प्रणाली सापेक्षकि रूप से बेहतर है।

आईसीएआर-सीबा द्वारा वन्नालमीश्रपिएप का प्रारंभ

सीबा ने झींगा पालन से संबंधति प्रौद्योगकियिों, उत्पादों, बाजारों तथा नीतयिों से संबंधति तकनीकी सूचनाओं को पणधारयिों तक नरिंतर पूछे जाने वाले पश्नोंर के रूप में एक एंड्रॉयड आधारति मोबाइल एप ''वन्ना मीश्रपिएप'' का प्रारंभ कयिा है। इस मोबाइल एप को नि:शुल्को गूगल प्ले स्टोर से डाउनलोड कयिा जा सकता है।

Executive Summary

Although brackishwater aquaculture has been practiced in India for several decades, the modern brackishwater aquaculture particularly shrimp farming started in mid 1980s. The growth of brackishwater aquaculture for the last three decades has been spectacular. ICAR-CIBA has been playing a pivotal role in shaping the industry, resolving the issues in aquaculture and assisting in framing the policies. Being one of the foremost research organizations in the country, the research work carried out by the Institute lead to outcomes that are crucial to the brackishwater farming sector. The year 2016-17 was a rewarding and fulfilling year of CIBA in terms of scientific contributions, and impacts on the sector. With a twenty nine in-house and external funded projects and out reaching activities the Institute was able to provide remarkable contribution for the science of brackishwater aquaculture that leads to the technological know-hows. The current year CIBA had 31 MoUs, and that generated a revenue of ₹ 2.5 million, During this year the Institute released 209 publications including 79 peer-reviewed scientific papers in high impact journals. Presented below are some of the highlights of the research and development that accomplished by the Institute during 2017-18

Penaeus indicus demonstration trials

Shrimp farming in India, which is based on exotic *Penaeus vannamei*, is at a cross road due to the emerging diseases, reduced survival, increase in the cost of production, and recent falls in prices. At this juncture development of native species is a viable option to ensure the sustainability of shrimp farming. Indian white shrimp, *P. indicus,* has been identified as a suitable candidate species for domestication and genetic improvement. In order to evaluate the farm level performance, 21 demonstration trials were carried out at

identified stations all along the Indian coast. The production ranged between 2- 6.5 mt/ha at stocking density of 15 to 45 PL/m^2, with a survival Salient observation is absence rate ranging between 80 and 98%. The FCR ranged from 1.4 to 1.65. The absence of emerging diseases such as EHP and running mortality syndrome, is found to be an important characteristic of *P. indicus*.

Doubling of farmers income through inland low saline shrimp farming in south western Punjab: Initiative of CIBA

South Western region of Punjab possesses abundant resources of inland saline groundwater with salinities ranging from 3 to 15 ppt. Vannamei farming in this area leads to a e success story in South Western Punjab, where farmers obtained an income of Rs. 2.0 lakh/acre from a four-month long crop, using the technological package for shrimp farming from CIBA. The technology of shrimp farming using saline groundwater with high-quality seed and cost-effective *desi* feed has become an income multiplier for farmers in Punjab.

Production system diversification: development of integrated multi-trophic aquaculture (IMTA):

Diversifying and improving the performance of production system and species cultured are the major priorities of aquaculture research. IMTA is the cultivation of two or more complementary crops where waste of one crop serve as input (feed or fertilizer) for other crops. Thus, environmental issues related to the coastal aquaculture could be solved to greater extend, and further cultivation of different crop optimize the economic returns. An open water IMTA was developed in Gad River, Sindhudurg district, Maharashtra. In a 32 m^2 cage seabass was reared along with green mussel as an extractive crop. After nine month of rearing, sea bass has grown to an average size of 990.1 g with a total production of 360 kg and survival of 63%. Farmers received revenue of ₹ 162000/ for a total cost of ₹ 120000/ for nine months

Biofloc based culture systems:

High-density culture systems with limited or no water exchange results in the production of large volumes of suspended flocculated organic particles including microalgae, autotrophic and heterotrophic bacteria. These, unique system, biofloc system, provides several beneficial effects to farmed species.

Milk fish: A 60 days experiment was carried out and evaluated growth performance of milkfish, *Chanos chanos* in biofloc based nursery rearing system using different carbon sources (Molasses, Wheat & Corn). The results revealed that milkfish fry reared in wheat based biofloc system showed significantly better growth performance. Although water quality characteristics such as ammonia, nitrate and nitrate was significantly higher in biofloc system, all these parameters found to be favorable for milkfish growth

Penaeus vannamei: The C/N ratio of the culture water can have extremely significant impact on water quality and biofloc biomass production. The effect of different C/N ration on production performance of *P. vannamei* was evaluated. C/N ratio up to 15: 1 is favourable for growth and survival of *P. vannamei*.

Pond reared brood stock for Indian shad, Hilsa

Development of captive broodstock is the essential pre requisite for developing protocol for mass rearing of any farmed species. Broodstocks of Hilsa were developed in the grow-out production system in Kakdwip research centre of CIBA. Reproductive maturation in pond system is found to be synchronized with natural breeding cycle.

Polyculture

Polyculture is the addition of one or two subordinate system, and it is one of the efficient ways of increasing productivity and optimizing the economic returns. Several experiments were carried out to evaluate the growth and production performance of

polyculture including shellfish and finfishes. In one experiment, growth performance of *Mystus gulio*, *Chanos chanos*, *Etroplus suratensis*, *Oreochromis niloticus* and *Penaeus monodon* was studied. The experimental trials demonstrates the promising results in terms of growth of various finfishes and shellfishes in the polyculture farming

Popularization of milkfish farming as *'Decan Hilsa'* in West Bengal:

Proper and efficient marketing is the essential component of a sustainable aquaculture. Milk fish has been marketed in West Bengal under the name,*'Decan Hilsa'*. As a part of this program, a collaborative research work with a private entrepreneur was carried out, and 2 mt of milkfish with an average body weight of 225 g was harvested

Seabass farming as a livelihood option for youth in Karnataka

CIBA started a seabass farming program to provide livelihood option for young farmers in Kasargoda village in Karnataka. With the hatchery reared seed provided by CIBA, farmers were able to harvest 512 kg of seabass from 0.2 ha pond for a period of 10 months.

Brackishwater seaweed, *Gracilaria* spp:

Gracilaria spp is one of the most important aquaculture resources, and it has been widely used for the production of agar and treatment of aquaculture discharges. Several experiments were carried out to evaluate the production technique and farming environment: for example pond and open lagoon. Production performance was higher in rope culture compare to net bags. The potential of seaweed as biofilter has been tested and seaweed based biofilter has been developed and tested for the efficacy.

Aeration efficiency

Mechanical aeration has been the general practice in feed based aquaculture system particularly in semi-intensive and intensive shrimp culture ponds. The efficiency of aeration is extremely important to optimize the economics of the culture system as well as to optimize the DO levels in the aquaculture ponds. Salinity levels in the water have been the major deciding factor that determines the DO levels. The oxygen requirement at different salinity levels were determined using different aerators such as paddle wheel, submersible, spiral, jet and impeller aerators.

Cryptic species of *Penaeus japonicus* from India

The previous studies on kuruma shrimp, *P. japonicus*, conducted by CIBA suggested the difference in the biology and in the aquaculture traits with reference to *P. japonicus* reported from other countries. Molecular signature of this species, using specimens obtained all along its distributional range in India, was evaluated using 16S rRNA gene and CO1 gene. Molecular phylogenetic analysis of 16S and CO1 demonstrated that the species reported in India is a cryptic species *of P. japonicus* group. The genetic distance between Indian species and *P, japonicus* and *P. pulchircaudatus* confirms a new species status for Indian taxa

Reproductive quality of male *Penaeus indicus* (Indian white shrimp) in relation to molting stages:

Reproductive management of males in shrimp hatchery is crucial in optimizing reproductive performance and seed stock production. The male spermatophore quality of *Penaeus indicus* was evaluated in relation to the molt stages, the average sperm count was significantly higher in premolt stage compare to inter molt stage although no difference in percentage of live or normal sperm between the two phases of molt cycle.

Artificial insemination (AI),

AI is a deliberate introduction of sperm into the female reproductive tract, and which is the crucial component of captive breeding program. Several trials of AI have been carried out in *Penaeus monodon, P. indicus* and *P. vannamei*. Success rate in *P. vannamei* is found to be higher than the *P. monodon* and *P. indicus*, presumably due to the difference in the

reproductive morphology.

Development of *In vitro* fertilization (IVF) of *Penaeus monodon*

In vitro fertilization in shrimp aquaculture is one of the important tools to study the developmental biology of shrimp that resolve the issues in captive reproduction. Further, it is important to evaluate the hybridization potential of the species, as *in vivo* hybridization often fails to understand the problems involved in the fertilization process. A novel IVF protocol is developed and tested the hybridization potential of *P. monodon* eggs with *P. vannamei* and *P. indicus.* High percentage of fertilization was achieved between *P. monodon* and *P. vannamei* compared to *P. monodon* and *P. indicus*.

Effect of salinity on survival, growth and osmoregulatory capacity of *Penaeus vannamei* and *P. indicus* with special reference to the inland saline ecosystem.

Recently, marine shrimp farming is extended to low saline coastal areas and inland brackishwater areas, where traditionally shrimp farming was not practised. Understanding the physiology of osmoregulation in low saline and inland brackishwater is vital for further refinement of low saline shrimp farming technology. Experiments were carried out to evaluate the growth, survival and osmoregulatory capacity of *P. indicus* and *P. vannamei* under reduced seawater salinities and reconstituted inland salinities. Survival of *P. indicus* was significantly higher at 10 ppt of seawater, whereas survival was significantly higher at 10 and 15 ppt in the reconstituted inland saline waters.

Improving the survival rate of mud crab, *Scylla serrata*, by different feeding schedule

High mortality rate of *Scylla serrata* zoea has been the major bottleneck in the initial phase (Z1 to Z3) of mud crab larval rearing. The poor survival rate at this phase is mostly attributed to the nutritional status of the crab larvae, which in turns depends on the feed quality and quantity. Rotifer fed on *Thalassiosira* and combination feed including *Chlorella* and *Tetraselmis* produced better survival.

Growth and reproductive parameters of grey mullet *Mugil cephalus*- variations of two captive stocks

Variations in biological parameters may serve as indicators of stock variations in fish. Growth and reproductive performance of the populations of *M. cephalus* obtained from east and west coast were evaluated, after rearing three years at similar environmental conditions. It was found that both stocks are significantly different in growth and reproductive characteistics indicating the variability of the stock.

Start-up program of seabass hatchery

In order to promote establishment of seabass hatchery, a private entrepreneur was allowed to use the facilities in CIBA hatchery. Seeds and technical knowhow were provided to entrepreneur. A total of 9,60,000 spawn supplied to entrepreneur, and he produced old 3,27,500 20-day old fry. The produce was sold to farmers for an amount of ₹ 6,88,625/- .. As a knowledge partner CIBA was shared an amount of ₹ 250000/.

Captive maturation and ovulation of *Liza parsia*

Development of regionally important small fishes for brackishwater aquaculture is one of the strategies for food security and livelihood diversification in coastal rural areas. Gold spot mullet, *L. parsia* is a high valued food fish in some states of the country. A breeding protocol has been developed for the induced maturation of *L. parsia*. For induced breeding, two phase rearing is required: fishes should be reared in low saline water for reproductive maturation and for final oocyte maturation and spawning fishes should be transferred to full strength seawater.

Larval development and rearing procedure of Hilsa

Larval development and detail ontogeny of larvae were studied and documented. Hilsa

larvae were reared in tanks for fifteen days using live feed such as *Chlorella*, copepod and *Artemia* nauplii. Subsequently the larvae were transferred to earthen pond for further rearing.

Extended breeding of milkfish under captivity

Milkfish breeding technology has further refined, and breeding period under captivity has been extended for eight months. A total of 1.39 million fertilized eggs were obtained from thirteen spawning. It has been observed that milkfish spawning is more correlated with increasing water temperature than salinity. A total of 75000 early milkfish fry were distributed among farmers from Kerala, Goa, Gujarat, Tamil Nadu, Andhra Pradesh and West Bengal along with 2.5 lakh fertilized eggs to the private entrepreneur for satellite nursery rearing. Total revenue generated was ₹ 97500 from seed sale. Multiple spawning of milkfish extended for eight months gives the possibility to overcome challenges of year round breeding

Breeding of Crescent perch, *Terapon jarbo*

Seed production protocol for the aquarium fish, crescent perch, has been standardized. Induced breeding protocol using LHRHa was successful, and larvae were reared using algae, *Nanochloropsis aculeate* and Rotifer. About 50000 larvae were produced during the experiment.

Culture of Cyclopoid copepod

Cyclopoid copepods are emerging live food organism, and procedure for mass rearing of a novel cyclopoid copepod was developed. Mass culture of copepod using a combination diet of *Nannochloropsis* sp and *Isochrysis* sp, *Chaetoceros* sp, rice bran powder and baker's yeast resulted 1500 to 4500 no/L within 14 days.

White spot disease and microsporidosis continue to haunt shrimp farming

Disease surveillance during 2015-2018 in 420 shrimp farms in three coastal states:Tamil Nadu, Andhra Pradesh and West Bengal revealed that the shrimp hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) had the highest prevalence of 43% in 2015, and during the last year, the prevalence decreased to 21%. The prevalence of white spot disease (WSD) was 37% and 11% during the corresponding years. The prevalence of infection hypodermal and haematopoietic necrosis (IHHN) also decreased from 6 to 3-% during the last three years. The other disease syndromes, such as stunted growth, white feces syndrome (WFS), running mortality syndrome (RMS), loose shell syndrome (LSS) and black gills were recorded in 27, 12, 4, 6% and 5% of the farms respectively during the year 2017-18. The shrimp culture in India was free from OIE listed diseases such as Taura syndrome (TS), yellow head disease (YHD), acute hepatopancreatic necrosis disease (AHPND) and necrotising hepatopancreatitis (NHP) during 2017-18. However, infectious myonecrosis (IMN) was detected in two P. vannamei farms in AP and TN during February- March 2017.

The Indian strain of Infectious myonecrosis virus (IMNV) showed highest sequence similarity to the Indonesian strain

Infectious myonecrosis virus (IMNV) was detected from some farms in Bhimavam in AP in 2017. The bioassay study reproduced the disease in *P. vannamei* and caused up to 80% mortality. The muscle of affected shrimp had ultrastructural changes such as fibrosis and vacuolation. The whole genome sequencing of this IMNV strain showed maximum identity with Indonesian IMNV strain KF836757.1.

Tilapia Lake Virus (TiLV) detected for the first time in GIFT Tilapia in India

Tilapia Lake Virus (TiLV) was detected for the first time in GIFT Tilapia samples of Andhra Pradesh and Tamil Nadu. The affected fish had ulcerative lesion in the skin, haemorrhages on body and caudal fins, and opacity of the eye lens. The disease was reproduced in tilapia by experimental bioassay resulting in 86.67 % mortality. The TiLV was adapted in primary culture of tilapia brain.

Parasitic profiling in brackishwater finfishes

Parasitic profiling of nearly 600 fishes of five candidate species (Lates calcarifer, Mugil cephalus, Chanos chanos, Scatophagus argus and Etroplus suratensis) indicated that Argulus and Caligus were the most common parasites affecting these brackishwater finfishes. Argulus spp. infection was observed in 10.5% of L. calcarifer, 6.3% of M. cephalus, 7.5% of S. argus and 5.0% of E. suratensis. Caligus spp. infection was restricted to S. argus and E. suratensis. Interestingly, no parasitic infection was recorded in milk fish, C. chanos.

Microbial diversity of EHP and white feces affected pond

The microbial diversity study of EHP and white fecal syndrome (WFS) affected pond was carried out using metagenomics. The dominant bacterial families included Pseudoalteromonadaceae (17.44%), Idiomarinaceae (11.12%), Flavobacteriaceae (7.71%), Pseudomonadaceae (5.58%) and Rhodobacteraceae (5.03%). The dominant bacterial genus was Pseudoalteromonas (16.54%), Idiomarina (10.99%) and Pseudomonas (5.45%). Only 0.12% of the total operational taxonomic units (OTUs) belonged to Vibrio spp.

Microbial profiling of nitrifying and denitrifying bacterial product 'CIBAMOX'

CIBAMOX is a microbial consortium containing ammonia oxidising bacteria (AOB), nitrite oxidising bacteria (NOB) and denitrifying bacteria (DNB). The microbial profiling by PCR-DGGE confirmed the presence of 2 DNB, 8 AOB and 11 NOB groups. Metagenomic analysis recovered 199 (OTUs) covering Alphaproteobacteria (32.4%), Gammaproteobacteria (28.6%), Betaproteobacteria (1.0%) and Deltaproteobacteria (0.7%).

Lysogenic filamentous phages are widely distributed among species of harveyi clade

Bioinformatic analysis of 60 isolates (NCBI database) of harveyi clade bacteria including *V. campbellii* and *V. harveyi* indicated that almost 50% isolates possessed filamentous lysogenic phage and appeared to play an important role the in virulence of these bacteria. Using specifically designed primers, its presence was confirmed in 33% of *V. campbellii* isolates at CIBA.

Improved diagnostic kits developed for *Enterocytozoon hepatopenaei* (EHP)

A nested PCR kit targeting spore wall protein gene was developed for rapid and specific diagnosis of EHP in shrimp. The PCR products of 486 bp (first step) and 349 bp (nested) were generated by an optimized amplification cycle. The kit also includes β-actin house-keeping gene to ensure nucleic acid extraction. The detection of EHP was 100% accurate in experimentally infected *P. vannamei* and had detection limit of 20 copies.

Inactivated vaccine was developed against nervous necrosis virus affecting Asian seabass

Inactivated viral vaccine was developed to control nervous necrosis virus (NNV) infection in juvenile Asian seabass. The SSN-1 cell line propagated NNV virus was inactivated using binary ethylenimine. An oil adjuvant vaccine was produced by mixing inactivated cell culture supernatant with Montanide Essai GR01 PR and Montanide IMS 1312 VG NPR adjuvants. The vaccinated fish recorded 60% relative percentage survival (RPS) on challenge with virulent virus.

Phage therapy was effective in controlling luminescent vibriosis in commercial shrimp hatchery

The efficacy of phage therapy was tested in four commercial shrimp hatcheries to control luminescent vibriosis. A consortium of four phages improved the survival of postlarvae by 35 – 53% compared to 100% mortality in untreated group in two commercial hatcheries severely affected with luminescent vibriosis. As a prophylactic measure, phage application improved the larval survival by 15 - 17% in two hatcheries having no record of vibriosis.

Degradation of oxytetracycline is dependent on salinity and temperature

Studies on the degradation of oxytetracycline indicated a positive influence of salinity, temperature and photoperiod. The rate of degradation was faster at lower salinity and higher temperature. Overall, 98% oxytetracycline was degraded in 2 days at 36°C compared to 5 days at 25oC.

Evaluation of newer feed ingredients for use in aquafeeds

Experiment on use of rice gluten indicated that it could be used up to 20% in the vannamei feed. Dried distiller's grains with solubles, a by-product from ethanol production can replace 25% of the fish meal, 30 % sunflower cake and 11.25 % mustard cake in fish polyculture feed. Fermented rapeseed meal can be included up to 7.5% in *P. indicus* feed compared to 2.5% with a raw meal. Similarly, combinations of fermented meals of soybean, groundnut, rapeseed and sunflower were able to replace up to 70% of fishmeal in shrimp feeds.

Demonstration of practical feeds developed by CIBA in farmers places

Cost effective feeds developed for shrimp vannamei, seabass, and crab such as VanamiPlus, Seebass Nursery Plus, SeebassPlus and ScyllaPlus respectively were taken for a demonstration in farmers places, and successful crops were obtained. The shrimps attained an average body weight of 24.5 g at 72 days with a production of 550 kg. Seabass fry got a survival of 95% final average body weight varying from 50 to 200 g in 90 days. In grow-out farming in cages, seabass obtained the size of 900 g - 1.25 kg in 6 months with a production of 460 kg and feed conversion ratio (FCR) of 1.85:1. After four weeks, 22% of the crabs showed moulting, and 93 % of the crabs survived.

Optimization of nutrient requirements for farmed fishes and shellfish

In seabass larval diet 0.5 % taurine supplementation was found to be optimum. Optimum lysine and methionine requirement of hilsa fry were found to be 3.54 % and 1.64 % of feed on a dry matter basis. The dietary vitamin C requirement for the growth of *Chanos chanos* larvae was estimated to be in the range of 183–204 mg ascorbic acid per kg of feed. The growth and survival of milkfish were positively related to the dietary PL concentration. It was found that 6% dietary fat with 25 % protein is optimum for M. gulio in its grow-out diet.

Feed management options

In juvenile pearlspot, the daily ration of 5% feed of average body was found to be optimum for better utilization of feed and good FCR. Experiments have indicated that periphyton can be better utilized by milkfish juveniles and it can reduce the FCR up to 46% in monoculture.

Live Feeds

The growth kinetics of different micro algae showed The *Tetraselmis* sp was showing extended exponential growth (>12 days) in its growth cycle. Extraction of bioactive pigment phycocyanin standardised for *Arthrospira maxima*, and the purity of crude extract of was on par with commercially available spirulina (*Spirulina platensis*). Micro algal suitability for larval rearing of shrimp showed that the highest survival, growth and fast conversion with a combination of *Thalassiosira*: *Tetraselmis* (1:1) followed by *Thalssisosira* : *Chaetoceros* and *Thalassiosira*.

WSSV complete genome sequence

For the first time, complete genome sequence of an Indian isolate of white spot syndrome virus (WSSV) has been deciphered. The length and repeat content of *Penaeus indicus* genome were estimated to vary between 1.57 to 1.87 Gb and 62.7 to 82.5 % respectively based on k-mer principle. The genome of Penaeus indicus cannot be assembled with short Illumina reads as the genome gets broken into several fragments

Genome size of candidate species

The genome size of candidate fish and shellfish species was estimated using flow cytometer. In shrimp, the genome size varied significantly between sexes

New model fish species

Breeding of Rice fish, Oryzias sp. has been achieved for the first time in captivity. The fish has the potential to be considered as a model organism for studies in brackishwater fishes

Genetic diversity of pearl spot and grey mullet

High genetic diversity was observed among the stocks of *Etroplus suratensis* based on an analysis using mitochondrial ATPase6/8 gene, as most of the stocks studied exhibited significant divergence from other stocks. In Mugil cephalus, mitochondrial ATPase6/8 gene indicated three distinct genetic stocks viz., Goa stock, Karnataka stock and the stocks from Kerala, Tamil Nadu, Andhra and Odisha

Genetic diversity in *Chanos chanos*

Significant genetic divergence was observed between Goa and Kerala stocks of Chanos chanos based on mitochondrial ATPase6//8 gene

Suitable site for inland brackishwater farming

Based on the soil and surface/ground saline source waters quality and suitability criteria, farming sites (districts of Jaipur, Ajmer,Jodhpur, Pali and Jalore) were identified for aquaculture farming in the inland saline regions of Rajasthan.

Adyar creek

Monthly monitoring of Adyar creek revealed that the variation in key water quality parameters under different seasons is within the desirable limit and suitable for cage culture of specific species of fish and crab.

Soil and water management

Peracetic acid of 10 ppm was effective in reducing bacterial count and inhibiting growth of luminescent *Vibrio* sp. and can be used as an alternative disinfectant. The residual effect of PAA reduced to zero after 48 hrs of application at 10 ppm conc compared to bleaching powder and sodium hypochlorite, which lasted upto 72 hrs.

Oxygen releasing compound

The prototype oxygen releasing compound (ORC) could be utilised as supplement to mechanical aeration under emergency condition rather than a replacement. Calcium peroxide and ORC could be utilized for the treatment of COD rich discharge water as well as source water.

Database on mineral status of shrimp culture ponds

Minerals status of shrimp culture ponds and source waters from Andhra Pradesh, Tamil Nadu and Gujarat showed no significant change for Ca, K, Mg, Zn and Cu with pond age and high concentration of available Na, Cl, Fe and Mn concentration were observed in 16-20 year aged ponds. Creek and bore well waters from different locations, even with similar salinity varied in their mineral composition and ionic ratios.

Adaptation of *P. vannamei* under various salinities

Study of *P. vannamei* under 0, 16 and 32 ppt salinities throughout the culture revealed that the mean water osmolality varied from 21, 419 and 909 mOsmol/kg under 0, 16 and 32 ppt salinity respectively. However, there was not much change in serum osmolality (614, 713 and 888 mOsmol/kg at 0, 16 and 32 ppt), indicating that *P. vannamei* adapts well to varying salinities. Moreover *P. vannamei* rapidly adapts to drastic changes in the mineral content of water, even as quickly as every 24-hours interval.

Identification of bacterial diversity in shrimp culture ponds by metagenomics

The study was conducted to understand the diversity of the bacterial communities at sediment-water interface (SWI) in *P. vannnamei* culture ponds of various salinities. It was found that more diverse microbial communities toward the end compared to early days of culture in all salinities. Actinobacteria were dominant at 30 DOC and Proteobacteria at 60 and 90 DOC in saline and high saline culture ponds, whereas in low saline

Proteobacteria was dominant during the whole culture period. The predominance of populations of sulfur-reducing bacteria starts from 60 DOC in low saline, throughout the cropping period in high saline, and at 90 DOC in saline culture ponds indicates the possibility of build-up of sulphide and reduced condition in the pond.

Environmental impact assessment

Monitoring of water and soil quality from source water, crab culture pens and ponds, and receiving water bodies in Sindhudurg District showed no negative environmental impacts of crab farming on the receiving water bodies. Carrying capacity assessment of the water bodies in the district revealed the scope of increasing the area for crab farming.

Soil water health cards to aquaculture farmers

Soil and Water Health cards were prepared in PPP mode by the Institute in collaboration with three private laboratories and Fisheries College in Nellore District. Portable water analysis kits developed were refined and proved to be more accurate than the counterpart kits available in the market.

Climate change on GHG emission, animal metabolism and survival

The pond bottom emitted higher amount of CO2 during the drying process compared to the emission during culture period, whereas CH4 emission was high during culture period, and N2O emission trend was not significant. In situ environment manipulation unit for conducting thermal stress experiments was fabricated. Seabass fry can tolerate acute temperature stress for a period of 72 h till 30°C with minimum mortality. Beyond 32°C water temperature, mortality was high and is not advisable for seabass nursery rearing. Temperature stress in *P.vannamei* juveniles showed increase in total lipid and fatty acid content in hepatopancreas and, increased fatty acid biosynthesis, pentose phoshphate pathway and biotin metabolism in shrimp reared at 31 and 33 but not at 35 oC.

Aquastat India 2017 -brackishwater aquaculture sector

A comprehensive database, *Aquastat India 2017- brackishwater aquaculture sector*, on the global and Indian scenario of brackishwater aquaculture was prepared. The compendium consists of resources, production, and trade statistics of aquaculture and also includes information on technical aspects of the brackishwater aquaculture and their economic impact.

Impact analysis of brackishwater aquaculture technologies

Analysis based on Input-Output time series intervention model for the period 2002-16 indicated that the total economic benefits accrued to the national exchequer cumulatively from the three brackishwater aquaculture technologies viz., WSSV kit (2002-2009), Introduction of *Penaeus vannamei* (2009-2016) and the product CIBASTIM (2012-2016) were to the tune of Rs. 34,413 crores.

Brackishwater Aquaculture- the prospective sector for doubling farmer's income

Scientific production and management of shrimp and finfishes yield high income to the farmers within a short span of time, which are four-fold increase than the traditional practices. Production of shrimp species like white shrimp (*Penaeus Vannamei*; net return of Rs.7 lakh/ha), milkfish (*Chanos chanos*; 2.40 lakh/ha), Asian Sea Bass (*Lates calcarifer*; 4.00 lakh/ha), and Pearl Spot (Etroplus suratensis; 2 lakh/ha) would fetch higher income within

Seabass rearing in a three-tier model of cage farming in brackishwater

The technology package for a three-tier model of cage farming of fishes in open brackishwater comprises of nursery rearing, pre-grow out and grow out phases was validated in partnership with the NIOT Chennai and fisher youth group at Vennangupattu village cluster in Kancheepuram district, Tamil Nadu. Asian seabass (Lates calcarifer) fish was chosen as culture species due to its growth potential,

availability of seed and feed and higher market value. The production cost was worked out to be Rs.190 per kg of fish and sale price was Rs.380 per kg with a BCR of 2.0.

Upgradation of Vanami Shrimpapp with additional modules

Vanami Shrimpapp is the first mobile app on shrimp farming and has been regularly followed by more than 7500 stakeholders (farmers and extension workers) across the globe (India, Indonesia, Vietnam, Brazil, Peru, Mexico, Ecuador, and the USA). The app is comprehensive and upgraded with Best Management Practices Module, Input Calculator, Disease Diagnosis using probabilistic techniques, Shrimp Farm Risk Assessment Module, Update and Advisories, Government Regulations, FAQ Module, Post a Query, etc.

The value chain of family participation in aquaculture sectors

SEAGA analysis of value chain mechanism of family participation indicated that women and their families had supported the men in aquaculture sectors (50%). They have adopted new techniques in fish farming practices (20%), entered into new markets and more profitable enterprises (20%) and both men and women play a major role in the aquaculture and fishery value chain (60%) and decision-making practices (60%) in value chain of fish and shrimp farming.

Social Status analysis of tribal farmers involved in brackishwater aquaculture

The social status of the 50 tribal families in the coastal tribal villages of Tamil Nadu indicted that their maximum age group (both men and women) were between 20 to 40 yrs. (60%) followed by 40 to 60 yrs. (20%), and 60 yrs and above (20%). 90% of them were illiterate followed by primary level education. Fishing, wild shrimp collection, and crab collection was their major occupation (90%). The majority (70%) of the beneficiary's monthly income ranged from Rs.4001- 10,000/- followed by Rs.1000- 4000/- (20%) and Rs. 10,001 - 15,000/- (10%). They also work as wage labourers in rice mills and agriculture fields which is their secondary occupation (10%).

Nursery rearing of Seabass (*Lates calcarifer*) by as a livelihood activity

A nursery rearing unit comprised of 10 hapas (2x1x1m size) with a total volume of 120 m^2 was selected, and the seabass fish fry of size 1.2-1.8 cm provided by CIBA was stocked @ 500 no. per hapa was reared for 57 days. The realized production was 1820 fingerlings of size 3-9.5 cm. The net income per cycle was ₹ 28, 000 and the families got an income of ₹ 7000/- per head. The survival realized was 35.80% (in open waters).

Demonstration of mud crab culture in the open water system at Adyar Creek.

In order to utilize open water bodies for aquaculture as livelihood option for marginalized rural poor, an aquaculture model was developed. Two demonstration trials were conducted, to standardize the potential aquaculture models. A 100 m^2 pen was erected in the estuary and mud crabs are reared for 40 days. Farmers obtained ₹16000/ at the end of the culture .

Attracting and Retaining Youth in Aquaculture

Fifteen batches of schools and college students mainly in and around Chennai visited CIBA HQ and MES Muttukadu and were exposed to learn about brackishwater aquaculture farming and to observe infrastructural facilities of CIBA HQ and MES Muttukadu. Student project module on brackishwater aquaculture for seven weeks was conducted during September-October, 2017. A batch of nine higher secondary students from the Kendriya Vidyalaya School, Island grounds, Chennai were given short-term projects to study the brackishwater resources for aquaculture. Totally 354 students from 04 Universities and 06 colleges and 05 schools visited CIBA during the period under report

Web-based knowledge centre in brackishwater aquaculture

Web-based knowledge centre in brackishwater aquaculture was designed based on the ADDIE model of Instructional System Design (ISD), including Analysis, Design, Development, Implementation, and Evaluation. Based on the needs assessment of 110 stakeholders, users of ICT projects of Village Knowledge Centre of MSSRF, Tamil Nadu, and Aquachoupal, Andhra Pradesh (50 nos); aqua/tribal farmers of Gujarat (50 nos.) and students (10 nos.). The required information was designed into eight categories viz., Overview of brackishwater aquaculture; Details of Shrimp; Details of fish; Details of Crab; Fisheries institutions; Aquaculture statistics; Fisheries policies; ICT tools and Important links.

Adyar Creek and Estuary Information System (ACEIS-Aqua) for aquaculture.

Adyar Creek and Estuary Information System (ACEIS-Aqua) was developed using MySQL database management system and PHP scripting language for the development of aquaculture in the water bodies. This web-based system describes the database/search modules that permit end users fast and easy access to large amounts of analyzed data which are collected in different sample locations and details of cultural practices which are suitable for these water bodies for the development of brackishwater aquaculture.

Web page updating and development of new portals

Institute webpage has been updated regularly, and the design of the site has been modified to suit the recent advances. Websites for Sophisticated Analytical Instrument Facility (SAIF), Society of Coastal Aquaculture and Fisheries and World brackishwater aquaculture conference have been created and maintained.

Introduction

All over the world, the demand for seafood has increased as people started taking seafood as a part of regular diet due to its beneficial effect to fight against cardiovascular disease, cancer, Alzheimer's and many other major illnesses. On the other hand, supply of seafood from oceans is almost stable or declining. Therfore, aquaculture, which involves breeding, rearing and harvesting of aquatic species has been recognised as the most competent option to meet the growing demand for seafood due increasing global population. At present, aquaculture sector contributes around 50 per cent of all seafood produced for human consumption, and that contribution will continue to increase.

Though aquaculture practised in all kinds of water resources (freshwater, brackishwater and seawater), the pressure on freshwater resources due to multi-user demands and climate change related impacts constraint the future expansion, hence the future aquaculture development is expected to occur mostly in brackishwater. Further, aquaculture in brackishwater helps in minimising the carbon footprint of fish production in freshwater water. In India excluding the 1.2 million hectares of the coastal land area identified suitable for pond based brackishwater farming, about 3.9 million ha of open brackishwaters comprises estuaries, creeks, backwaters, and lagoons remain unutilized for fish production. Furthermore, brackishwater environments are rich in biodiversity and productive ecosystems than the open marine waters, which are challenging to manoeuvre. Therefore brackishwater resources are perceived as ideal for aquaculture in the future. As an added advantage, high tolerance of brackishwater flora and fauna to the extremes of the water quality make them more appropriate for farming under controlled conditions. In addition to the food production, coastal aquaculture can generate substantial employment opportunities in diversified fields across coastal India.

India emerged as a fastest growing major economy in the world and the second largest producer of farmed fish and shellfish. Frozen shrimp produced from brackishwater sector continued to be the major valued item accounting for a share of 70% of the total export earnings (about US$ 6.5 billion). After playing a crucial role in the introduction of exotic *P. vannamei* to Indian shrimp farming, ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) realizes the risk of complete dependence of the sector entirely on imported broodstock. As a futuristic alternate strategy, CIBA has identified native Indian white shrimp, *P. indicus* as native candidate species for research in the direction of stock improvement through selective breeding. Farming of seabass in customized open-water cages, and other fishes such as milkfish, hilsa, mullet and pearlspot gained a notable impetus and given confidence to the coastal farmers. CIBA as a nodal agency in brackishwater aquaculture development, not only developing technology for producing seeds of candidate species but also engaged in issues related to the environment, cost-effective feed production, farm and hatchery construction, disease diagnosis, monitoring and advocating remedies etc.. Besides production-oriented research, CIBA also researches to preserve the valuable natural resources like land, water and energy, to have more sustainable, eco- friendly and socio-economically viable brackishwater aquaculture in this country.

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

utilized for farming. The unutilized resource can be made highly productive for fish farming by proper planning and implementation of technological advancements.

At ICAR-CIBA, we support cutting-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 utilising 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 resource, ecosystems, and vibrant coastal communities.

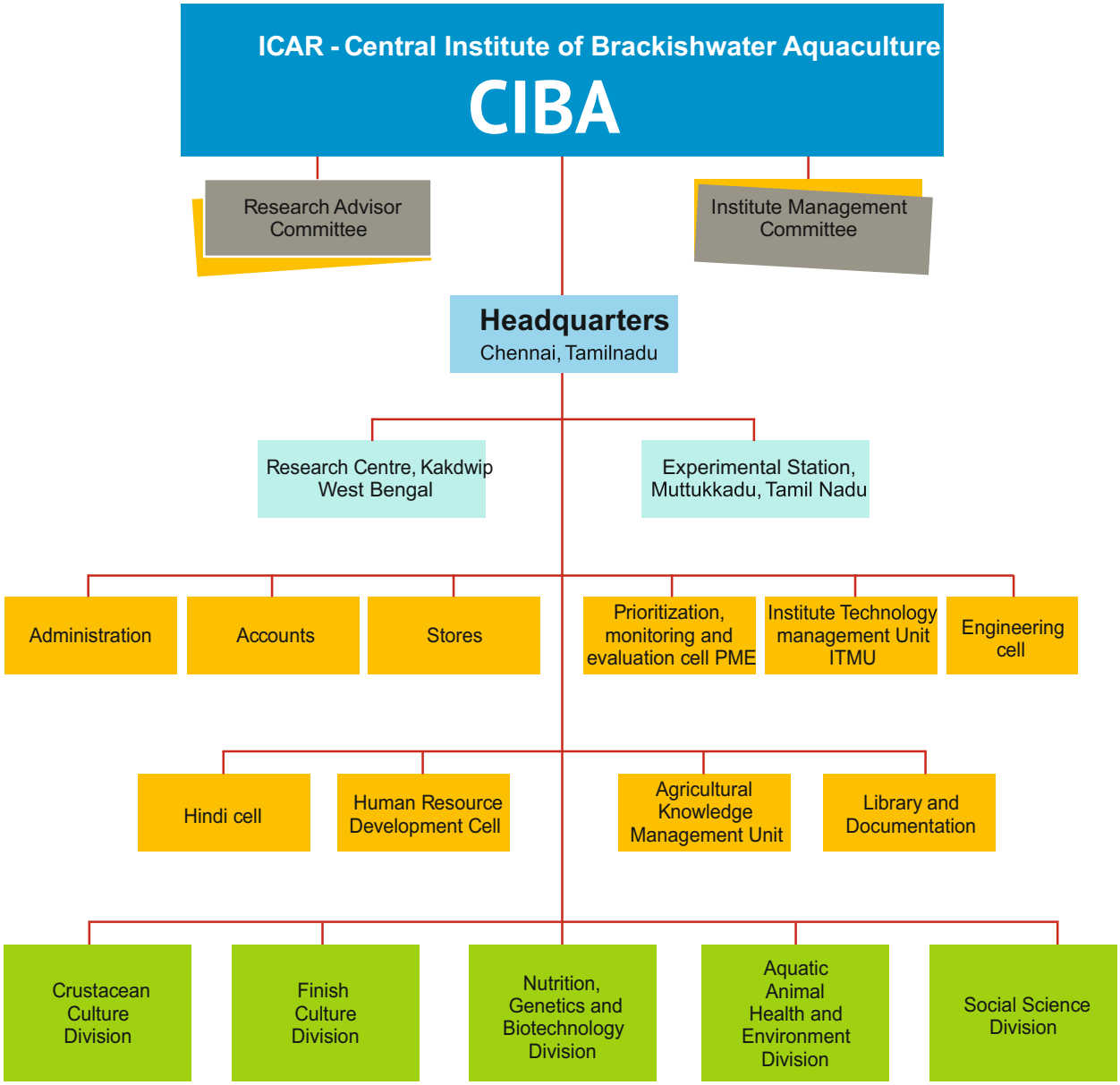
Established in the year 1987, ICAR-CIBA headquartered at Chennai has its experimental station at Muttukkadu and research centre at West Bengal. The headquarters with the administrative office-cum-laboratory is located on the banks of Adyar river creek in MRC Nagar, Chennai, since 2001. The Muttukadu Experimental Station (MES) is located about 30 km south of Chennai on the east coastal highway connecting Puducherry. The Kakdwip Research Centre (KRC) in West Bengal is situated about 100 km south from Kolkata close to the deltaic region called the Sundarban of Hooghly estuarine complex.

The research programs in CIBA are diverse. In the year 2017-18 the institute has handled 12in-house and 21 externally funded projects. Our research programs are prioritised according to the fixed mandates.

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 repository of information on brackishwater fishery resources with a systematic database.
- Human Resource Development, capacity building and skill development through training, education and extension.

Organisation Chart



Unified Budget of ICAR-CIBA - 2017-18

(Rupees in lakhs)

Sub-Head	Budget Estimate	Revised Estimate	Actual Expenditure
Grants for creation of CAPITAL ASSETS (Capital)			
Works - Office building	145.00	175.00	175.00
Equipment	70.00	75.00	75.00
Information Technology	20.00	20.00	20.00
Library Books and Journals	25.00	15.00	15.00
Furniture & Fixtures	20.00	25.00	25.00
Sub-total (A)	**280.00**	**310.00**	**310.00**
Grants in Aid - SALARIES (Revenue)			
Establishment Expenses			
(A) Salaries	1685.50	1741.00	1738.70
(B) Loans & Advances	7.00	7.00	0.50
Sub-total (B)	**1692.50**	**1748.00**	**1739.20**
Grants in Aid - GENERAL (Revenue)			
Pension & Other Retirement Benefits	1430.00	2014.00	1827.46
Traveling Allowances	25.00	28.00	28.00
Research & Operational Expenses	166.00	178.00	178.00
Administrative Expenses	706.00	690.00	690.00
Miscellaneous Expenses (HRD & Others)	16.50	17.50	17.50
Sub-total (C)	**2343.50**	**2927.50**	**2740.96**
TSP			
Capital	15.00	15.00	15.00
Revenue	12.00	12.00	12.00
Sub-total (D)	**27.00**	**27.00**	**27.00**
GRAND TOTAL (A+B+C+D)	**4343.00**	**5012.50**	**4817.16**

Official Language Implementation Programme

Official Language Implementation Committee meetings were held on 01.07.2017, 21.10.2017, 06.01.2018 and 08.05.2018 during the year 2017-18. Usage of Hindi in official correspondences, bilingual use of Hindi and English in files, publications in Hindi were reviewed in these meetings. Hindi Saptah (week) celebrations were celebrated at the Institute from 14.09.2017 to 20.09.2017. As part of the Hindi Saptah celebrations, Hindi Kavita Path, Hindi noting & drafting and Hindi Prasnothari competitions were organized. Hindi Day was celebrated on 20.09.2017. During the valedictory function, Sri. R. Sudarsan, All India Radio, Chennai has been invited for delivering lecture on Official Language implementation and thereafter the 1st, 2nd, 3rd and consolation prizes were given to the winners of Hindi competitions by the Director.

Hindi Week Celebration at KRC

Hindi week was celebrated at KRC, Kakdwip during 16-22 Sept. 2017 to promote the use of Hindi in Official and Scientific works. In this connection various competition such as singing, quiz, extempore were conducted among the KRC-staffs. Chief Guest of the valedictory function, Mr. Ramdayal Sharma (Hindi officer, NIRJAFT, Kolkata) delivered motivating talk on how to use Hindi in official and scientific works. He also encouraged the uses of Hindi in file noting.

Staff Position
The details of sanctioned, filled and vacant position as on 31.03.2018

Category	Sanctioned	Filled	Vacant
RMP/Director	1	1	0
HOD/Principal Scientist	5	2	3
Senior Scientist	10	6	4
Scientist	52	59	-7
Total	**68**	**68**	**0**
T-4	1	1	0
T-3	14	10	4
T-1	16	11	5
Total	**31**	**24**	**7**
Administrative Officer	1	1	0
Finance & Accounts officer	1	0	1
Deputy Director (OL)	1	0	1
Asst. Administrative Officer	3	3	0
Junior Accounts Officer	1	1	0
Private Secretary	1	0	1
Personal Assistant	2	2	0
Stenographer Grade – III	1	2*	*1 excess
Assistants	7	6	1
Upper Division Clerk	3	2	1
Lower Division Clerk	5	4	1
Total	**26**	**20+1***	**6**
Skilled Support Staff	55	28	27
Grand Total	**180**	**141**	**39**

On–going research projects

Sl. No.	Project Title	Funding	Project Team
Crustacean Culture Division			
	Institute Funded Projects		
1.	Technology upgradation and refinement for sustainable development of diversified systems and species of penaeid shrimp	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, Dr. T.K. Ghoshal, Dr. M. Kumaran, Dr. K. Ambasankar, Dr. Sanjoy Das, Dr. R. Geetha, Mr. Jose Antony, Dr. N.S. Sudheer, Mr. I.F. Biju, Mr. R. Aravind, Ms. Suvana Sukumaran, Mr. Pankaj Amrut Patil, Dr. T.N. Vinay, Dr. S. Sivagnanam, Shri S. Rajamanickam
2.	Issues in biology, reproduction, larval rearing of candidate crustacean species for brackishwater aquaculture	ICAR	**PI: Dr. C.P. Balasubramanian** **Co-PIs:** Dr. C. Gopal, Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. P. Nila Rekha, Dr. P. Shyne Anand, Ms. L. Christina, Dr. N.S. Sudheer, Mr. Jose Antony, Mr. I.F. Biju, Mr. R. Aravind, Dr. T.N. Vinay
3.	Demonstration of improved culture technologies in shell fish and finfish aquaculture and TSP programmes in Gujarat	ICAR	**PI: OIC, Navsari** **Co-PIs:** Dr. M. Kailasam, Dr. M. Muralidhar, Dr. P.K. Patil, Dr. P. Mahalakshmi, Dr. T. Ravisankar, Dr. M. Jayanthi, Dr. A. Panigrahi, Dr. P. Shyne Anand, Dr. Aritra Bera, Dr. S. Sivagnanam, Shri R. Puthiyavan
4.	Development of inland saline aquaculture in Punjab, Haryana, Rajasthan, Gujarat & Maharashtra	ICAR	**PI: Dr. K.K. Vijayan** **Co-PIs:** Dr. M. Kailasam, Dr. Aritra Bera, Mr. I.F. Biju, Mr. Jose Antony, Mr. R. Aravind, Mr. Pankaj Amrut Patil, Mr. Tanveer Hussain, Mr. Dani Thomas, Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. Debasis De, Dr. K.P. Kumaraguru Vasagam, Mr. K.P. Sandeep, Dr. M. Muralidhar, Dr. P.K. Patil, Dr. S.

			K. Otta, Dr. P. Kumararaja, Dr. Satheesha Avunje, Dr. N.S. Sudheer, Ms. Suvana Sukumaran, Dr. T. Ravisankar, Dr. C.V. Sairam, Dr. B. Shanthi, Dr. P. Nila Rekha
	Externally Funded Projects		
5.	Upgradation of breeding and culture technology of Indian white shrimp *Fenneropenaeus indicus* through stock evaluation and culture demonstrations	NFDB	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. G. Gopikrishna, Dr. C. Gopal, Dr. S. Kannappan, Dr. K.P. Kumaraguru Vasagam, Dr. P. Mahalakshmi, Dr. K. Vinaya Kumar, Dr. P. Shyne Anand, Ms. L. Christina
6.	Seaweeds for bioremediation in recirculatory aquaculture system	DST	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. K. Ambasankar, Dr. A. Panigrahi, Dr. K.P. Kumaraguru Vasagam
7.	Evaluation and refinement of indigenous automatic feeder for shrimp farming	NFDB	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. K. Ambasankar
8.	Healthy Shrimp and 'GIFT' tilapia production through bio-floc based farming system: Development of technology and standard operating procedure	DBT	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. P. Nila Rekha, Dr. K.P. Kumaraguru Vasagam
9.	Optimization of aerators use to reduce production cost of shrimps under different brackishwater farming conditions		**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. T. Ravisankar, Dr. M. Muralidhar, Dr. R. Saraswati, Dr. Aritra Bera
Finfish Culture Division			
Sl. No.	**Project Title**	**Funding**	**Project Team**
	Institute Funded Projects		
10.	Evaluation of reproductive biology, breeding, larval biology and seed production of candidate finfish species for brackishwater aquaculture development	ICAR-CIBA	**PI: Dr. M. Kailasam** **Co-PIs:** Dr. M. Makesh, Dr. Satyanarayan Sethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. B. Sivamani, Dr. K.P. Kumaraguru Vasagam, Dr. J. Raymond Jani Angel, Smt. M.U. Rekha, Mr. Pankaj Amrut Patil, Mr. Tanveer Hussain, Mr. Dani

			Thomas, Mr. T. Sivaramakrishnan, Mr. R. Subburaj
11.	Development and refinement of finfish culture technologies for sustainable brackishwater aquaculture development	ICAR-CIBA	**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Kailasam, Dr. Satyanarayan Sethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Mr. Tanveer Hussain, Mr. Dani Thomas, **Mr. Pankaj Amrut Patil**, Mr. T. Sivaramakrishnan, Mr. R. Subburaj

Aquatic Animal Health and Environmental Division

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
12.	Invertebrate and finish diseases in brackishwater aquaculture and development of prophylactic and therapeutic strategies	ICAR-CIBA	**PI: Dr. S.V. Alavandi** **Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. P.K. Patil, Dr. S. K. Otta, Dr. Sanjoy Das, Dr. P. Ezhil Praveena, Dr. R. Ananda Raja, Dr. Sujeet Kumar, Dr. T. Bhuvaneswari, Mrs. Mary Lini, Dr. Vidya Rajendran, Mr. T. Sathish Kumar, Mr. Joseph Sahaya Rajan
13.	Development of water and soil health card for environmental management of brackishwater aquaculture systems	ICAR-CIBA	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Satheesha Avunje, Ms. Suvana Sukumaran, Mr. Jose Antony, Dr. A. Nagavel
	Externally Funded Projects		
14.	National surveillance programme for Aquatic Animal Health	NFDB	**PI: Dr. S.V. Alavandi** **Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. Sanjoy Das, Dr. Sujeet Kumar, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja, Mr. T. Sathish Kumar, Dr. Vidya Rajendran
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. Sanjoy Das, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. Satheesha Avunje, Dr. M. Makesh, Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. C.V. Sairam, Dr. T. Ravisankar, Dr. R. Geetha
16.	Development of diagnostics and vaccines for sustainable aquaculture	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. Satheesha Avunje, Dr. Vidya Rajendran
	d. Development of probiotics and immunostimulants for shrimp		**PI: Dr. P.K. Patil** **Co-PIs:** Dr. S.V. Alavandi, Dr. Satheesha Avunje, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja
	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. Ezhil Praveena, Dr. M. Poornima, Dr. S.K. Otta, Mr. T. Sathish Kumar, Dr. Vidya Rajendran
17.	National Innovations in Climate Resilient Agriculture (NICRA)-Impact of climate change on aquaculture and mitigation options for minimizing green house gases from aquaculture sector	ICAR	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. M. Jayanthi, Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Dr. S.K. Otta, Mr. J. Ashok Kumar, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Aritra Bera, Dr. Satheesha Avunje, Ms. Suvana Sukumaran, Dr. A. Nagavel

Nutrition, Genetics & Biotechnology Division

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
18.	Biotechnological interventions and application of bioinformatic tools for improvement of brackishwater fish and shellfish	ICAR-CIBA	**PI: Dr. G. Gopikrishna** **Co-PIs:** Dr. K.K. Vijayan, Dr. M. Shashi Shekhar, Dr. Sherly Tomy, Dr. K. Vinaya Kumar, Dr. B. Sivamani, Dr. J. Raymond Jani Angel, Ms. Misha Soman
19.	Newer feed resources and feed additives for development and improvement of shrimp and fish feeds	ICAR-CIBA	**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru Vasagam, Mr. K.P. Sandeep, Ms. Leesa Priyadarsani
	Externally Funded Projects		
20.	Outreach activity on fish feed	ICAR	**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru Vasagam, Ms. Leesa Priyadarshini
21.	Outreach activity on nutrient profiling and evaluation of fish as a dietary component (Lead Centre: CIFRI, Barrackpore)	ICAR	**PI: Dr. J. Syama Dayal** **Co-PIs:** Mr. K.P. Sandeep, Mr. Jose Antony, Mr. T. Sivaramakrishnan
22.	Outreach activity on fish genetic stocks (Lead Centre: NBFGR, Lucknow)	ICAR	**PI: Dr. G. Gopikrishna** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. C.P. Balasubramanian, Dr. Sherly Tomy, Dr. J. Raymond Jani Angel, Dr. T.N. Vinay, Ms. Misha Soman
23.	Whole genome sequencing of Indian white shrimp *Penaeus indicus*	ICAR	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. G. Gopikrishna, Dr. K. Vinaya Kumar, Mr. J. Ashok Kumar, Dr. C. P. Balasubramanian, Dr. S.K. Otta, Dr. Santhosh J. Eapen (ICAR-IISR)
24.	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. G. Gopikrishna, Dr. K. Vinaya Kumar, Mr. T. Sathish Kumar
25.	Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)	NASF	**PI: Dr. Debasis De** **Co-PIs:** Dr. Prem Kumar

Sl. No.	Project Title	Funding	Project Team
Social Sciences Division			
	Institute Funded Projects		
26.	Research and developmental interventions for sustainable brackishwater aquaculture	ICAR-CIBA	**PI: Dr. C.V. Sairam** **Co-PIs:** Dr. V.S. Chandrasekaran, Dr. T. Ravisankar, Dr. B. Shanthi, Dr. D. Deboral Vimala, Dr. M. Kumaran, Dr. P. Mahalakshm i, Mr. J. Ashok Kumar, Dr. R. Geetha
	Externally Funded Projects		
27.	Investigations on pathogenic microorganisms of shrimp aquaculture using metagenomic and other bioinformatics approaches		**PI: Mr. J. Ashok Kumar** **Co-PIs:** Dr. S.V. Alavandi, Dr. K. Vina ya Kumar, Mrs. Mary Lini, Dr. Satheesha Avunje, Dr. Monendra Grover
Kakdwip Research Centre			
Sl. No.	**Project Title**	**Funding**	**Project Team**
	Institute Funded Projects		
28.	Development of economically viable and sustainable brackishwater aquaculture practices with special reference to Sundarban Mangrove biosphere	ICAR-CIBA	**PI: Dr. T.K. Ghoshal** **Co-PIs:** Dr. Debasis De, Dr. Sanjoy Das, Dr. G. Biswas, Dr. Prem Kumar, Ms. L. Christina, Ms. Leesa Priyadarsani
	Other Projects		
29.	Agri-Business Incubation centre (ABI) at CIBA, Chennai	NAIF - ICAR	**PI: Dr. T. Ravisankar** **Co-PI** : Dr.P.K.Patil
30.	Intellectual property Management and Transfer/ Commercialization of Agricultural Technology Scheme (Up-scaling of existing components i.e. Intellectual property Right (IPR)	NAIF - ICAR	**PI: Dr. T. Ravisankar** **Co-PI** : Dr.P.K.Patil

BRACKISHWATER PRODUCTION SYSTEM AND RESEARCH

Penaeus indicus demonstration trials

Shrimp farming in India, which is based on exotic *Penaeus vannamei*, is at a cross road due to the emerging diseases, reduced survival, increase in the cost of production, and recent falls in prices. At this juncture development of native species is a viable option to ensure the sustainability of shrimp farming. Indian white shrimp, P. indicus, has been identified as candidate species for domestication and genetic improvement, owing to its relative ease in captive breeding compared to other closed thelycum species. In order to evaluate the real world performance of this species several culture demonstrations were conducted across different geographical locations. These participatory approaches enabled the farmers to make ensure the advantage of *P. indicus* farming. Multi-location culture demonstration of Penaeus indicus was carried out Nationwide in six coastal states: Odisha, West Bengal, Kerala, Andhra Pradesh, and. Gujarat. Demonstration trials were carried out at stocking density of 15 to 45 individuals/m2 in ponds ponds of 0.2 to 1 ha ponds with a formulated feed developed by CIBA, 'indicus plus'. At the end of 100 -120 days of culture period, a final body weight of 22-24 g with a survival up to 98% and a production ranging from 3 to 7 tons/ ha was obtained. The culture demonstration conducted across different salinities starting from 3 ppt to 60 ppt showed better growth could be observed in the range of 15 to 35‰ salinity. This species was cultured at very low salinity at Kattur village (Thiruvallur district, Tamil Nadu), and obtained a production of 3633/ha with 90 % survival. It is against the popular belief that P. indicus is not a suitable species for low saline culture

Demonstration trials of *Penaeus indicus* at different coastal states of India

***Penaeus indicus* production characteristics at different states**

Production characteristics	Kerala	Odisha	West Bengal	Tamil Nadu	Andhra Pradesh
Stocking Density (no/m²)	15	35-40	40	40-60	25-50
Days of Culture	122	115-125	118	80-110	60-70
Weight at Harvest (g)	15.7	21.7-23.1	22.7	7.5	9.1
Daily weight gain (g/d)	0.13	0.18	0.19		
Survival (%)	98.1	72-80	75	70-90	78-90
FCR	1.82	1.42-1.66	1.62	0.8-1.1	1.1
Production (kg/h)	2850	1398-1480	6320	3113-3380	2418
Profit per Kg	125	200	140		130-140
Salinity (ppt)	15-35	5-15	12-20	40-45	10

Doubling farmers income through inland low saline shrimp farming in south western Punjab

ICAR-CIBA initiative under Skill India Programme South Western region of Punjab in India possesses abundant resources of inland saline groundwater with salinities ranging from 3 to 15 ppt. The districts of Bathinda, Muktsar, Fazilka, and parts of Mansa have regions with underlying low saline ground water. Agricultural productivity in this region is lower compared to the rest of Punjab due to low soil fertility, poor irrigation network, absence of major riverine systems and the presence of saline groundwater. To double the income of farmers in this region, farming of Pacific white shrimp, Penaeus vannamei was successfully demonstrated using amended inland low saline water at Sangat Kalan Village, Bathinda, Punjab with M/S Blancas Aqua, Bathinda in a partnership farming mode. The stocking of shrimp seed in the two 4000 m2 ponds was carried out in June 2017 using P. vannamei PL 13 (Avg. Length~7.3mm, Avg. BW~1.745±0.15 mg) sourced from a Coastal Aquaculture Authority (CAA) certified hatchery. The shrimp seed quality were assessed through PCR screening and stress tests at CIBA laboratory in Chennai before packing and transportation. Each of the 4000 m2 (1 acre) ponds were stocked with 1.2 lakh PL (Stocking density – 30 PL/m2) during the evening hours following standard acclimation procedure. The salinity and pH during the culture varied from 4.5 to 5.0 ppt and 8.1 to 8.9, respectively. The ionic profile of the culture medium was analysed once every week at CIBA based on which the mineral supplementation for potassium, magnesium and other trace elements were carried out. Mineral supplementation is a critical operation in inland shrimp farming as the ionic profile of inland saline groundwater varies significantly from the coastal saline waters. The shrimp attained a marketable size of 20 g (average body weight or ABW) within three months, and attained an ABW of 26.3 g within four months (36-40 count). The survival rate and feed conversion ratio (FCR) observed during the trial were 79.18 % and 1.2 respectively. At the end of 120 days of culture (DOC), a production of 2.5 tonnes was obtained from each of the 4000 m2 ponds resulting in a productivity of 6.25 tonnes/ha. The harvested shrimp realised a farm gate price of Rs. 320/Kg thus resulting in total revenue of Rs. 16 lakhs against an operating cost of Rs. 12 lakhs, creating a net profit of Rs. 4 lakhs, i.e., 2 lakhs/acre/crop. The cost-effective white shrimp feed of CIBA, Vanamiplus which was competitively priced at Rs. 60.0 as compared to vannamei shrimp feed marketed by MNCs (Rs. 74/Kg to Rs. 88/Kg) resulted in an additional 25 % reduction in the production cost on feed, thereby increasing the profit of the farmer. The harvest of the farmed shrimp was done on October 25, 2017, in the presence of Shri. Diprava Lakra, IAS, Deputy Commissioner, Bathinda, officials from State Fisheries Department, CIBA scientists, and farmers from nearby villages.

Highlights

The success story in South Western Punjab, where farmers obtained an income of Rs. 2.0 lakh/acre from a four-month long crop, using the technological package for shrimp farming from CIBA. The technology of shrimp farming using saline groundwater with high-quality seed and cost-effective desi feed has become an income multiplier for farmers in South Western Punjab. However, the development and expansion of inland saline aquaculture in the state need to be done sustainably, maintaining a balance between the freshwater resources and possible issues of salinization arising from shrimp farming, through scientific planning.

Production system diversification

Diversifying and improving the performance of production system and species cultured are the major priorities of aquaculture research. Integrated multi-trophic aquaculture (IMTA) is the cultivation of two or more complementary crops where waste of one crop serve as input (feed or fertilizer) for other crops. Thus, environmental issues related to the coastal aquaculture could be solved to greater extend, and further cultivation of different crop optimize the economic returns. The purpose of this research is to evaluate and demonstrate an IMTA system in Sindhudurg district of Maharashtra. Open water IMTA was set in the Gad river, Juva Pankhol, Malvan with a cage size of 8X 4X 1.2 m outer cage with 40 mm mesh and four inner cages of 3 X 2 X 1 m and 16 mm mesh. The cage was stocked with 800 sea bass nursery reared fry (TL=120 mm; 19.5 g) that was transported to the culture site from Andhra Pradesh. As an extractive crop 50 ropes of green mussels, *Perna virdis,* also have been stocked as extractive crop. Animals were fed with low valued fish by catch initially at the rate of 15% of wet biomass and gradually reduced to 8%. For the determination of growth rate and feed adjustments, samples were collected periodically (every 2-4 weeks). After nine month of rearing, sea bass has grown to average size of 990.1 g with a total production of 360 kg and survival of 63%. For nine months culture, revenue of Rs 162000/ for a total cost of Rs 120000/.

As mortality was occurred during monsoon season, culture period can be scheduled by excluding monsoon months.

Salinity tolerance of estuarine oyster, *Crassostrea cuttackensis*, as a potential extractive species in IMTA

Bivalves are one of the most suitable extractive crops in IMTA systems. Edible estuarine oyster, *Crassostrea cuttackensisis,* is one of the most abundant bivalves in Sundarban, West Bengal. One of the most important biological traits to be considered while developing an IMTA system in a brackishwater ecosystem is: salinity tolerance limits of the species used for cultivation. An experiment was carried out to evaluate the salinity tolerance limit of *C*. *cuttackensisis.* After acclimation to 20 ppt, oysters were transferred directly to different salinity levels ranging from 0 to 30 (0, 5, 10, 15, 20, 25 and 30 ppt) in triplicate tanks (100 L). After 7 days, highest survival (90%) was observed at 15 and 20 ppt and lowest survival was at 0 ppt (Fig.). The results indicated that, optimum salinity for this species is 15-20 ppt and it can be effectively used in the brackishwater IMTA systems after proper acclimatization.

High-density nursery rearing of milkfish

The recent breakthrough in captive breeding of milkfish would help to meet the increasing seed requirement for brackishwater culture system. In order to optimize the grow-out production of milk fish, high density nursery rearing of milk fish in earthen pond has been developed. After treatment of pond bottom with lime, water was filled to a depth of 30-40 cm and fertilized with mustard cake, urea and single super phosphate at 200, 20 and 20 kg/ha, respectively for the growth of benthic algal complex (*lab-lab*).

After 10days of fertilization, ponds were stocked with milkfish fry (0.1 g/ 26.4 mm) at 200000 nos/ha. Formulated powder feed prepared from locally available ingredients (mustard cake, rice bran, wheat flour, fishmeal etc.) was provided as supplementary feed @ 20 to 5% of body weight. Liming was done fortnightly with lime stone powder at 250 kg/ha. After liming, ponds were fertilized fortnightly with the above mentioned fertilization dose. After 60 days of rearing, fingerlings were harvested and they attained 6-8 g body weight with 80% survival. A total of 3000 milkfish fingerlings were supplied to a farmer for grow-out culture demonstration. High density farming of milkfish seed is advantageous over low density rearing as the former is found to produce more number of fingerlings from the same water area.

Harvested milkfish fingerlings for stocking in grow-out pond

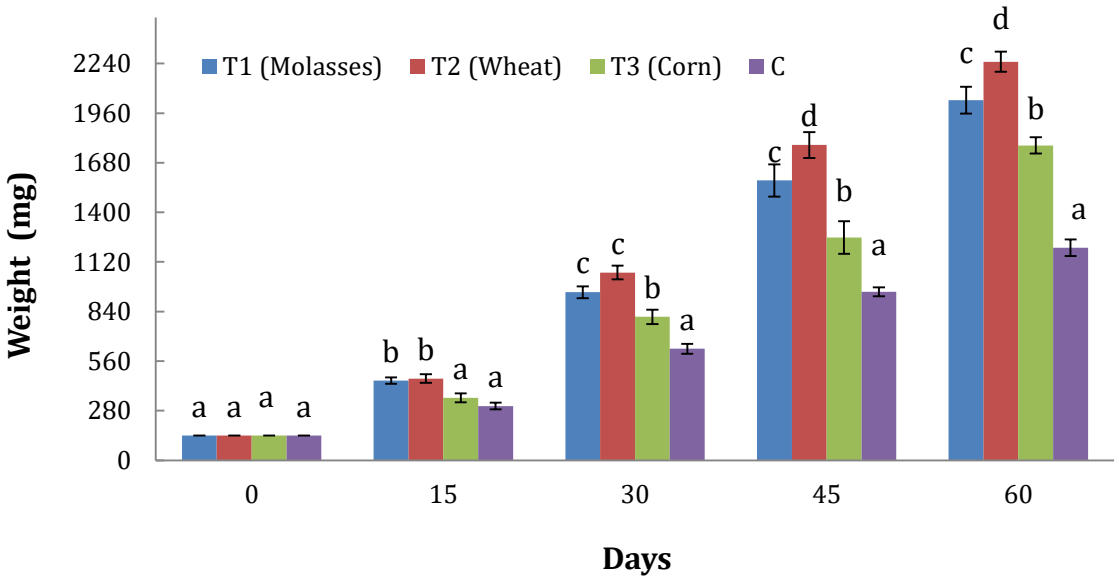
Nursery rearing of *Mystus gulio* in net cages (hapa)

Brackishwater catfish, *Mystus gulio* is a small size indigenous fish species having high consumer preference. Backyard hatchery technology of this species has been developed and there is huge quantum of seed demand among farmers for the same. To reduce the larval rearing time and operational expenditure at hatchery, a nursery rearing trial was conducted with 10-day old fry (0.01-0.02 g/ 8-11 mm) in net cages (hapa: 2×1×1 m) at three stocking densities, 500, 750 and 1000 nos/hapa. Fry was fed twice a day @ 4 to 10% of body weightwith CIBA formulated larval diet (CP 30%, CF 6%; Price: Rs. 30/ kg). After 60 days rearing, fry attained significantly higher growth of 1.31±0.28g and 1.35±0.37g at 500 and 750 nos./hapa densities respectively compared to that (1.26±0.36g) of 1000 nos./hapa group (P<0.05). However, survival was significantly higher(48.0±1.1%) at the lowest density with the lowest number of shooter emergence (3.8%). Therefore, the optimal stocking density for nursery rearing of *M. gulio* can be recomended @ 500 no /hapa.

Harvested *Mystus gulio* fingerlings from net cage rearing system

Biofloc based nursery rearing of Milk fish, *Chanos chanos* using different carbon sources

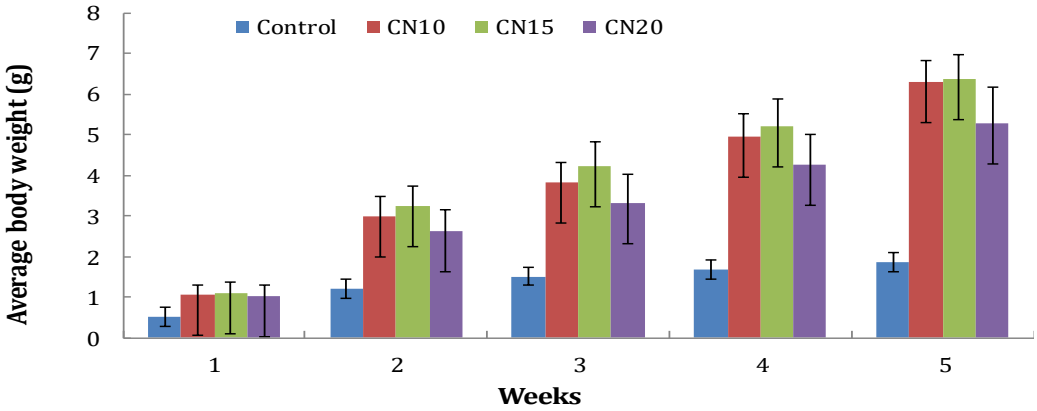
A 60 days experiment was carried out to evaluate growth performance of milkfish *Chanos chanos* in biofloc based nursery rearing system using different carbon sources (Molasses, Wheat & Corn) assigned as treatments T1, T2 and T3 along with control (C). Each group consisted of triplicate tanks and each treatment was stocked with 20 day old *C. chanos* early fry (1.78± 0.07 cm and 140± 0.09 mg) with a stocking density 70 early fry/120 l. The results revealed that milkfish fry reared in wheat based biofloc system showed significantly ($p<0.05$) in terms of growth, weight gain (2250±56.72 mg), percentage weight gain (1507.1±54.29) and specific growth rate (4.62±0.04) compared to molasses based and corn based biofloc treatments and control. Growth, feed conversion ratio (FCR), feed efficiency ratio (FER), specific growth rate (SGR), the survival rate of milkfish fry reared in biofloc treatments were significantly better as compared to control. Proximate composition of biofloc showed significant difference ($p<0.05$). Whereas, wheat based biofloc showed highest crude protein(36.0± 1.18 %) and ether extract (2.06b ± 0.12 %). Mean water quality showed a significant difference ($p<0.05$), mean ammonia, nitrite and nitrate was recorded highest in biofloc treatments as compared to control. But all the water quality parameters in biofloc system found to be favorable for the culture of milkfish. Total settle able solids maintained in the range of 7 -12 ml/litre in all the biofloc treatments. From, the whole results, the study suggests that all the carbon sources are best for nursery rearing of milkfish fry in biofloc system. However, from the overall results, it was found that milkfish fry attains fingerling stage in 30-40 days of rearing in wheat and molasses based biofloc system.



Growth performance of milk fish fry under different carbon sources in biofloc based system and control over a period of 60 days

Effect of three C/N ratio on production performance of *P. vannamei*

High-density shrimp culture systems with limited or no water exchange results in the production of large volumes of suspended flocculated organic particles including microalgae, autotrophic and heterotrophic bacteria. These, unique system, biofloc system, provides several beneficial effects to shrimp farming. The C/N ratio of the culture water from feed or direct organic supplementations can have extremely significant impact on water quality and biofloc biomass production. In order to evaluate the effect of various C /N ratio on production performance of P. vannamei, an experiment was conducted under biofloc based system with combination of three carbon sources(molasses, rice and atta) with three C/N ratios 10:1, 15:1 and 20:1. The results showed that shrimps reared in CN:10 and CN:15 biofloc systems showed significantly (P=0.0229 and 0.0263) higher growth as compared to control and CN:20. All treatments showed survival rates above 91 % with no significant differences between treatments. The total ammonia nitrogen, nitrite (NO2) and nitrate (NO3) in the water column were reduced significantly in the order of increasing the C/N ratio from 10 to 20 (P< 0.001).



Effect of different C/N ratio on production performance of *P. vannamei*

Effect of growth performances, water quality, and immunological status on different stocking density under biofloc based *P. vannamei* culture system

In order to assess the growth performance, water quality, and immune status of *Penaeus vannamei* post-larvae in bio-floc based system using different stocking densities. To achieve this, Asian pacific shrimp *P. vannamei* post-larvae (PL8) were cultured in biofloc based system of 15:1 CN ratio in three different stocking densities: 3500, 7000 and 10000 post-larvaes per m^3. The experiment was carried out for 5 weeks. Treatments consisted of three sources of organic carbon, atta, rice bran, and molasses at two rates of 2.5 g/L, 5 g/L, 10 g/L respectively. The immune status results revealed that shrimps cultured under three different densities with three different carbon sources based biofloc system increased the total haemocyte cell count, lysozyme activity than those of control. Our findings proved that BFT is effective and highly potential technology for P. vannamei nursery culture in higher densities and would be baseline for extrapolating this practice to field level to increase the production.

Microbial community in the culture system with zero water exchange

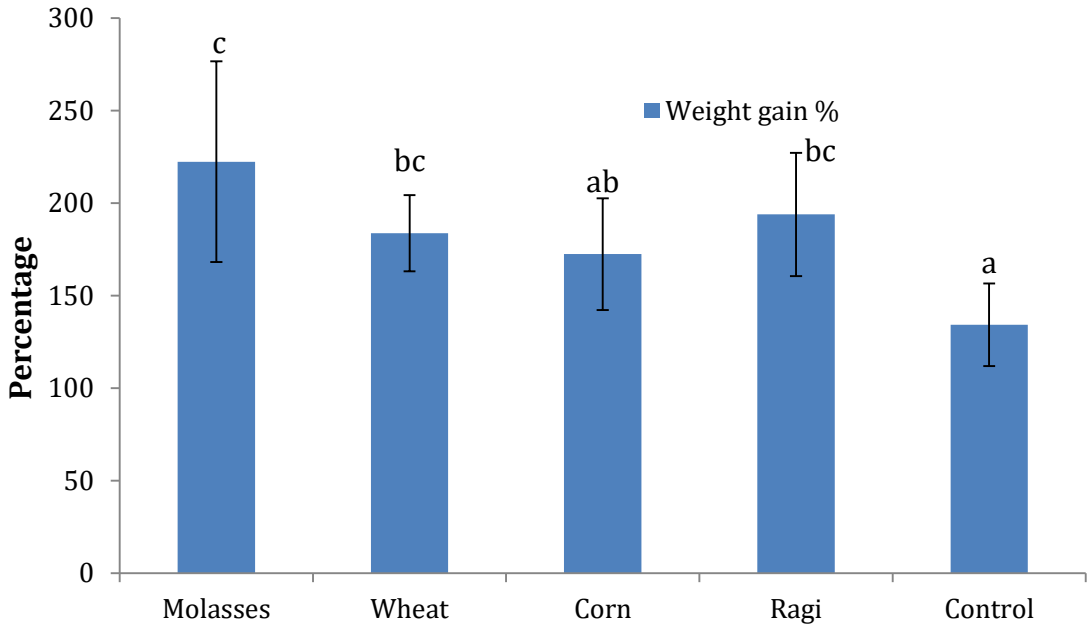
A study was conducted to evaluate the effects of four different ratios of Carbon and Nitrogen (CN: 5; 10; 15; 20) on microbial community in the culture system with zero water exchange. The experiment was conducted with four different level of C:N ratio (5, 10, 15 and 20) and designated as C:N 5:1, C:N10:1, C:N15:1 and C:N 20:1. All treatments had three replicates and allocation for each treatment was completely randomized to generate the biofloc in all the treatment tanks. Molasses as carbohydrate source (200 ml), probiotics consortium (Bacillus strains (5.4 X 109 CFU/ml), were mixed in autoclaved seawater (10 L) and dissolved thoroughly and brewed for 24 h for fermentation. The fermented inoculum was applied in all the treatment tanks @ 50 ml/tank every day for five days to generate the heterotrophic bio-floc. Carbohydrate supplementation significantly increased the total heterotrophic bacterial (THB) count in increasing order from C:N5 to C:N20. As the culture proceeds, the increasing biomass had a significant effect ($P < 0.01$) over total microbial load with higher level recorded in C:N15 and C:N20. Similarly, carbohydrate supplementation had a significant effect on reduction of Vibrio count (TVC) in water ($P < 0.01$). TVC levels were greatly reduced in C:N10, C:N15 and CN20 reared water (91.80 ± 0.3%) whereas in control it was highest followed by C:N5. The carbohydrate supplementation resulted in 71.7 ± 3.3% increase in TVC in water of BFT groups respectively. The proportion of Vibrio count to total heterotrophic bacterial count (V/T) was lower in the biofloc groups in decreasing order as we proceed from C:N5 to C:N20 compared to that of the control group. In spite of increase in Vibrio load, the V/T ratio was non-significantly lower in the BFT groups with different C:N ratios. The bacterial diversity and the frequency distribution of bacterial phyla differed between the treatments. Both in control and C:N5 treated water, the Vibrio of 79% and 37% were the most dominant operational taxonomic unit respectively. In C:N10, Thauera (62%) was most represented taxa. In C:N15, Attheyaceae (56%) and Peridiniaceae (30%) were the most dominant phyla. In C:N20, the Psychrobacter (26%), Proteobacteria (25%) and Peridiniaceae (20%) phyla were found to be dominated phylum.

Biofloc based nursery and grow-out for Indian white shrimp, *Penaeus indicus*

Biofloc consortium and carbon sources and consortium with bacterial combinations were found to induce significantly higher growth and survival after six weeks of nursery rearing. Following this, grow-out farming demonstration in farmer's facility successfully conducted with a high survival of 90.6 % with a final average body weight of 18 g and a total production of above 3.1 tons/ha from a low input low stocking of 15 nos/m2 in grow-out culture in 65 days.

Evaluation of growth performance of spotted scat, *Scatophagus argus* in biofloc based system using different carbon sources

A 30 days experiment was carried out to study the growth performance of *Scatophagu sargus* in biofloc system using 4 different carbon sources (Molasses, Wheat flour, Corn flour &Ragi flour) were assigned as treatments T1, T2, T3 & T4 with replication and control (C) with clear water. C:N ratio (15: 1) maintained in all the biofloc treatments. 54 day old scat fry with initial length and weight of 2.02±0.06 cm &380±0.08 weight respectively were stocked @ 30 nos /100 l in all the treatments. Fry was fed with 30 % crude protein feed at 5 % body weight. The results revealed that growth performance was significantly higher in the treatment where molasses used as carbon sources ($p<0.05$) in terms of final weight gain 1225±70.76 mg followed by wheat flour based system (1116.7±60.09 mg) and lowest was observed in control (890.0±40.79 mg. Survival rate was found the maximum in T1 (88.33±2.30)followed by control (84.66±2.20) and lowest was indicated T3 (77.66±2.02). From the overall results, indicated that Molasses based biofloc system found to be the best for growth and survival of *Scatophagus argus* compared to other treatments.



Growth performance of spotted scat fry under different carbon sources in biofloc based system

Raising of stunted milkfish for grow-out culture

Application of compensatory growth phenomenon by using stunted fingerling has been proved to have greater potential in increasing fish production. The milkfish fingerlings (6-8 g) were reared with maintenance level of feeding (0.5-1% body weight) and periodic fertilization in the pond. After 5 months, fishes attained 20-40 g size with 90-95% survival. This step could meet up the seed demand for culture during fallow season at shrimp farms (Aug-February), when hatchery produced seeds is unavailable

Stunted milkfish yearlings

Development of pond reared brood stock of Indian shad

A total of 45 brooders (25 numbers of 250-300 g and 20 numbers of 60-80 g size) were maintained in brackishwater pond ecosystem at KRC of CIBA. For maintenance, periodical liming, fertilization and addition of phyto and zooplankton at 30 days interval is carriedout. To assess the maturity round the year monthly sampling was carried out. It is found that female attained the maximum average oocytes diameter of 510 µm in the month of January, which is thenaturalbreeding time of Hilsa in Ganges River.

Monthly sampling of Hilsa stock

Comparative study of multi-tier farming and polyculture with different brackishwater species combination is evaluated

Comparative growth performance of *Mystus gulio, Chanos chanos, Etroplus suratensis, Oreochromis niloticus* and *Penaeus monodon* was studied in two different rearing system: multitier farming and polyculture. In both the systems, *Mystus gulio* (average weight: 0.8 g; stocking density: 20 m^{-2}), *Chanos chanos:* average weight: 4.5 g; stocking density: 3 m^{-2}), *Etroplus suratens* (average weight: 0.40 g; stocking density: 5 m^{-2}), *Oreochromis niloticus* (average weight: 2.5 g; stocking density: 5 m^{-2}) and *Penaeus monodon* (average weight: 0.25 g; stocking density: 18 m^{-2}) were stocked. Fishes were fed with polyculture feed @ 5% of total biomass. Results of the study showed that after 5- months of culture, weight gain of cultured fishes were measured as 32 g, 79 g, 20g, 76 g and 21 g for gulio, milkfish, pearl spot, tilapia, and tiger shrimp respectively. The experimental trials pointed the promising results in terms of growth of various finfishes and shellfishes in the polyculture farming.

Popularization of milkfish farming as *'Decan Hilsa'* in West Bengal

Proper and efficient marketing is the essential component of a sustainable aquaculture. Milk fish has been marketed in West Bengal under the name,*'Decan Hilsa'*. As a part of this program, a collaborative research work with a private entrepreneur is initiated. A total of 12000 hatchery produced fry was given for culture. Nursery rearing of milkfish was done for 45 days in 16 ppt salinity in pond condition. Survival during nursery rearing achieved 85% survival rate could be obtained with an average body weight of 20 g. Stocking was done in 1 ha pond for grow out culture and around 2 t crop (average 220 g body weight) is expected to harvest from 1 ha pond (salinity > 7 ppt) with 90% survival at Joynagar, S-24 Pargana district

Milkfish partial harvest at West Bengal

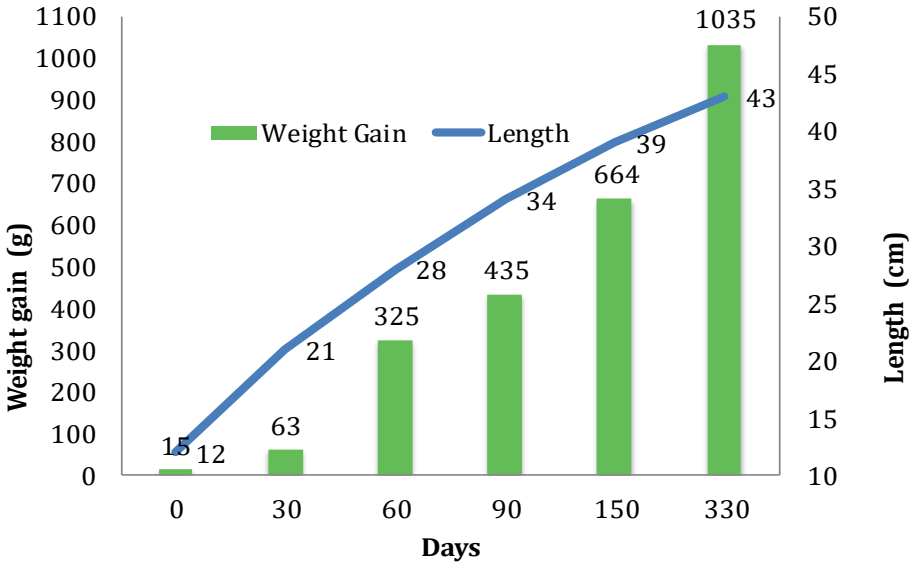
Milkfish monoculture demonstration in Kerala

As an initiative to promote milkfish farming in Kerala, CIBA supplied 6000 of hatchery produced milkfish seed to the farmer in Kollam district of Kerala. Seeds were stocked in 2 acre pond and feed on formulated diet. In six month culture period the fishes attained a size range of 250 to 450 g. Framed fishes were sold on the basis of

demand by partial harvesting (catching 10 to 30 kg by gill netting on a daily basis) and sold @ 350/kg for retail buyers and Rs. 220-250/kg to wholesale buyers.

Seabass grow out cage culture in public private partnership mode (PPP)

In order to promote seabass farming in Public Private Partnership mode (PPP), ICAR-CIBA has initiated the demonstration of cage farming of Asian Seabass (*Latescalcarifer*) in Kollam District, Kerala. Seabass juveniles (7-8gm size) were stocked @ 750 nos/cage in grow out cages (4x4x2 m GI cage). Fishes were fed with CIBA's formulated indigenous feed (Seabass^{PLUS}) @ 2 to 3% of their body weight. The fishes reached to the average size of 350gm within 6 months culture period.



Brackishwater Fish Harvest Mela and Farmers Interaction Meet: Inaugurated by Dr. K. K. Vijayan, Director ICAR-CIBA.

Seabass grow out cages

Asian seabass a livelihood option for youths in Kazargoda village, Uttarakannada, Karnataka

ICAR –CIBA has made its mark in Karnataka by popularizing brackishwater aquaculture as an alternate livelihood option for rural youths. A total of 600 nos of Asian seabass seed (average total length 13 cm & 15 g weight) were supplied to the farmers in Kasarkod, Uttarakannada district, Karnataka and stocked in the 0.18 ha pond, and cultured for 10 months Fishes were fed with trash fish (Sardine and Tilapia) @ 5 % body weight. Fishes attained weight of 980 – 1050 grams with total production of 512 kg/0.18 ha. Farmers were able to sold the farmed seabass in the Goa m arket @ 450Rs/kg.

Brackishwater seaweed

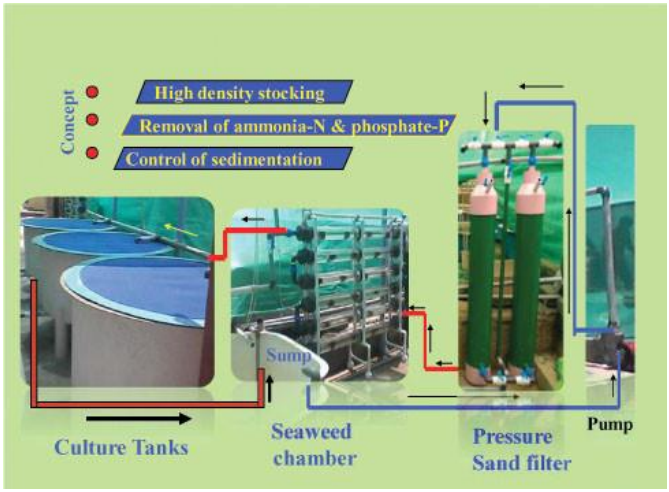
Gracilaria spp, is one of the most important aquaculture resources, and it has been widely used for the production of agar and treatment of aquaculture discharges. In order to evaluate the brackishwater seaweed resources along the coast of Chennai, periodic surveys were carried out in Vennangupattu Lake (12°14'41" N, 79°58'58" E). The study revealed that the major species found in the lake is Gracilaria *sp.* (Rhodophyta).The species was identified

morphologically and further confirmed by molecular methods as *Gracilaria tenuistipitata,* which was 100 % identical with the specimen identified previously from Muttukadu (Tamil Nadu)

Different methods of propagation of this species, net bag and rope method were tested in two different ecosystems: pond and lagoon ecosystem. Further the growth and production at different stocking density, g/m*2*) were also evaluated. The production and growth of seaweed was found to be higher in rope culture method compared to net bag in lagoon, however net bag culture showed better production and growth in pond systems. In variably in both the ecosystem low intensity culture provided better production and growth. both the ecosystem. Further it is also showed that lower intensity gives higher growth rate compared to higher biomass intensity.

Seaweed based biofilter for RAS

Two porotypes of filter has been fabricated and tested for its efficiency as a biofilter. Series of experimentals trial on biofiltration potential of two models: M1 and M2. The efficiency was evaluated by observing the concentration of nutrients (NH_4-N and PO_4-P) at two hours interval. Nutrients concentration at control (without seaweed) was not significantly changed with time (R^2 was <<0.5) for both nutrients. Both filtration systems was efficiently removed N and P at a considerable level after 48 hours but removal efficiency was faster at M2 than M1 for both nutrients (Fig. 3a-b). Full experimental set up has depicted below for design 2.



Assessment of standard aeration efficiency of different aerators at different salinities

Assessment of the oxygen transfer performance of the aerators was carried out in 50 T plastic tanks having dia of 7.2m and depth of 1.2 m. Evaluation trials have been carried out to deoxygenate the water. Then aerators were used to increase the dissolved oxygen (DO) concentrations at different salinities: 5 ‰, 20‰, 35‰ and 50‰ The DO deficit was computed for each time till saturation. The oxygen-transfer coefficient is adjusted to 20OC, used to estimate the standard oxygen-transfer rate (SOTR) of aerator based on American Society of Civil Engineers (ASCE) standard method for aerator evaluations. The standard aeration efficiency (SAE) of paddle wheel, submersible, spiral, jet and impeller aerators were arrived from SOTR and the power consumed for different salinities to understand the performance efficiency.

It was found that SAE of commonly used paddle wheel aerators ranged from 1.545 to 0.423 kg O2 / hr at a salinity range of 5 to 50 ppt. Spiral leaf aerators SAE ranged from 1.228 to 0.761 kg O2 / hr; air jet aerators SAE ranged from 1.771 to 1.005 kg O2 / hr; Submersible aerators SAE ranged from 0.504 to 0.226 kg O2 / hr and Impeller aerator efficiency ranged from 2.319 to 1.549 kg O2 / hr for a salinity range of 5 to 50 ppt. The varying aeration efficiency at different salinities indicated the varying requirement of aerators for the same stocking density, and the possibility for saving the energy use and production cost.

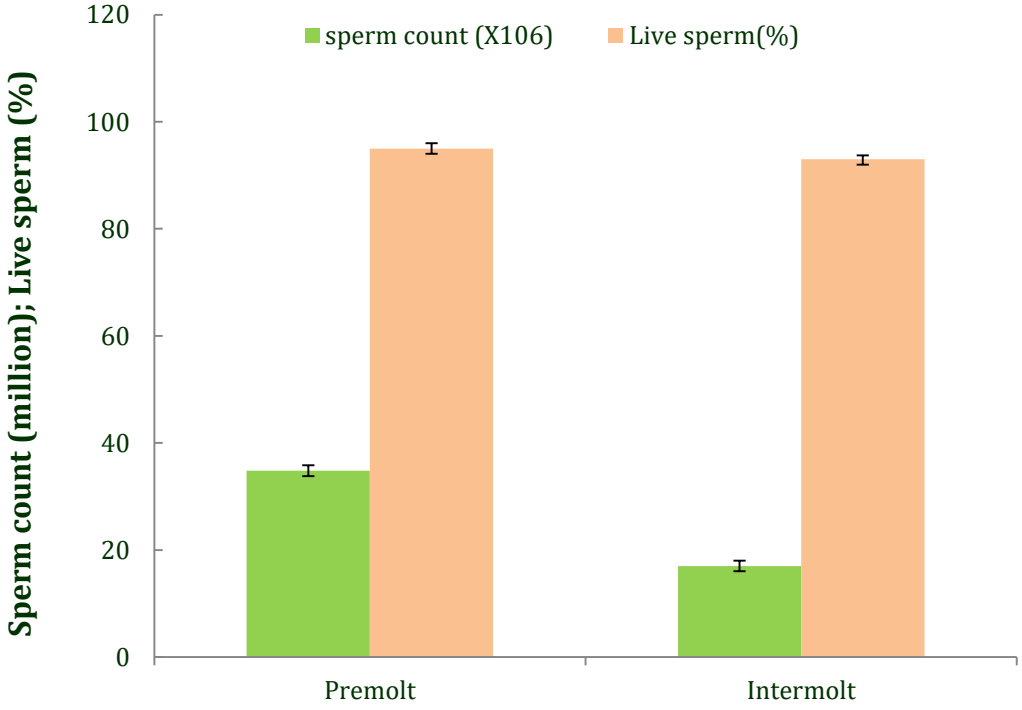
Mapping of coastal resources and identifying suitable areas for expanding integrated multi trophic aquaculture (IMTA) in Maharashtra

A preliminary survey was conducted to identify the suitable creeks based on physical and chemical characteristics of waterbodies. The creeks in Maharashtra have been mapped and water quality such as physicochemical and biological parameters were analyzed from five district namely Palghar, Thane, Raigad, Ratnagiri and Sindhudurg) creeks and river waters of Maharashtra state. The water depth and current flow has been measured in all creeks. The resource mapping of land and water has been initiated. Two seasonal water characteristics have been analysed and the water quality is found to be optimum for the aquaculture. The sites are being identified based on the physical and chemical characteristics of creeks.

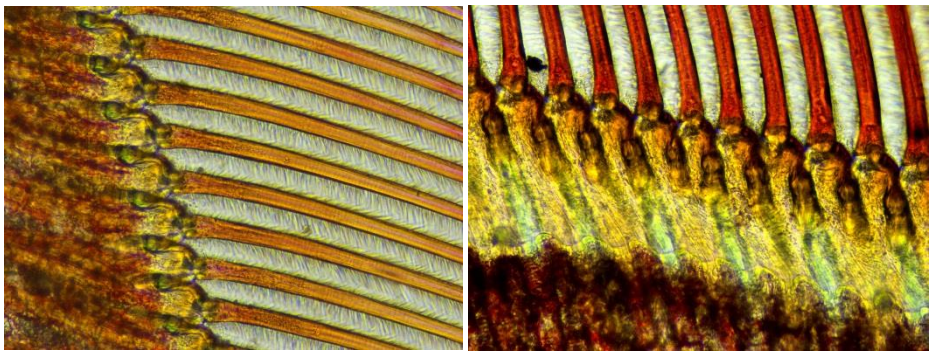
REPRODUCTION, BREEDING AND LARVAL REARING

Reproductive quality evaluation of male *Penaeus indicus* (Indian white shrimp) in relation to molting stages

Reproductive management of males in shrimp hatchery is crucial in optimizing reproductive performance and seed stock production. The male spermatophore quality of Penaeus indicus was evaluated in relation to the molt stages. Setal morphology of the uropod was adopted to ascertain the molt stages. The average Spermatophore weight (g) observed was 0.122 ± 0.01 and 0.118 ± 0.01 in the premolt and intermolt stage respectively. The average sperm count observed was 34.8±4.57 X 106 and 16.98±1.25 X 106 no during the premolt stage and intermolt stages respectively and was significantly higher in the premolt stage (Table 1). The average percentage live sperms and sperms with normal morphology were not significantly different in the intermolt and premolt stages.



***Peaneaus indicus*: Male reproductive quality**

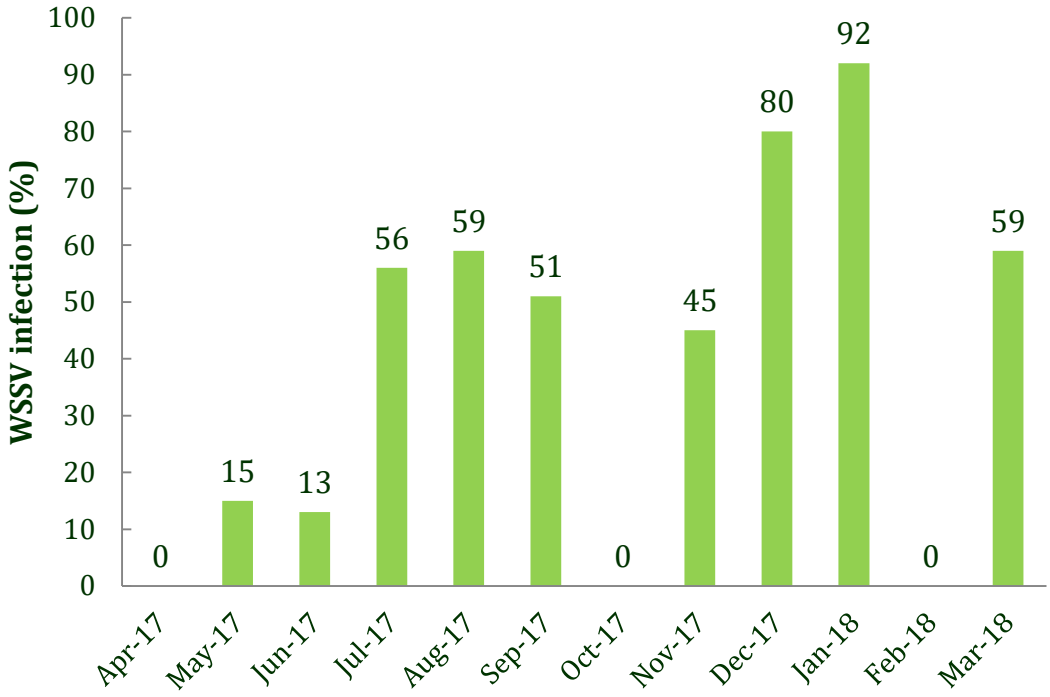


Setal morphology of intermolt and early premolt stages of *Penaeus indicus*

Hatchery production of *Penaeus indicus*

A total no. of 471 *P. indicus* adults was procured form the local fisherman during the period from May 2017 – January, 2018. Out of the total broodstock procured 218

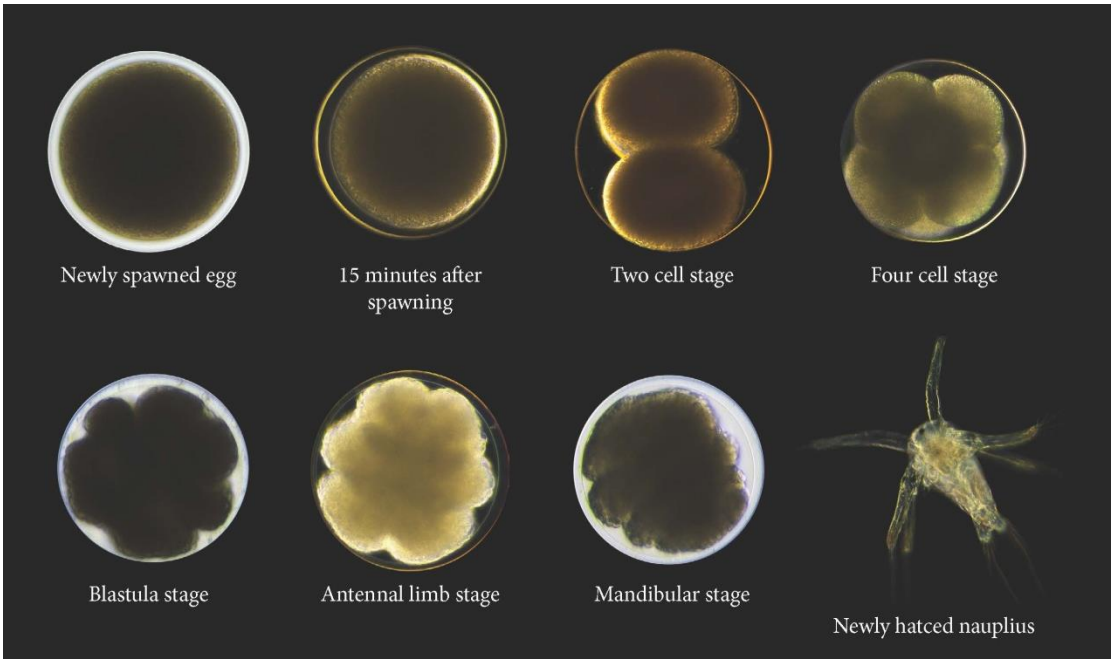
(46.2%) animals were found to be WSSV positive. Major WSSV infections were found during December and January, 78 and 90% respectively. Average fecundity was 3304 eggs/gm body weight. A total of 10 spawning were realized from the WSSV free stock and a total of 0.2 million larvae were produced. In order to evaluate the effect of size on reproductive performance, various size groups of brooders (30-40, 40-50 & 50-60 g) were segregated, and reproductive performance was evaluated.. The result showed that 40 – 50 g size group was performed significantly higher spawning, fecundity, hatching rate and larval conversion when compared to other groups.



Incidence of WSSV

Penaeus indicus-early developmental stages

In order to resolve the issues in fertilization and further development of eggs, the detailed knowledge of embryogenesis is extremely important. A comprehensive study of early embryogenesis of *P. indicus* was documented.



Embryonic stages (picture)

Artificial insemination (AI)

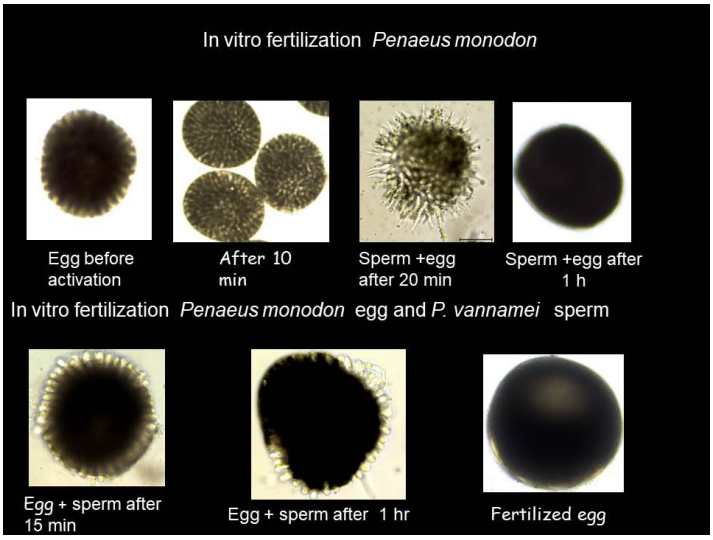
Deliberate introduction of sperm into the female reproductive tract, is the crucial component of captive breeding program, and that revolutionized breeding programs in livestock. Although AI techniques have been studied in penaeid shrimps, since the advent of shrimp farming, detailed documented evidences are limited particularly in the closed thelycum species. Detailed studies have been carried out on AI of *Penaeus monodon* and *P.vannamei*. In *P. monodon* post molted females were inseminated with newly extruded spermatophore, and inseminated females were induced for maturation and spawning by eyestalk ablation. In *P.vannamei*, the post-molted female was ablated after 3 days, and inseminated in stage IV of maturation, whereas in *P.monodon*, only few females reached reproductive phase (23%), In *P. vannamei*, 40% of artificially inseminated females produced fertilized eggs. Lower success rate in *P. monodon* may be due to the morphological differences of the external reproductive organ.

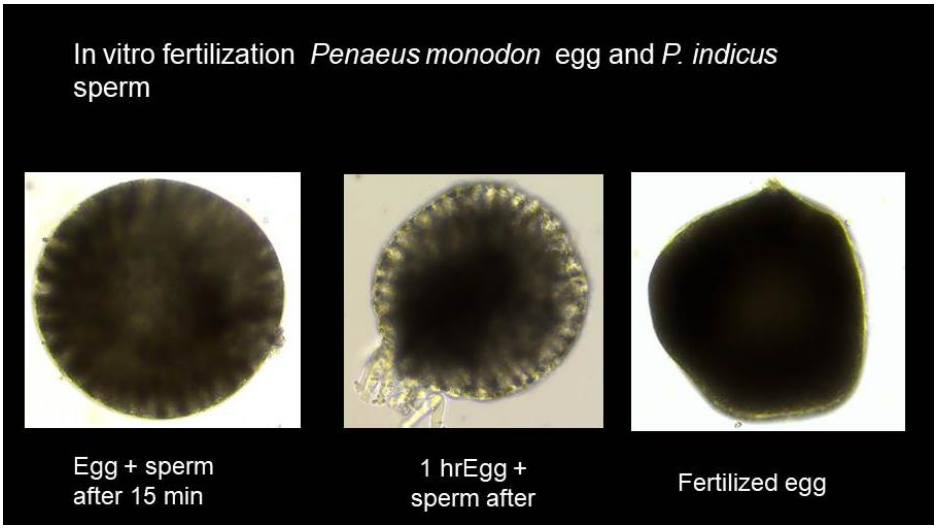
R4 FIGURES (photos)

Development of In vitro fertilization of *Penaeus monodon*

The major objective of this work was to evaluate the feasibility of fertilizing pre ovulatory oocytes of *P. monodon*, and to evaluate the potential hybridization of *P. monodon* oocyte with *P. vannamei* and *P. indicus* spermatozoa in vitro. Additionally the events during the fertilization have been studied. Male spermatozoa of *P. vannamei* and *P. indicus* were removed using sterilized micro forceps, and macerated in 1 ml filtered seawater, and counted. Females with ripe ovaries were dissected and kept at 4 °C for 5 minutes. Eighty thousand oocytes were mixed with 1 ml of sperm suspension (1 ml contains 34 million) in 2 L of filtered seawater for each treatment (Treatment 1: *P. monodon* X *P. monodon*; Treatment 2: *P. monodon* X *P. vannamei*; P*. monodon* X *P. indicus*). Fertilization and embryonic development were evaluated at every l5 minutes. Immediately after the contact with seawater cortical rods emerged from the eggs and cortical rod dissipated forming a jelly coat around the eggs. The thick hatching envelope was then developed. The study shows that pre ovulatory eggs are capable for egg activation and fertilization. Fertilizability of *P. monodon* eggs are found with both

conspecific and inter specific spermatozoa. The fertilizability was highest in the conspecific interaction (40%), and minimum in the crossing between *P. monodon* and P. indicus (10%). Surprisingly moderately high percentage of fertilization was achieved between *P. monodon* and *P. vannamei*.

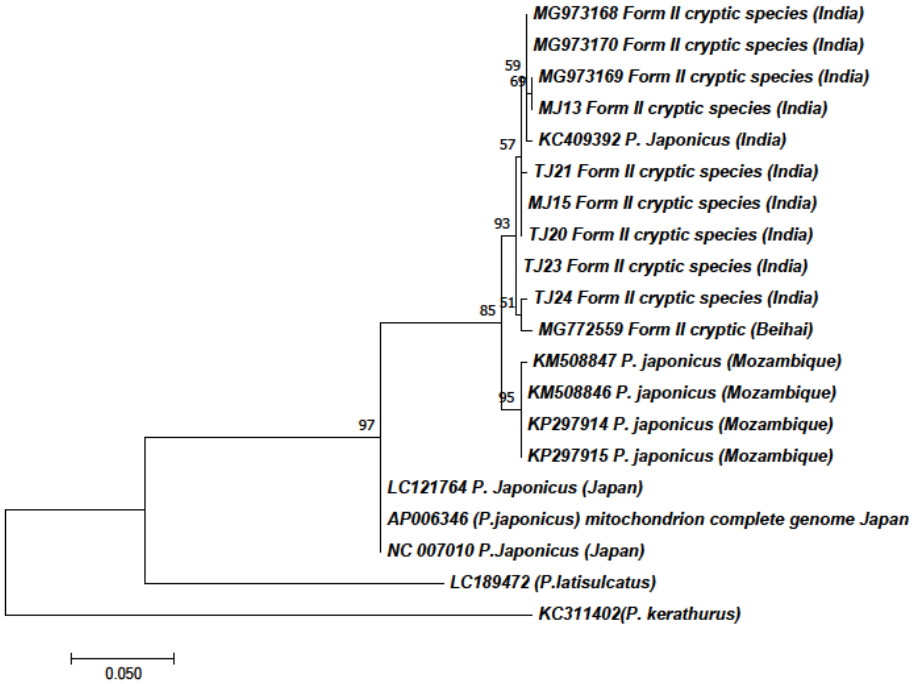




A new species status for Indian shrimp taxa

Kuruma shrimp, *Penaeus japonicus* is reportedly the most high valued penaeid shrimp, because of its outrageously high price in Japan. The previous studies conducted by us suggested the differences in the aquaculture traits and biology with reference to *P. japonicus* reported from other countries, although organoleptic studies conducted by us proved no taste difference between native *P. japonicus* and Indian species. Molecular signature of this species, using specimens obtained all along its distributional range in India, was evaluated using 16S rRNA gene and CO1 gene. Molecular phylogenetic analysis of 16S and CO1 demonstrated that the species reported in India is a cryptic species of Penaeus japonicus group. The genetic distance between Indian species and *P, japonicus* and *P. pulchircaudatus* confirms a new species status for Indian taxa.

***Penaeus japonicus* cryptic species**



Phyloogenetic analysis of Kuruma shrimp, *Penaeus japonicas*

Kuruma shrimp, *Penaeus japonicus* seed production

In order to refine the hatchery production of kururma shrimp, several hatchery runs were carried out. Brooders of kuruma shrimp were obtained from coastal fishers, and all the animals were screened for WSSV. WSSV negative broodstock were divided into two groups for the study: maturing and empty stage depending upon the ovarian maturity stage. After eyestalk ablation, the maturing group attained full maturity within 14 days was observed whereas females of spent group attained full maturation only after 25 days.. The average egg production per spawning was 30,000 no with a fecundity of 541.41 ± 31.01 eggs/gm body weight in the mature group and 486.71 ±19.16 in the empty group. There was no significant difference in the larval survival between the mature and empty group

Reproductive performance of *Penaeus japonicus*

Maturation stage	Body weight (g)	Latency period	Fecundity	Fecundity (no/g)	Hatching rate (%)

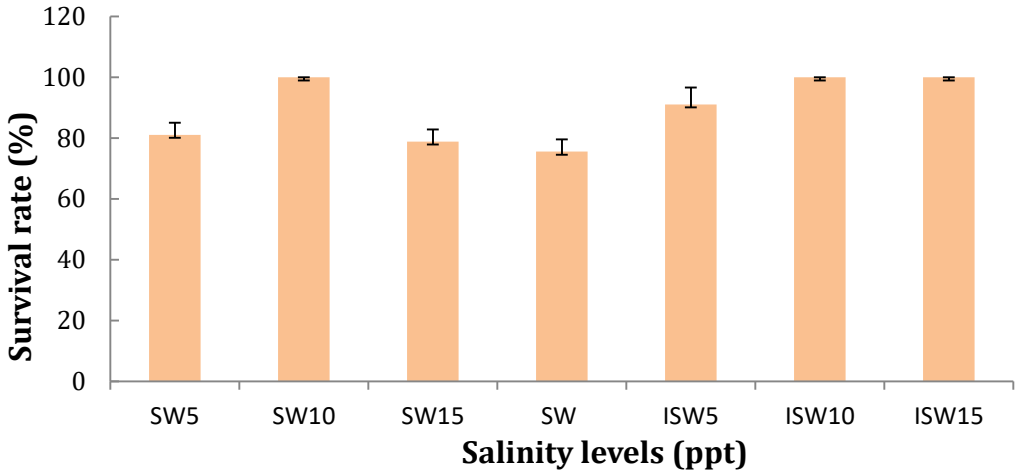
		(days)			
Maturing	59.6 ±5.1	14 ± 1.4	32320	541.9 ± 53.3	37.7 ± 2.7
Empty	56.1 ± 5.0	25 ±2.2	26986	486.71 ± 19.1	25.5 ± 3.5

Effect of different salinities, coastal and inland, on growth and osmoregulation of penaeid *shrimps*

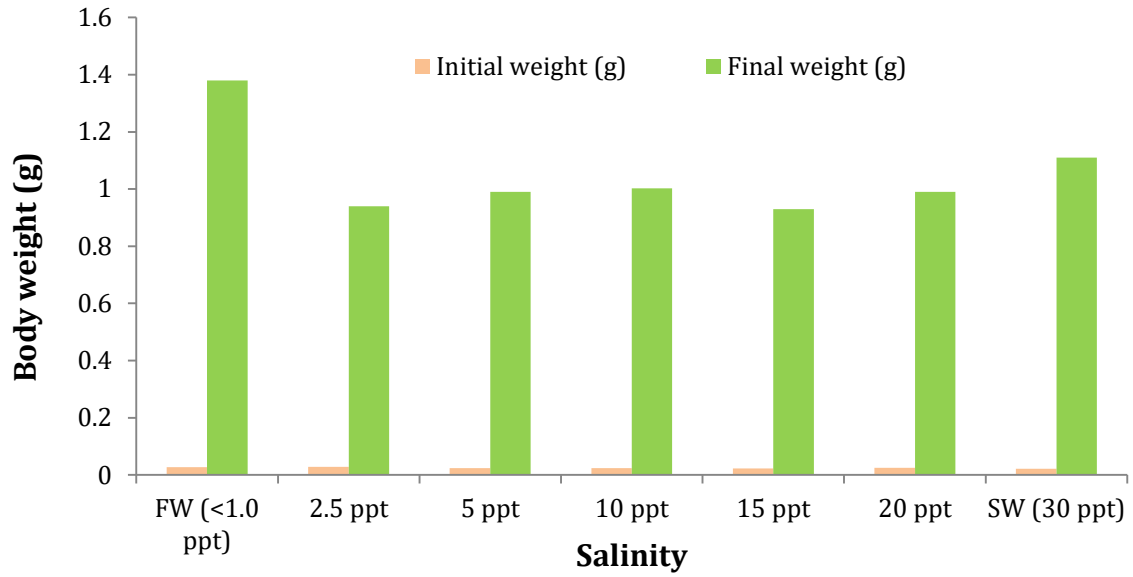
Recently, marine shrimp farming is extending to low saline coastal areas and inland brackishwater areas. Understanding the physiology of osmoregulation in low saline and inland brackishwater is vital for further refinement of low saline shrimp farming technology. In order to evaluate the physiological characteristics of *P. indicus* cultivating in these areas a 45 days indoor trial was carried out. Inland saline groundwater of different salinities were prepared through mixing of different salts viz. NaCl, KCl, MgCl2.6H2O, CaCl2.H2O, NaHCO3, MgSO4.7H2O and KBr in various proportions with freshwater. The ionic profile of the artificial amended inland saline groundwater was formulated to match the ionic composition of saline groundwater used for shrimp aquaculture in North-western India with a Mg2+/Ca2+ ratio of 1.7:1 to 1.8:1 and a Na+/K+ ratio of 43:1 to 44:1 respectively. A total of thirty *P. indicus* juveniles (BW – 0.06924 ± 0.0023 g) were randomly stocked in to several 100 litre dark coloured FRP tanks filled with seawater and inland saline water of different salinities in triplicate. The mean final individual weight of shrimp in all the treatment and control salinities did not vary significantly. However, the survival rate at the end of 45 days was significantly higher for shrimp reared in seawater of salinity 10 ppt (SW10) and amended saline groundwater of salinities 10 and 15 ppt (ISW10 and ISW15). The survival rate of shrimp reared in seawater of salinities 5 ppt, 15 ppt and 27 ppt did not vary significantly indicating that the farming of Indian white shrimp at high and low salinities is economically viable. The iso-osmotic point of juveniles reared in seawater and inland saline water has been determined as 793.80 mOsmol/Kg and 774.05 mOsmol/Kg respectively. The serum osmolality of shrimp reared in inland saline groundwater was observed to be significantly lower compared to their counterparts reared in seawater of similar salinities. The study concludes that the farming of Indian White Shrimp using inland saline groundwater is technically and economically feasible.

In another experiment, a 45 day indoor trial was conducted to study the growth, survival and osmoregulation of *P. vannamei* PL reared in freshwater and seawater diluted to different salinities. The present trial consisted of 6 treatment salinities i.e. FW (0.7-0.8 ppt), 2.5 ppt, 5 ppt, 10 ppt, 15 ppt, 20 ppt and seawater of salinity (29-30) ppt served as the control group. The shrimp PL were acclimatised to the treatment salinities from a salinity of 30 ppt at a rate of 2 ppt every 30 minutes until 5 ppt post which salinity was dropped at a slow rate of 0.5 ppt every 60 minutes. The mean final individual weight was observed to be significantly higher for shrimp reared in freshwater (Salinity <1.0 ppt). The mean final individual weight of shrimp did not vary significantly among the other treatments. Significantly lower survival rate was observed for shrimp reared in freshwater and SW respectively. The survival rate of shrimp in all the other treatment salinities ranging from 2.5 ppt to 20 ppt did not vary significantly. This indicates that the farming of *P. vannamei* can be carried out economically at salinities varying from 2.5 to 20 ppt. The higher growth for shrimp reared in SW may be attributed to the lower survival rate in SW resulting in larger sized shrimp. However, in the case of shrimp reared in FW, it was observed that the shrimp were growing at a faster rate and slow continuous mortality started setting in post 30 days of culture. The shrimp reared in FW had the same level of activity as observed for shrimp in other salinities and no signs of disease were observed in shrimps reared in any of the treatments. Interestingly, the weight gain (%) of shrimp reared at the different treatment salinities except FW and SW did not vary significantly indicating that the growth of shrimp at salinities ranging from 2.5 ppt to 20 ppt to be similar. The iso-osmotic point for P. vannamei in the trial was 770.2 mOsmol/Kg (iso-osmotic salinity -

25.93 ppt) based on hyper osmoregulation and hypo osmoregulation of the shrimp at different salinities. The study concludes that the lower survival rate of shrimp in raw freshwater (Salinity < 1.0 ppt) without ionic supplementation would translate in to poor production economics.



Survival rate of *Penaeus indicus* at different salinities



Growth of performance of *Penaeus vannamei* at different salinity levels

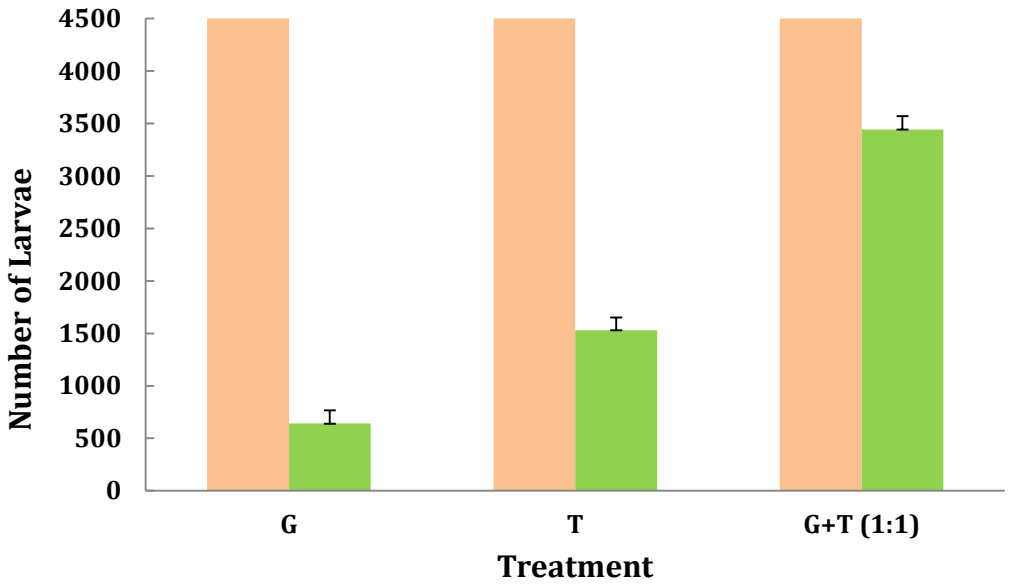
Mud crab, Scylla serrata

Improving the survival rate of *Scylla serrata* zoea through use of rotifers reared on different algal species: High mortality rate of *Scylla serrata* zoea is observed during the initial phase (Z1 to Z3) of mud crab larval rearing. The poor survival rate at this phase is mostly attributed to the nutritional status of the crab larvae, which in turns depends on the feed quality and quantity. Two studies were conducted to evaluate the effect of feeding crab larvae with rotifers reared using different algal species and their combinations. In the first trial, five feeding treatments viz., rotifers grown on yeast (Y), rotifers grown on yeast and enriched on 1:1 mix of Chlorella sp. and Tetraselmis sp. for four hours (Y + G), rotifers grown on 1:1 mix of Chlorella sp. and Tetraselmis sp. (G), rotifers grown Thalassiosira sp.(T) and rotifers grown on yeast and enriched on Thalassiosira sp for four hours (Y + T) were evaluated for the effect on the survival rate of Zoea at the end of 10 days. The rotifer and algal density in the tanks were maintained at around 20 ind./ml and 1 lakh cells/ml respectively. At the end of 10 days the survival

rate of larvae grown on treatments T (rotifers grown on Thalassiosira sp.) and G (rotifers grown on 1:1 combination of Chlorella sp. and Tetraselmis sp.) was significantly higher than the other treatments though there were no significant differences among them. Larvae reared on yeast fed rotifers resulted in 98 % mortality by day 5 and 100 % mortality by the end of the trial. The study indicate that rotifers grown on Thalassiosira sp. can be used as feed for the crab larvae and is a viable alternative to the traditional Chlorella sp. based rotifer production. The use of rotifers reared on baker's yeast or the ones reared on yeast and enriched with other algae or its commercial pastes are not recommended for use as feed for crab larvae due to the lower survival rates observed.

In the second trial three feeding treatments viz. rotifers reared on Chlorella sp. (G), Thalassiosira sp. (T) and a 1:1 combination of Chlorella sp. and Thalassiosira sp. (G+T) were evaluated during the larval rearing of zoea. The rotifer and algal density in the tanks were maintained at 20ind./ml and 1lakh cells/ml respectively. Feeding crab larvae using rotifers reared on a 1:1 combination of Chlorella sp. and Thalassiosira sp. resulted in a significantly higher survival rate of 76.5 % over 34 % and 14 % observed in the case of larvae fed using rotifers reared individually on Thalassiosira sp. and Chlorella sp. respectively. The study concludes that the use of rotifers developed on a combination of Thalassiosira sp. and Chlorella sp. as feed for the zoea 1 would result in a higher survival rate to zoea 3 stage.

Mud crab megalopa production: Megalopa stage in the mud crab, *S. serrata* larval cycle encounters high mortality during the nursery rearing phase due to intense cannibalistic behaviour, moult death syndrome resulting in poor survival to the crab stage. The survival rate of megalopa to crab instar can be improved through nutritional interventions and reduction in the stocking density. Four feeding treatments viz., artemia biomass (T1), clam meat (T2), crab larvae (T3) and artemia nauplii (T4) were evaluated for their effect on crab instar conversion. Megalopa (3 to 4 days old, Avg. BW – 5.05 ± 0.26 mg) produced in the hatchery were stocked in to FRP tanks at the rate of 1 megalopa/4 litres. The feeding treatments artemia biomass (T1) and clam meat (T2) resulted in significantly higher survival rate of 74.7 % and 72% respectively at the end of 8 days. Artemia nauplii (T4) resulted in poor survival rate of megalopa to crab stage. The study concludes that artemia biomass and clam meat are suitable nursery feeds for rearing of mud crab megalopa to crab instar stage.

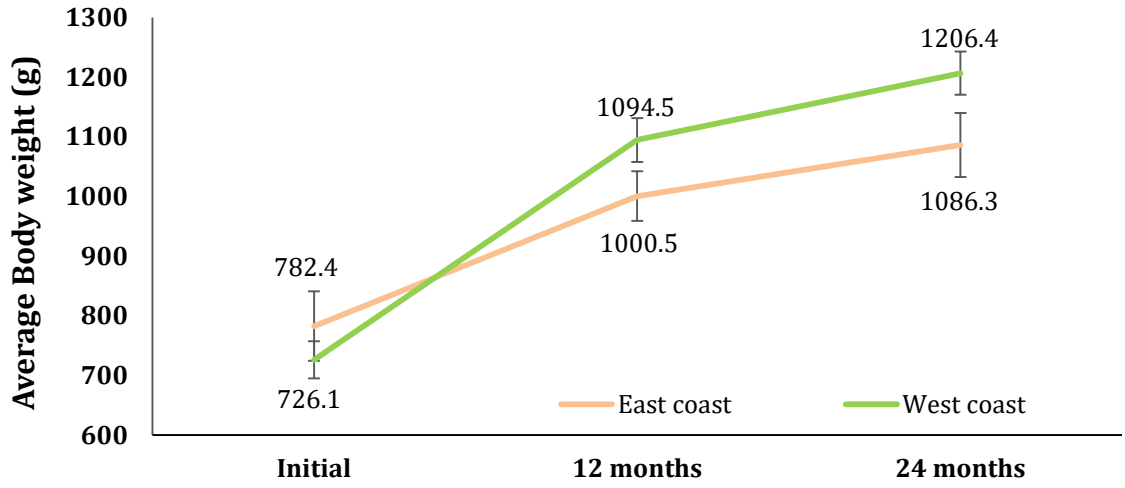


Survival rate of *Scylla serrata* at three different feeding regimes: *Chlorella* sp (G), *Thalassiosira* sp. (T), *Chlorella* sp+ *Thalassiosira* sp. (G+T)

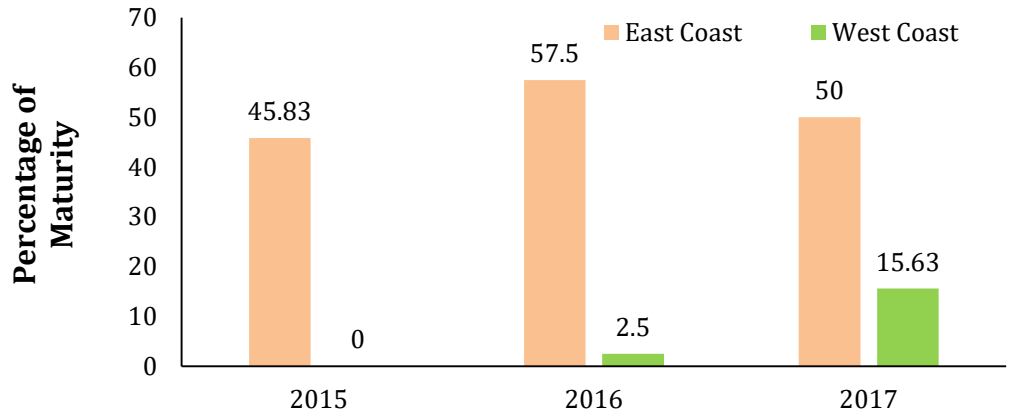
Growth and reproductive parameters of grey mullet *Mugil cephalus*- variations of two captive stocks

Variations in biological parameters may serve as indicators of stock variations in fish. Grey mullets collected from two locations; East coast (Chennai, Tamil Nadu) and West coast (Ernakulam, Kerala) were maintained in 100 t RCC provided with continuous flow through of seawater for two years; feeding was done on formulated broodstock feed developed by CIBA (twice daily at 3-4%). After 12 and 24 months, the growth performance of grey mullet from the west coast was significantly (*P<0.05*) higher than fish from the east coast, Specific Growth Rate (SGR) of east coast stocks after 12 and 24 months were 0.18± 0.02 and 0.04±0.01 % day^{-1} and that of the west coast stocks were 0.45±0.12 and 0.06±0.01 % day^{-1} (fig 1).

Variations were also recorded in the reproductive characteristics of captive grey mullet brooders from East coast and West coast; the average oocyte growth was 7.6±0.3 (7.1 to 8.3 µm per day) in the east coast stocks and 4.1±0.1 (4.0 to 5.2 µm per day) for the west coast stocks. The peak breeding season for captive east coast stocks was November and December for the captive west coast stocks. No milting males were observed in the west coast stocks. The percentage of captive maturity of east coast stocks was 45.83%, 57.5% and 50% in 2015, 2016 and 2017 respectively. The percentage of captive maturity of west coast stocks was 0, 2.5 and 15.63% in 2015, 2016 and 2017 respectively. The maximum oocyte size recorded in fish from the west coast stock was 564.33±21.56 µm, the maximum oocyte size recorded in fish from east coast stocks was 538.13±5.70 µm. These variations could be recorded as both the stocks were maintained in captivity under similar conditions at one location. The reproductive parameters may potentially indicate reproductive isolation of the two stocks of grey mullet.



Average body weights of captive grey mullet broodstock from east and west coast after 12 and 24 months culture period (G)



Percentage of maturity of East and West coast stocks during from 2015 to 2017 (G)

The closing life cycle of grey mullet in captivity- milestones achieved and challenges ahead

The closing life cycle of grey mullet in captivity has been one of the major programs of ICAR-CIBA. For this, an alternate approach of farm-reared captive broodstock for induced breeding was tried at the west coast. Five successive induced breeding trials conducted between June to July 2017 were successful and resulted in larval production. Female fish with average oocyte diameter above 550 µm were selected and administered with exogenous hormones. Latency period was between 12-16 h. After ascertaining completion of final oocyte maturation and ovulation, dry stripping was done, 0.7- 1.5 million eggs were obtained. Fertilisation percentage varied from 5 to 75% in the different trials; average fertilisation rate was 35-40%. Size of fertilised egg ranged from 750- 870 µm. Size of oil globule was 270- 300 µm. Eggs were packed under oxygen packing and sent to fish hatchery, MES, CIBA. A maximum of 10,000-15,000 larvae was obtained post transportation to MES, CIBA. Larval survival was obtained upto 8 DPH. At farm site 5-10% of the fertilised eggs were retained; the larvae obtained were 1000 numbers, 30,000, 24,000, 12,000 and 10,000 numbers in the respective trails. Maximum survival was obtained upto 5 dph at the farm site. Size of newly hatched larvae was 2.1 mm. After 24 h and 48 h tl of larvae was 2.4 mm and 2.55 mm respectively. Research efforts will be continued for filing the gap of getting successful juvenile production from the larvae produced.

Grey mullet breeding at west coast was conducted by ICAR-CIBA in partnership with Mr. M. A. Nissar; Fish Farmer from Ernakulam, Kerala. Dr. K. K. Vijayan, Director, ICAR-CIBA; Shri. M.A. Nissar and Mr. Dani Thomas with hatched out larvae of grey mullet (P)

Eight DPH larvae of grey mullet (P)

Captive broodstock development of mangrove red snapper (*Lutjanus argentimaculatus*) in land based systems

A total of 47 fishes of mangrove red snapper is being maintained in 100 tonne capacity RCC tank and reached to the size range from 1.6 to 2.7 kg from the initial size of 40 g in 24 months period with the average size of 2110 g. Presence of oil globule noticed through biopsy examination during February 2018 and no matured fished observed in this stock. Maintenance of fishes is being continued.

Mangrove red snapper in broodstock tanks

Standardization of methodology for captive maturation and spawning of *Liza parsia*

Gold spot mullet, *L. parsia* is a high value food fish in India. It is catadromous in nature and needs sea water for breeding. Two separate brood stock holding RAS (10 t) were maintained, one with brackishwater (7 to 8 ppt) and other with high saline water (30 ppt). In each RAS, 25 female and 50 male were stocked. To accelerate the captive maturation, all the brood stock in both systems were implanted during the month of November with cellulose-cholesterol LHRH, a implant (@ 30 µg/Kg). In case of brackishwater RAS, salinity was gradually increased to 30 ppt in 15 days. In the month of December, 100% oozing male and mature female having oocytes diameter of 560±20 µm was noticed in brackishwater RAS, whereas only 12% of female showed maturity in high saline water. With the standardized dose of inducing hormones (pituitary gland extract @ 20 mg/Kg and human chorionic gonadotropin @20000 IU/kg) 20 breeding trials were conducted from brackishwater reared stock. Successful spawning was noticed in 15 cases; however eggs failed to fertilize. From the study it is concluded that, a primary dose of pituitary gland extract and a secondary dose of HCG for induced maturation and spawning of *L. parsia* in captivity are essential. Further it is observed that for captive maturation brackishwater is required for initial maturation and high saline water is required for final maturation of *L. parsia.* Keeping only in high saline water may not suitable for captive maturation.

Induced breeding of *Liza parsia*

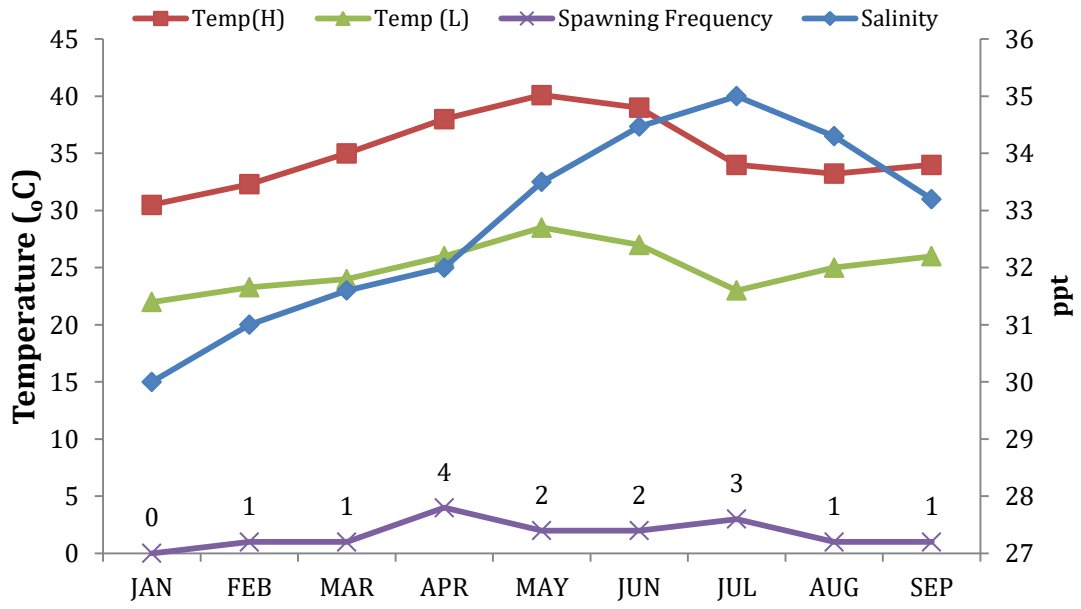
Embryonic and larval development of Hilsa

Larval development and rearing procedure of Hilsa in the tank system

Mature male and female (Female weight: 500-700 g; Male weight: 250-300 g) in sex ratio of 3:1 (male: female) were used for breeding through stripping method. Female having oocytes diameter of 750-800 µm were selected for breeding. Larvae were reared in FRP tanks for 15 days on *Chlorella,* copepod and *Artemia* nauplii and later on transferred to larval rearing pond. From the study embryological and larval development with detail ontogeny is documented.

Extended breeding of milkfish under captivity

Milkfish breeding technology has further refined, and breeding period has been extended for eight months (Feb-September) in captivity during 2017. A total of 1.39 million fertilized eggs were obtained from thirteen spawning. It has been observed that milkfish spawning is more correlated with increasing water temperature than salinity. Maximum spawning (four) was observed during April with increasing air temperature of 38^{o}C and sea water salinity of 32 ppt. Lunar cycle found to be positively influence milkfish spawning and highest number of spawning occurred 4 th day during new moon or full moon. Fry production enhanced by 4.6 times (total 1.43 lakh fry) compared to 2016 (total 31080 fry) .The fry production activities carried out in following optimum live prey feeding schedule and introducing semi-outdoor yellow colour background tanks. A total of 75000 early milkfish frys were distributed among farmers from Kerala, Goa, Gujarat, Tamil Nadu, Andhra Pradesh and West Bengal along with 2.5 lakh fertilized eggs to the private entrepreneur for satellite nursery rearing. Total revenue generated was Rs. 97500 from seed sale. Multiple spawning of milkfish extended for eight months gives the possibility to overcome challenges of year round breeding.

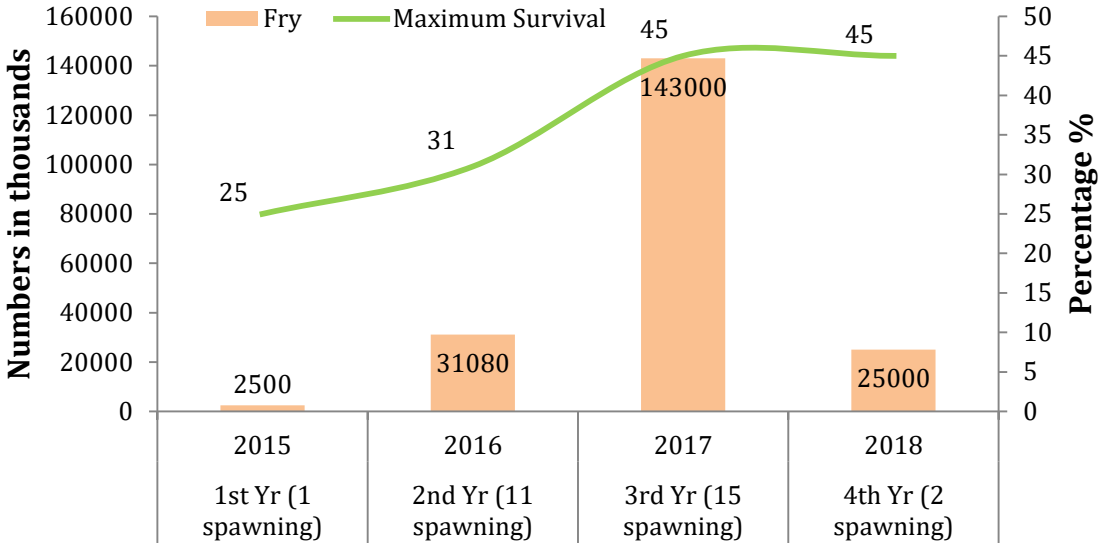


Relation of temperature-salinity on spawning frequency

Yellow colour tanks with high prey visibility enhances the foraging, growth, and survival of young milkfish larvae

Issues like mass mortality and variable survival occur often during milkfish larval rearing. Reports are scanty on use of different tank colour and strict feeding regime to improve milkfish larvae survival unlike other marine species. An experiment was designed to understand which tank background colour: white, blue and yellow under artificial and solar illumination improve foraging capacity, growth and survival. Fifteen RCC tanks (capacity, 8 t; water salinity, 32 ppt) with three different background colours, white, blue and yellow were divided in five (05) treatments groups with triplicates, i.e. indoor white (T1/C), blue (T2), yellow (T3) color tanks under artificial light and semi outdoor blue (T4), yellow (T5) colour tanks under sunlight. Newly hatched milkfish larvae (total length 3.4 mm) were stocked in the experimental tanks @ 10 no l-1. Apart from background colour and source of light, other factors such as feeding time, water exchange rate etc. was uniform in all the treatments. Phytoplankton, *Chlorella salina* @ 103 – 104 cells ml-1 were maintained from 2 dph to 20 dph; rotifer, *Brachionus plicatilis* (enriched with green algae paste Nannochloropsis oculata) were

provided @ 20-30 no/ml from 3 dph to 14 dph depending on the larval density. Artemia nauplii @ 0.5– 1.0 no/ml was introduced from 15 dph. At the end of the experiment at 20 dph, highest ($p<0.05$) larval survival (42 %) was achieved in tanks providing yellow background colour (T5) compared to control and other treatments. Larval growth (total length, 18.7± 0.94 mm) was also found to be highest ($p< 0.05$) in T5. Survival and growth of milkfish larvae gradually decrease in artificially illuminated yellow tank (T3), outdoor blue tank (T4), indoor blue tank (T2) and white tank (T1/C). The highest growth in T5 may be associated with significantly higher ($p< 0.05$) larval gut rotifer and artemia content relative to other treatments It was found that milkfish larvae being a day feeder does maximum foraging during 0700h to 1600h. Experimental data suggests that yellow background tank (T5) may be enhancing visibility and contrast of prey for milkfish larvae. Visibility enhancement during said period may be linked to enhanced foraging evident from higher gut rotifer content. Milkfish seed production in yellow colour tank may be useful for mass scale seed production.

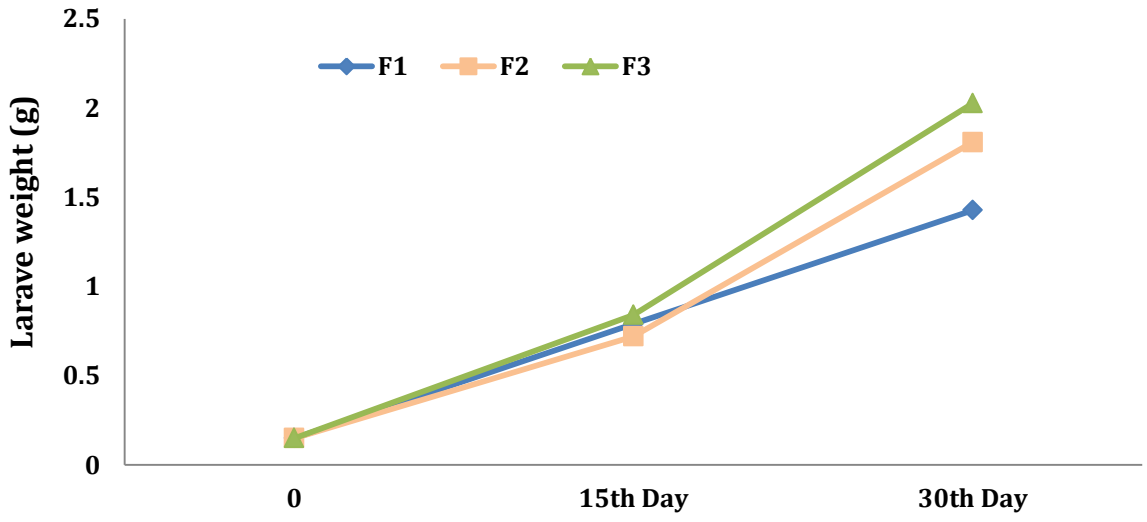


Year wise milkfish seed production

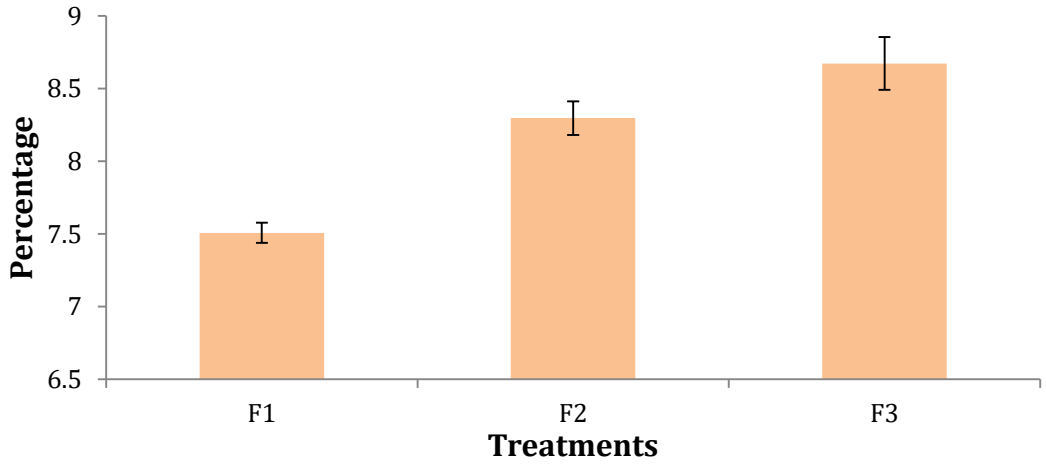
Yellow colour tanks for milkfish larval rearing

Growth performance, feed utilization efficiency and body indices of milkfish, *Chanos chanos* larvae fed with different micro-particulated feeds

A suitable micro-particulate feed is critical for attaining optimal growth and survival after weaning finfish larvae from live feeds. A 30 day feeding experiment was conducted in triplicates for testing two indigenous larval micro-diets (F1 and F2) and commercial larval feed (F3) for milkfish larval rearing. The nutritional composition of two experimental larval feeds was crude protein (CP) and crude lipid (CL); 42% and 9%, 38% and 7% respectively; the CP content of commercial larval feed was 45%. The experiment was conducted in nine circular mesh basket floated inside outdoor FRP tank (capacity, 1tonne). Milkfish larvae, 18 dph (0.15±0.05 g) stocked at a density of 100 larvae/ basket were fed at 10% body weight twice daily. At the end the feeding trail, the survival rate estimated between 90 and 95% in all the treatments.The highest final avg. body wt., total length and specific growth rate in F3 were 1.87±0.21g, 7.5±1.2 cm, 8.67±0.36 respectively, followed by F2and F1. Feed efficiency (FE) and protein efficiency ratio (PER) were similar among the different treatments. The feed conversion ratio (FCR) showed significant effects ($P < 0.05$) in relation to the feed treatments. A better FCR (0.78) was observed in F1 which had 38% protein and it was higher (1.1) in feed F1 which had 42% protein. The hepatosomatic index (HSI) and visceral somatic index (VSI) values increased with the decreasing dietary protein and lipid level. Significantly higher ($P<0.05$) crude lipid content (13.4%) was observed in the milkfish fry that were fed with F3 diet than that of other treatments. Although, a higher feed conversion was obtained with the commercial feed (F3) as compared to indigenous larval feeds (F1 and F2), the overall growth performance was observed superior with indigenous micro-particulate feeds. The relatively lower feed cost and higher growth performance observed in indigenous larval feeds indicate that it is a potential alternative to commercial feed for larval rearing of milkfish.



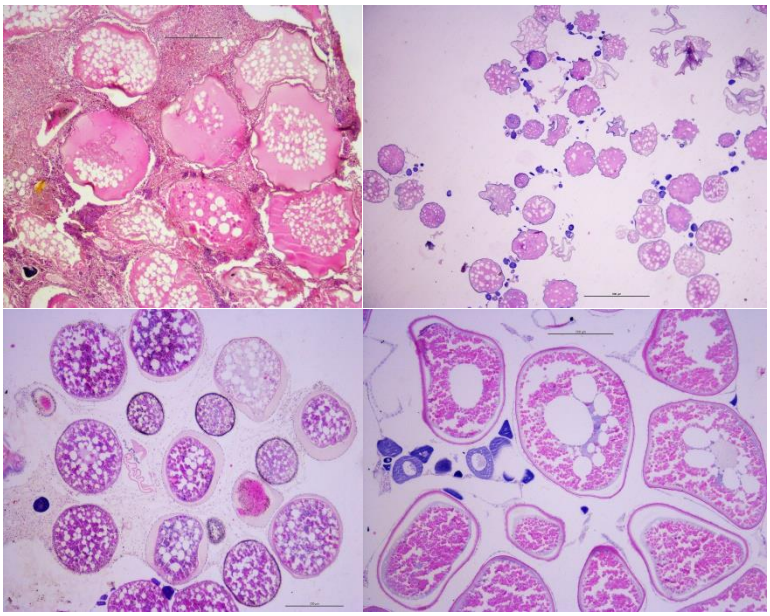
Growth of milkfish larvae fed with different micro-particulated feeds

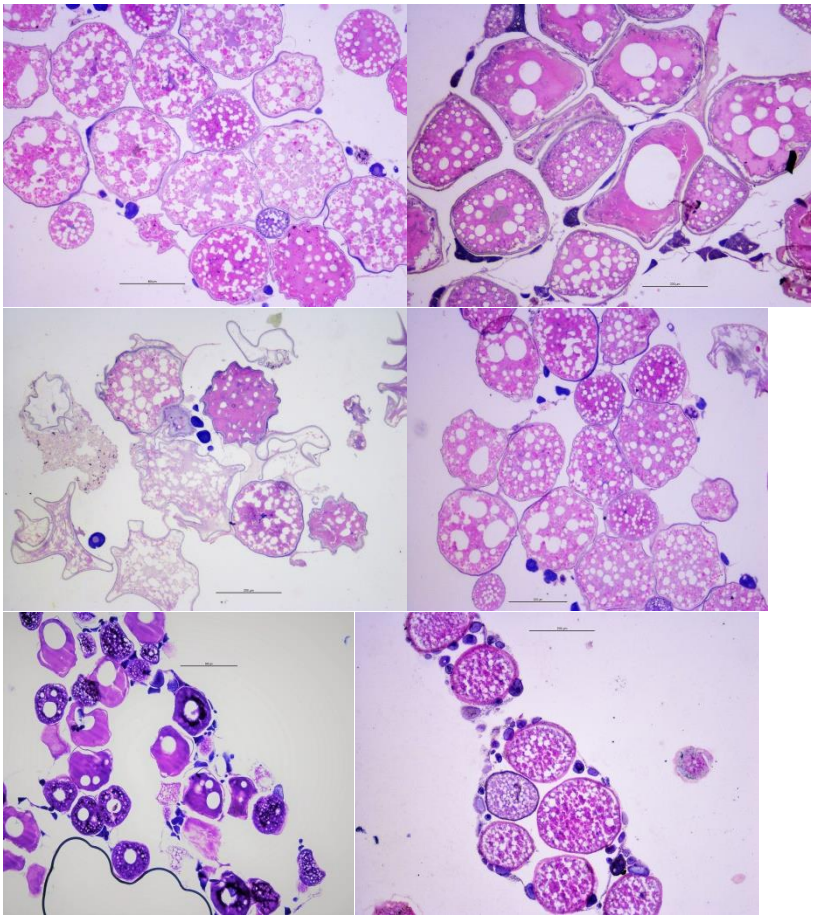


Feed utilization of *Chanos chanos* larvae feed with different micro particulated feed

Domestication and year round maturity status of spotted scat under captive condition

Spotted scat brood stock in pond-based systems was refined. Year round maturation profiles of adults in stock were monitored monthly. Mature fishes of both sexes were reported from April to November months where highest (28 %) milting males were found during June and the highest 33% of mature females (Tertiary yolk stage Oocytes) were found during August. Environmental parameters such as water salinity and water temperature were at peak of 31 ppt and 32° C during June & July respectively. Longest day length hour of 12.5 was recorded in the month of June. Each month biopsy samples of oocytes were collected and stored for histological preparation which revealed different phases of maturation during different months. Successful spawning was achieved during May – November months with highest fertilization (25.9 %) and hatching (70 %) percentage in August. A total of 21,639 fries were produced this year.





Monthly oocytes maturation stages of Female Spotted Scat

Monthly spawning and seed production profile of spotted scat in captive condition

Months	Female (g)	Absolute fecundity	Relative fecundity	Oocyte diameter (mm)	Fertilization (%)	Hatching (%)
May	256.5	127265	716.98	411.18	13	65
June	228.75	184652	1060.77	487.21	15.7	67
July	239.17	194652	844.47	473.31	24	60
August	273.14	212628	786.05	496.65	25.9	70
September	210	186866	725.69	460.81	22	50
October	263.66	147713	749.81	485.76	20.76	30
November	226.63	158880	762.01	420.30	10	20

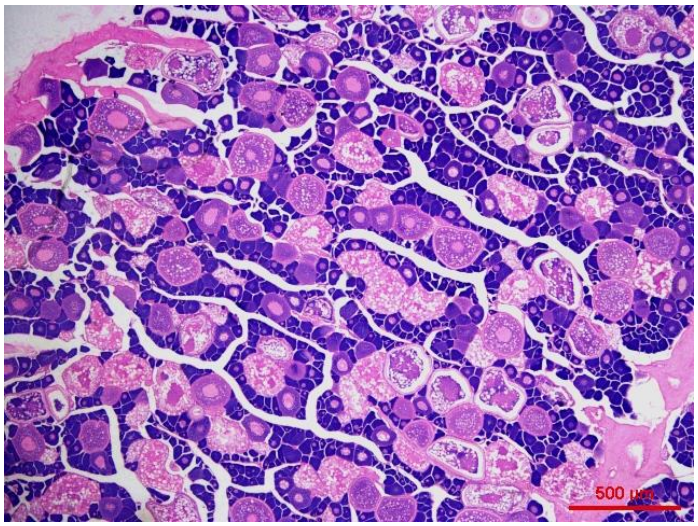
Broodstock development of silver moony, *Monodactylus argenteus*

A total of 200 wild caught juvenile *Monodactylus argenteus* were maintained to brood size in net hapas with the participation of the fishermen of Venangupattu village, Kanchipuram district, Tamil Nadu. During the rearing period, fishes were fed with feed developed by CIBA. The fishes were reared up to 60- 70gm size, and 110 fishes were transferred to the hatchery site and stocked in 2x1x1 net cages for captive maturation and breeding experiments. Monthly sampling was conducted to assess the health and maturity. Milting males could be observed during December, 2017 to April, 2018. Histological examination of the gonadal tissue indicated that, the females were found to be in different stages of developing oocytes and it resembles like ovary of a batch spawner.

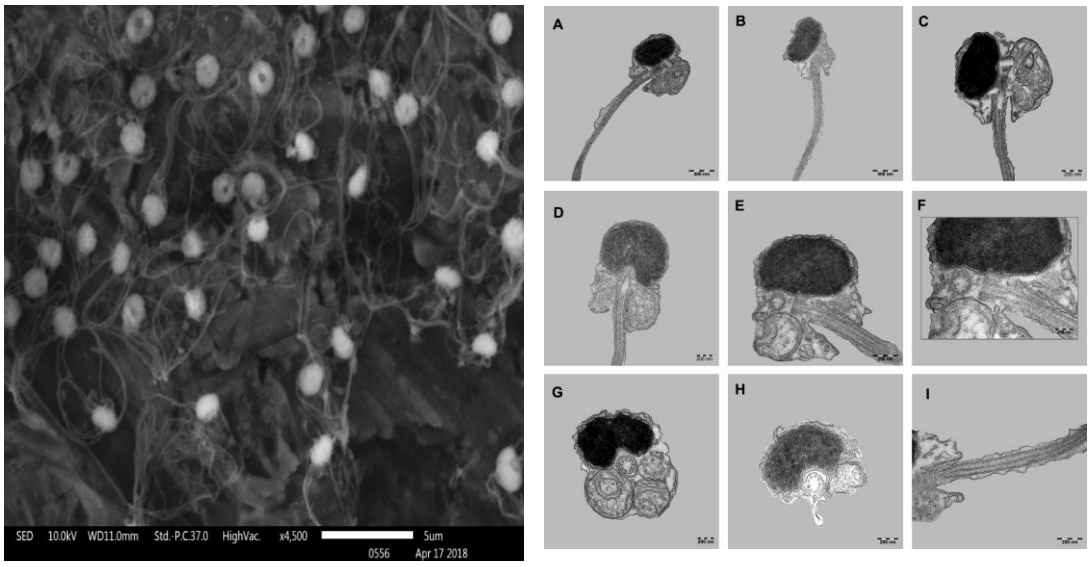
***Monodactylus argenteus*, a potential brackishwater ornamental fish**

Spermatological parameters and seminal fluid chemical composition of *M. argenteus*

Parameters		Mean	SE
Sperm volume (µl)		20	10
Density (x 10^9/ml)		7.75	3.25
Total number of spermatozoa		18.75	14.25
Motility (%)		80	15
Osmolality (mOsmol L^{-1})	Seminal fluid	363	13
	Seminal plasma	73.5	3.5
Sodium (mML^{-1})		25.45	0.85
Potassium (mML^{-1})		2.46	0.23
pH		7.7	0.1



Histological cross-sections of the *M. argenteus* ovaries with different stages of development



A, B & C) Longitudinal section of sperm showing elongated nucleus with axial nuclearfossa which contains the cetriolar complex, D, E, F) Cross section of head and mid-piece, G & H) Mitochondrion ring and 9+2 axonemal doublet, I) Cross section of flagellum with side fins

Scanning electron microscopy and transmission electron microscopy study of sperm cells in *Monodactylus argenteus*

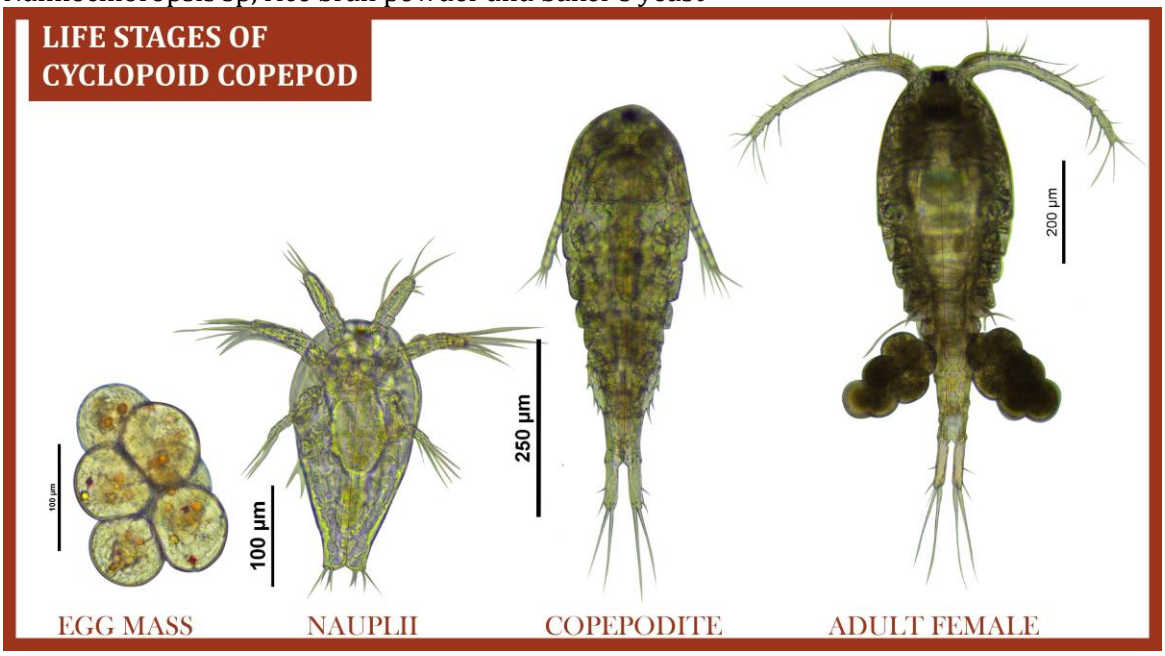
Induced breeding and seed production of crescent perch

Mature male and female fishes were collected from Bay of Bengal, Ennore, Chennai and acclimatized to captive condition for a 6 months under flow through system. To assess the maturity, female fishes were cannulated and male were gently pressed near the vent. Female having the oocyte diameter more than 460 µm were selected along with the oozing male. Three breeding set was arranged, and in each set 2-male and one female was introduced. From the three sets two set were administered with hCG@300 IU/Kg and other one set were with LHRHa @ 70 µg/kg, and males were given half the dose. After 36 h of post injection LHRHa injected set was spawned and embryo was semi-buoyant in nature, and after 16-18 h of incubation hatching was observed. After 12 h of post hatching concentrated algae (*Nanochloropsis aculeata)* were introduced in the rectangular larval rearing tanks @ 20 lit/400 lit and after 48 h rotifer, *Brachionus plicatilis* feeding was started. Fifty thousand larvae of Crescent Perch were estimated

Fertilized eggs and newly hatched larvae of Crescent Perch, *Terapon jarbua*

Culture of Cyclopoid copepod using combination of micro algae and yeast

An experiment was conducted for the culture of cyclopoid copepod isolated from Adyar creek using combination of microalgae and yeast for a period of 20 days in test tube. The study was conducted to find the best combination of microalgae as diet in order to produce the maximum number of copepod nauplius with a minimum period of time. The microalgae fed at the rate of 30000-35000 no/ml. Newly hatched copepod nauplii matured within 7-16 days depending up on the combination of microalgae given as feed on daily basis. Salinity tolerance was observed between 5-40 ppt and size of the nauplius (Nauplius I- VI) is in the range of 73.2-265.3µm. Size of copepodite (Copepodite I-V) is observed in the range of 272.5- 668.7µm. Copepodite VI (Adult) is observed in the range of 670- 1012.5µm. Average fecundity was 20 (Range 12-45). Mass culture of copepod was carried out in 500 litre tanks fed with combination of microalgae, baker's yeast and rice bran. Highest density was observed i.e. 1500- 4500 no/litre within 14 days using combination of Nannochloropsis sp and Isochrysis sp, Chaetoceros sp and Nannochloropsis sp, rice bran powder and baker's yeast

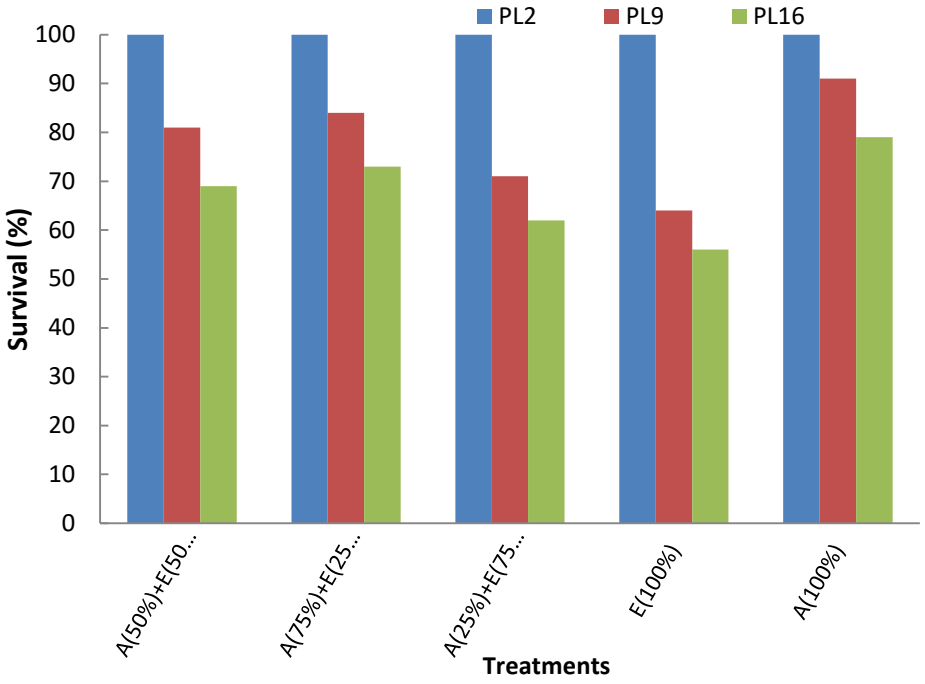


Experiment on frozen crab zoea, Cyclopoid and *Artemia* nauplii as feed for post larvae of *P. indicus*

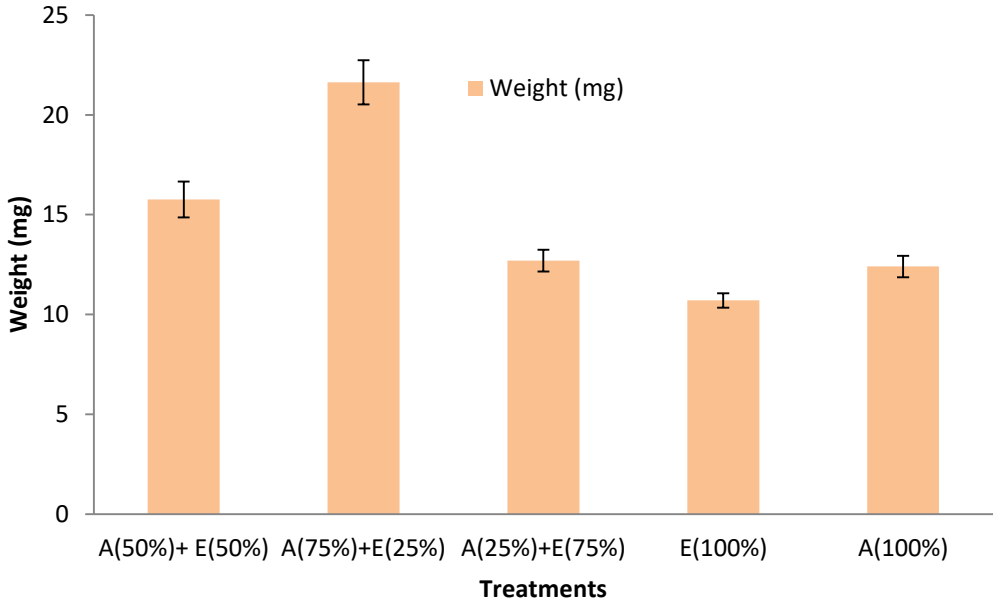
An experiment was conducted to check frozen crab zoea, copepod and artemia nauplii as feed for post larval stages of *P. indicus*. Post larvae was stocked at a rate of 100 number per 20 L tub, and fed with frozen crab zoea, cyclopoid and Artemia nauplii at the rate of 5 number at a time twice in a day and water exchanged on daily basis for a period of 15 days. Highest survival of post larvae was observed in the treatment fed with Artemia naupli (92%) followed by Copepod nauplii (82%) and Frozen crab zoea (72%). Copepod nauplii (73-350 µm) can be taken as feed which is comparatively less compared to treatment with Artemia nauplii due to its fast jerking movement. In most mud crab hatcheries only less than one million zoea are used for rearing and remaining are unused. These unused larvae could be used for rearing of shrimp as an alternative to *Artemia* nauplii

An experiment was conducted using cladoceran species which was collected from the Adayar creek for the complete or partial replacement of artemia nauplii during the post larval 2 stages of *P. indicus*. This species was mass cultured using different combination of diet and found that highest diversity was observed at 30ppt salinity within 7 days fed with chicken manure and chlorella sp (4000-5500 nos/litre) A feeding experiment was

conducted in 20 litre tubs for a period of 14 days and the post larvae of *P. indicus* was fed with artemia nauplii and cladoceran species at the rate of 4-6 nos/ individual thrice in a day with daily exchange of water. The overall result found that survival of post larvae was higher (79%) in treatment with A(100%) compare to other treatment but weight of post larvae was higher in the treatment with A(75%) + E(25%) followed by A(50%) + E(50%). There is a significant difference in weight of post larvae between control and A(75%) + E(25%). The results conclude that partial replacement of artemia nauplii were possible using the cladoceran species (upto 50%) during the post larval stages of *P. indicus*



Survival of *P. indicus* post larvae fed different live feed



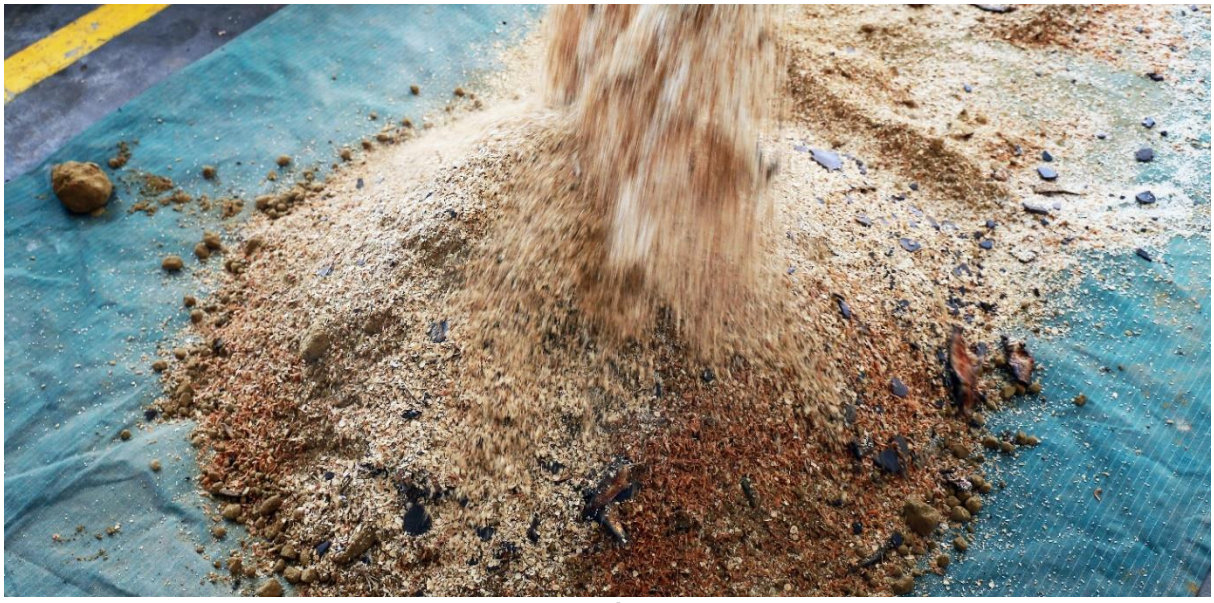
Growth performance of *P. indicus* post larvae fed different live feed

NUTRITION AND FEED TECHNOLOGY

In aquaculture, feed and its management continue to be the major recurring cost, which often ranges from 40 to 60 % of the total cost of production and a key factor in determining the profitability to the farmer. India's aqua feed sector was more vibrant with current production around 2 million metric tons of feed, and it is expected to grow geometrically in coming years. Our dependency on overseas companies for the hatchery feeds continues and it creates a pressure on the hatcheries in producing quality seeds in a cost-effective way. Envisaging these situations, CIBA's nutrition research focus more on issues directly applicable to the stakeholders such as cost-effective grow-out feeds, indigenous hatchery feed technology, live feed, feed management options considering natural feeds etc.

Evaluation of newer feed ingredients for use in aquafeeds

Feed ingredients are drivers in determining the quality and price of the feed. Having more choice of ingredients in the feed basket will assure a stable feed price irrespective of volatile ingredient prices. India being an agri based economy, there are hundreds of agriculture byproducts and terrestrial byproducts available for use in aqua feeds. CIBA continue bringing in more and more potential ingredients to feed basket with an aim for cost-effective feeds for brackishwater candidates.



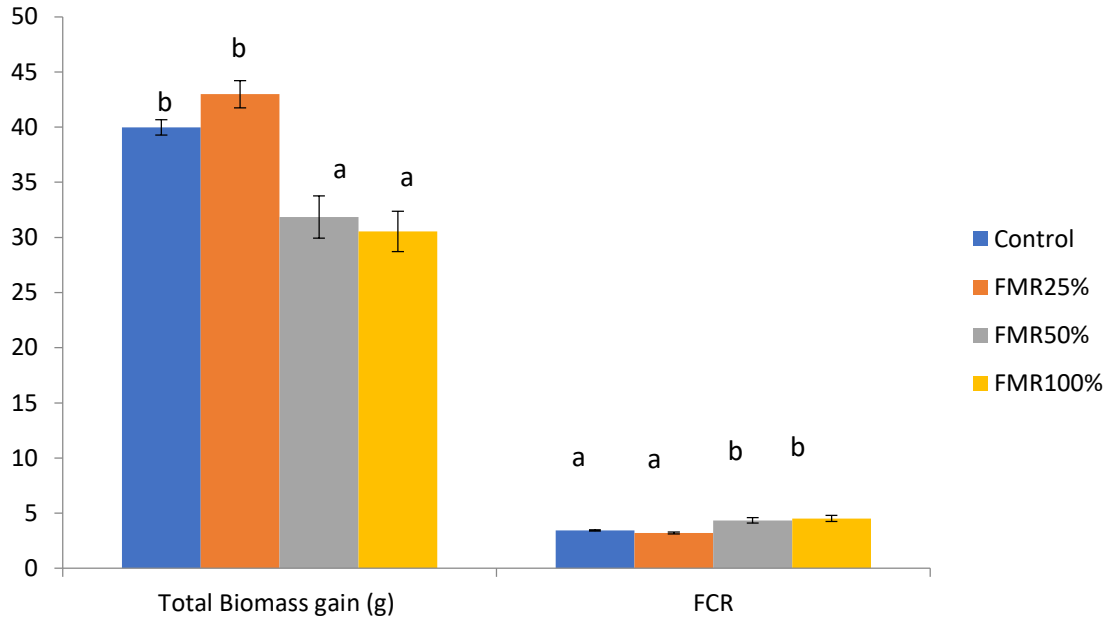
Indigenously sourced feed ingredients in Vanami*Plus* formula is mixed manually

Rice gluten as an alternate for soybean meal in the diet of shrimp, vannamei

Rice Gluten (RG), a byproduct of rice, with a protein content of 60.0% has been identified as a novel protein ingredient source and explored for its nutritional value in the diet of shrimp. Amino acid profiling revealed its richness in Lysine (2.65%) and Methionine content. An experiment for 60 days was conducted in vannamei juveniles to study the effect of replacement of, soybean meal, a very common plant protein source widely used in shrimp feeds. RG was included at 10,15,20,25 and 30% replacing hi-protein soya on (W/W) basis in the shrimp diet. The results indicated that RG could be effectively used up to 20% in the vannamei diet.

Dried distillery grain with soluble (DDGS) as an ingredient in polyculture feed replacing high priced ingredients

Indoor experiment was carried out to study the potential of dried distillers grain with solubles (DDGS) in replacing fish meal in polyculture feed with an objective of further reduction of feed cost for species composition of *Mugil cephalus, Liza parsia, L.Tade, Scatophagus argus, Mystus gulio* and *Penaeus monodon* in the ratio of 1:1:1:1:3:1 respectively. The experiment revealed that when 25 % fish meal was replaced with DDGS, there was no difference (P>0.05) in biomass gain and FCR when compared with control. When 50 and 100% fish meal was replaced biomass gain was significantly (P<0.01) lower and FCR was higher as compared to control. Therefore, it can be concluded that DDGS can replace 25% of fish meal, 30 % sunflower cake and 11.25 % mustard cake in polyculture feed without affecting the production performance.



Effect of fish meal replacement with DDGS on biomass gain and FCR

Fermented rape seed meal as a feed ingredient for Indian white shrimp *Penaeus indicus*

The inclusion level of rape seed meal (RSM) is very limited (2.5%) in shrimp diets due to its high fibre fractions (10%) and antinutritional factors like glucosinolates, tannins and phytic acid. The solid-state fermentation offers several economical and practical advantages to the agricultural by-products by enriching their nutritional quality and also reducing the antinutritional factors. The RSM was fermented with *Aspergillus niger* for three days. The fermentation has significantly (P<0.05) reduced glucosinolates, tannins and phytic acid from 3.13, 8.89, 27.4 to 1.28, 5.09 and 8.97, respectively. Both unprocessed and fermented RSM were incorporated at 0, 2.5, 5, 7.5 and 10% in the diet by replacing fish meal. The experimental feeds were tested in *P. indicus* juveniles (2.6g) in a 45-day feeding trial. The weight gain % was significantly (P < 0.05) higher in shrimp fed with diets having fermented ingredients compared to raw ingredients at all inclusion levels. The results indicated that incorporation could be increased up to 7.5% by using fermented RSM in *P. indicus* diet compared to 2.5% with raw RSM.

Effect of incorporation of fermented RSM on growth and nutrient utilization in

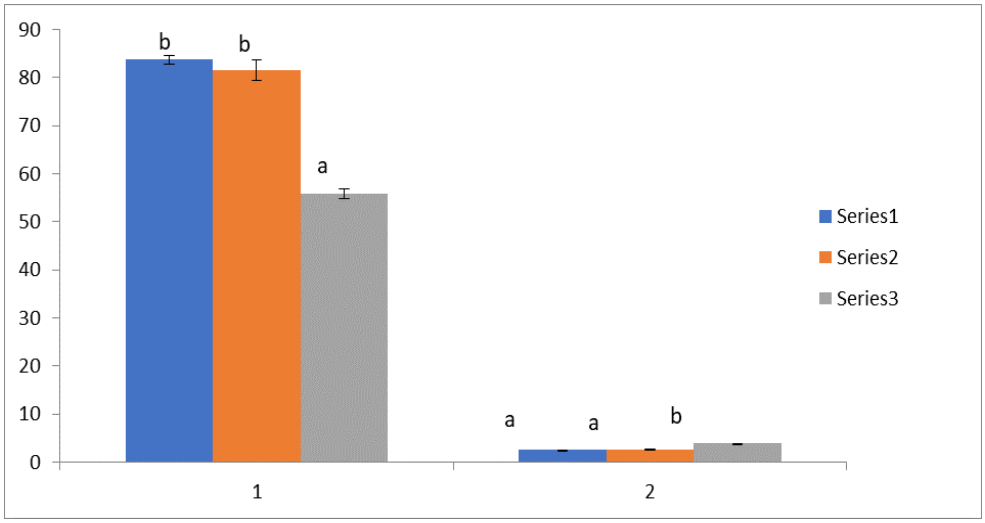
	Control	2.5%		5.0%		7.5%		10%	
		RSM	FRSM	RSM	FRSM	RSM	FRSM	RSM	FRSM
SGR	2.43^{a}	2.49^{a}	2.41^{ab}	2.37^{ab}	2.39^{ab}	2.14^{cd}	2.32^{abc}	2.02^{d}	2.06^{cd}
DGC	1.43^{ab}	1.46^{a}	1.47^{a}	1.38^{abc}	1.40^{ab}	1.26^{bcd}	1.35^{abc}	1.16^{d}	1.20^{cd}
Survival (%)	91.11	91.11	91.11	91.11	80	86.67	86.67	86.67	91.11

Penaeus indicus

Dried fish silage powder as an ingredient in polyculture feed

The indoor experiment was carried out to study the potential of fish silage in replacing fish meal in polyculture feed with an objective of further reduction of feed cost. A 42 days experiment was conducted with juveniles of *Mugil cephalus* (2 nos), *Liza parsia* (2 nos), *L.Tade* (2 nos), *Scatophagus argus* (2 nos), *Mystus gulio* (6 nos.) and *Penaeus monodon* (2 nos) per replicate and were stocked in fibre reinforced plastic (FRP) tanks containing 600 liter strained clear brackish water with continuous aeration. Experiment revealed that when 50 % fish meal was replaced with fish silage there was no difference ($P>0.05$) in biomass gain and FCR when compared with control. When 100% fish meal was replaced biomass gain was significantly ($P<0.01$) lower and FCR was higher as compared to control. Therefore, it can be concluded that dried fish silage powder can replace 50% of fish meal, 20 % sunflower cake and 5 % mustard cake in polyculture feed without affecting the production performance.

Dried fish silage powder



Effect of fish meal replacement with fish silage powder on biomass gain and FCR

Nutritional value of fermented ingredients in combinations as alternates for fishmeal in diets of Pacific white leg shrimp, *Penaeus vannamei*

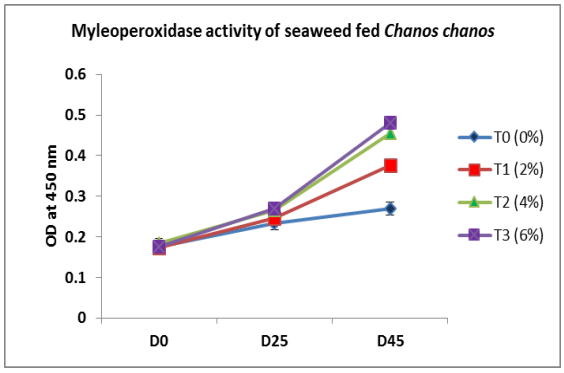
In our earlier studies, the effect of utilization of fermented ingredients was studied individually and the maximum level of inclusion of was determined. The results revealed that the *Aspergillus niger* fermented ingredients like soybean meal, groundnut oil cake, rapeseed meal and sunflower oil cake could be used up to 15 (in addition to the 20% in control diet), 10, 7.5 and 5%, respectively. Based on the level of inclusion and dry matter digestibility, three fermented ingredients viz., groundnut oil cake, rapeseed meal and sunflower oil cake were mixed in the combination of 6.3:4.8:2.5, respectively and the four fermented ingredients viz., soybean meal, groundnut oil cake, rapeseed meal and sunflower oil cake were mixed in the combination of 13.7:6.3:4.8:2.5, respectively. Three ingredient combinations were used to replace fishmeal at 0, 30, 40, 50 and 60% levels and four-ingredient combinations were used to replace fishmeal at 0, 50, 60, 70, 80 and 90% levels. These diets were evaluated in a 45-day growth trial in *Penaeus vannamei*. The three fermented ingredient combinations were able to replace 30-40% of fishmeal whereas four fermented ingredient combinations were able to replace up to 70% of fishmeal.

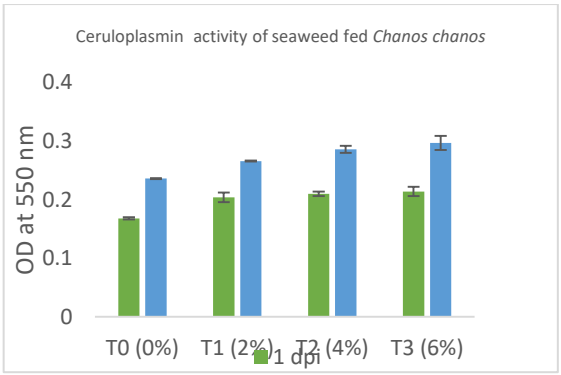
Effect of graded fishmeal replacement using combinations fermented ingredient mixture on performance and nutrient utilization in *Penaeus vannamei*

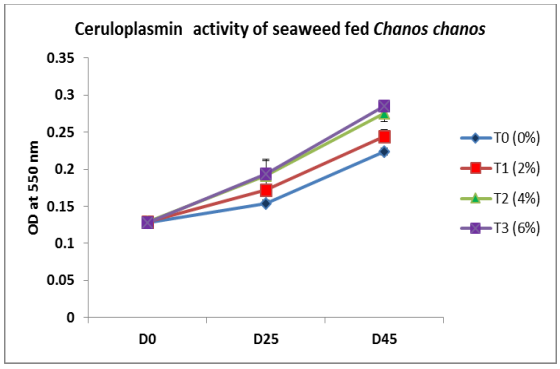
	SGR	DGC	Survival (%)	FCR	PER	APU
Control	2.28^{a}	1.37^{a}	93.33	1.82^{c}	1.38^{a}	22.86^{ab}
50%	2.27^{a}	1.37^{a}	93.33	1.78^{c}	1.46^{a}	23.78^{a}
60%	2.26^{a}	1.35^{a}	95.56	1.86^{c}	1.37^{a}	22.26^{ab}
70%	2.23^{a}	1.32^{a}	93.33	1.88^{c}	1.36^{a}	21.37^{b}
80%	2.02^{b}	1.18^{b}	95.56	2.17^{b}	1.21^{b}	19.45^{c}
90%	1.75^{c}	1.00^{c}	95.56	2.65^{a}	0.98^{c}	15.64^{d}

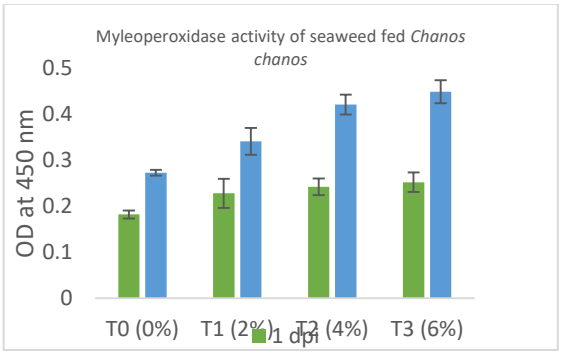
Seaweed as a growth and health promoting feed additive in milk fish (*Chanos chanos*) fingerlings

Among the commonly available seaweeds, *Enteromorpha intestinalis* was found to contain highest protein (CP-19.04%) as compared to *Catenella repens* (CP-8.49%) and *Ulva lactuca* (CP-5.25%). *E. intestinalis* has antioxidant property which helps to enhance immunity. A forty-five days feeding trial was conducted to study the effect of seaweed supplementation Control (T0), 2% (T1), 4% (T2) and 6% (T3) on growth and health of in the in milk fish fingerlings. The group fed 4% (T2) recorded highest weight gain followed by T3. Similarly, a better FCR (1.13) was observed in T2 compared to rest of the diets. Ceruloplasmin level increased significantly with increased percentage of seaweed supplementation in the diets. The Myeloperoxidase activity levels of milk fish increased significantly ($P < 0.05$) with increase in days of feeding with seaweed. The results suggest that seaweed (*E. intestinalis*) can be used at 4% of feed as additive in milkfish for enhancing the immunity of milk fish fingerlings.









Non-specific immune parameters of fish supplemented with different percentage of seaweed

Demonstration of practical feeds developed by CIBA in farmers places

Vanami*Plus*

As addition to the series of demonstrations completed, a demonstration of Vanami*Plus* feed was carried out in Ernakulum, Kerala in collaboration with CMFRI. About 1,00,000 Post larvae of *P. vannamei* stocked in one acre pond owned by, Mr. Josey Jacob and fed Vanami*Plus* feed throughout the culture as per the guidelines given by CIBA. The shrimps attained an average body weight of 24.5 g at 72 days of culture, with a production of 550 kg.

Broadcasting of Vanami*Plus* in demonstration pond in Kerala

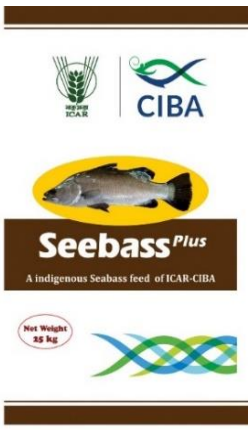
Seebass Nursery *Plus*

Nursery rearing is the critical link in seabass farming where in provision of apt feed is the significant element which determines the success of seabass farming. Considering this essentiality CIBA developed a speciality nursery feed, and branded Seebass Nursery *Plus*. The performance of this feed has been demonstrated in a farmer's pond using hapas at Atiramapatinam near Pattukkottai. About 22,000 seabass fingerlings of 5 to 7 g size were stocked in hapas and the nursery rearing was carried out for 90 days. During the entire nursery pahse CIBA seabass Nursery Plus was fed to satiety at three feeding frequencies. A survival of 95% was achieved with the final average body weight varying from 50 to 200 g at the end. The juveniles were transferred to grow-out pond for further rearing.

Nursery rearing of Seabass using Seebass Nursery *Plus* in battery of cages installed inside the pond

Seebass*Plus*

Lack of an indigenously manufactured cost-effective seabass feed is another missing element in expansion of seabass farming in India. A cost effective, indigenous feed developed by CIBA specially for cage farming of seabass, and branded as Seebass*Plus* . Its performance has been demonstrated in a three tier cage farming model with appropriate feeds for the respective life stages in partnership with an inland fisher group. A slow sinking feed costing around ₹ 80 to 90/ kg was formulated to contain 42-48% protein and 13% of lipid. The final standing biomass during harvest was 15 kg /m^3. In grow-out phase, the juveniles were grown to a marketable size of 900 g - 1.25 kg in 6 months. A productivity of 460 kg was realised with an average Feed Conversion Ratio (FCR) of 1.85:1. A unique feed management strategy, algivorous Rabbit fish (*Siganus javus*) were stocked as supporting species for keeping the cage mesh clean. By consuming the macro algae and uneaten feed an additional fish biomass of 30 kg Rabbit fish was realised. We demonstrated the feasibility of seabass farming using indigenously formulated feed as a farming option in open brackishwaters.



Seebass*Plus*

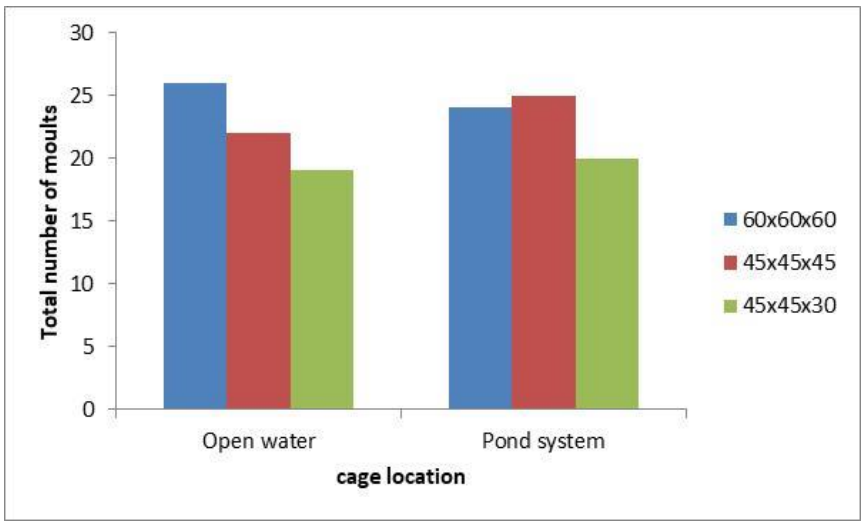
Crab feed (Scylla*Plus*) in recirculating aquaculture system (RAS)

A formulated compressed pellet feed was tested in an indoor RAS system specially engineered for crabs at Avanigadda, Krishna district, Andhra Pradesh. A total of 54 crab holding containers (9 columns x 4 rows) were stocked individually with mud crab *Scylla serrata* 200 g. The crabs were fed with a 4.5 mm **Scylla*Plus*** having 36% crude protein 6.5% ether extract. At the end of 4 weeks 22% of the crabs showed moulting and 93 % of the crabs survived.

Indoor mud crabs rearing facility where the feeds were tested

Comparative growth performance of mud crabs, *Scylla serrata* using individual cages installed in open water and pond systems

Crab is a high value seafood finds a good demand both international as well as in national markets. The culture trials in ponds have indicated lower survival due to the cannibalism and escape because of its burrowing habitat of *Scylla serrata*. Optimization of rearing system along with good feed and its management strategies specific to rearing system is very much required. We did a comparative grow out trials in ponds as well as in open waters using galvanised cages. In order to increase the survival, sixty galvanized cages were fabricated into three size groups viz., 60x60x60, 45x45x45 and 45x45x30 cm. Thirty cages were placed in open water Krishna River and other thirty cages were kept in adjacent brackishwater pond system in Nagayalanka. The initial average size of the stocked crabs was 200g. After 160 days of culture, 80% of crabs survived. The crabs which have moulted three times have attained >750g, i.e., XXL size which fetches maximum price. The size of the cage is having significance ($P<0.05$) influence both on the number of moults and number XXL sized crabs harvested. In open water system, the cages having 60x60x60 cm had better performance whereas in the pond system the better performance was observed in 45x45x45 cm cages.



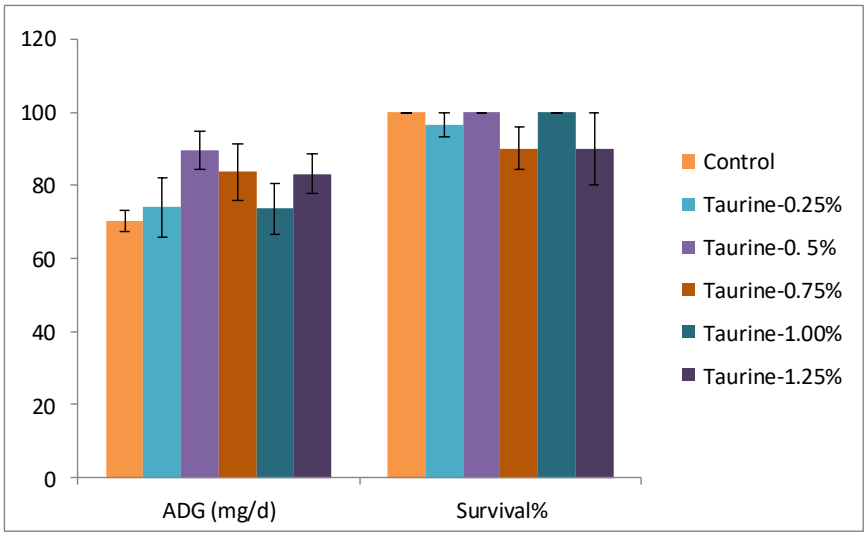
Effect cage size in number moults observed in mud crab, *Scylla serrata*, reared in open water and pond system of culture

Feeding of mud crabs reared in bottom cages

Optimization of nutrient requirements

Refining of Seabass larval diet with taurine supplementation

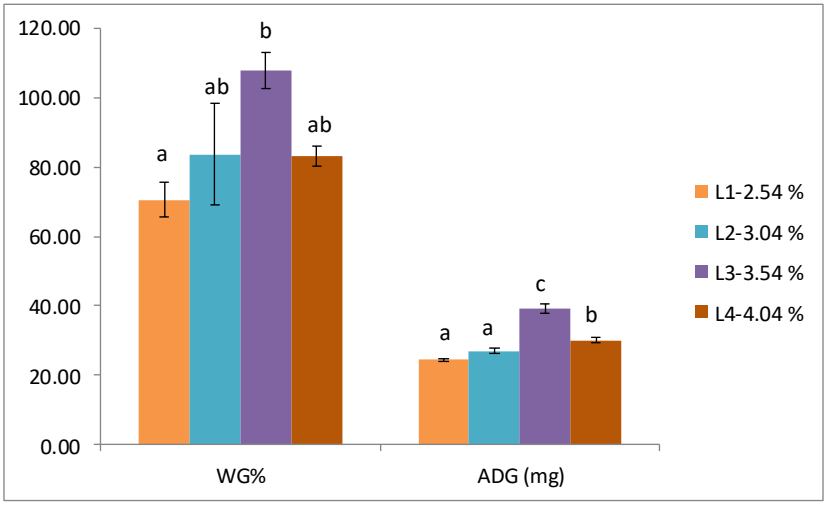
Larval feed of Asian seabass was prepared with varying level of taurine i.e., 0, 0.25, 0.5, 0.75, 1.0 and 1.25 %. All the feed were isoproteinous and isolipidic. Asian seabass larvae (Av. Body wt. 0.497 g) were randomly distributed in glass tanks (90 L water each) of recirculatory aquaculture system (RAS) @ 40 larvae per tank and the feeding trial was carried out in triplicate for 6 weeks. Average daily gain, Weight gain percent, specific growth rate were higher and FCR was lower in seabass supplemented with 0.5 % taurine. No difference in survival was observed in seabass supplemented with varying level of taurine. Experiment revealed that 0.5 % taurine supplementation was found to be optimum in diet of seabass larvae.



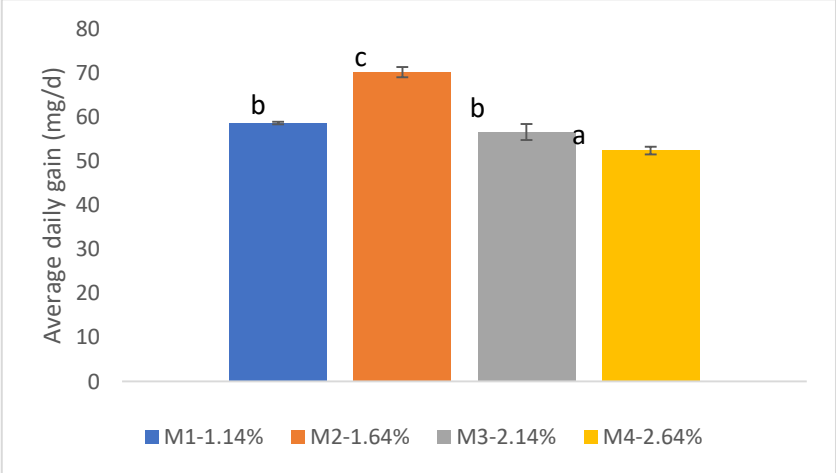
Effect of taurine supplementation on average daily gain and survival of seabass larvae

Methionine and lysine requirement of hilsa fry

Methionine and lysine graded level of lysine and methionine revealed that average daily gain was higher (P<0.01) in hilsa fry fed with 3.54 % lysine and 1.64 % of methionine. FCR was lower (P<0.05) and PER and SGR were higher (P<0.05) in hilsa fed with 3.54 % lysine. FCR was also lower (P>0.05) in hilsa fed 1.64 % methionine. Results of the experiments indicated that optimum lysine and methionnine requirement of hilsa fry is 3.54 % and 1.64 % of feed DM.



Growth performance of hilsa fry with varying level of lysine in diet

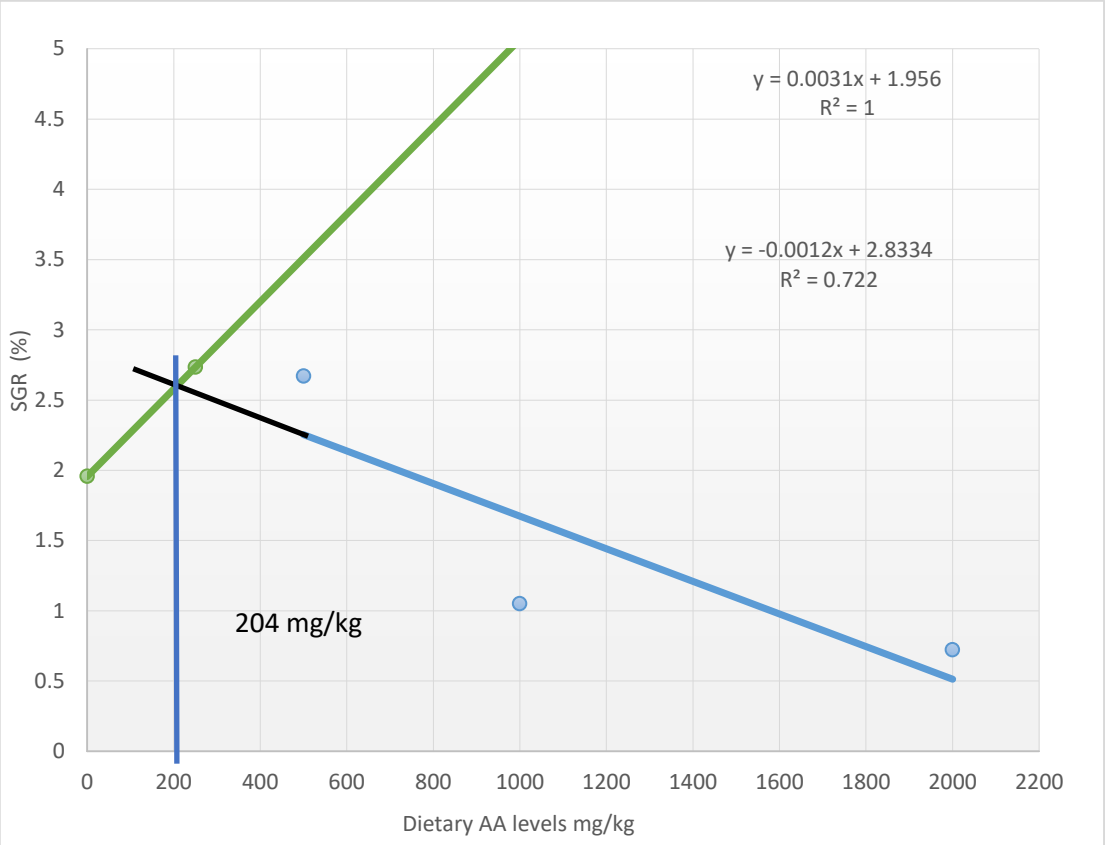


Growth performance of hilsa fry with varying level of methionine in diet

Optimum dietary vitamin- C for better growth and survival of milkfish, *Chanos chanos* larvae

Vitamin C is an important nutrient in fish larval feed and fish larvae are extremely sensitive to vitamin C deficiency. A forty five-day study was conducted to examine the effect of dietary ascorbic acid (AA) levels on the growth of milkfish, *Chanos chanos* larvae. Five iso-nitrogenous and iso-energetic (550 g protein per kg and 70 g lipid per kg) experimental basal diets were prepared with different levels of ascorbic acid such as control (0), T_1 (250),T_2 (500), T_3 (1000) and T_4 (2000) mg ascorbic acid (L-ascorbyl-2-polyphosphate) equivalent per kg diet. Milkfish larvae (ABW 9.64 mg) were stocked (hundred larvae per tank) in triplicates following a completely randomized design. The results revealed that milkfish fed 250–500 mg/kg of vitamin C was optimum in realizing a better growth performance and survival. On the other hand, the milkfish larvae fed above

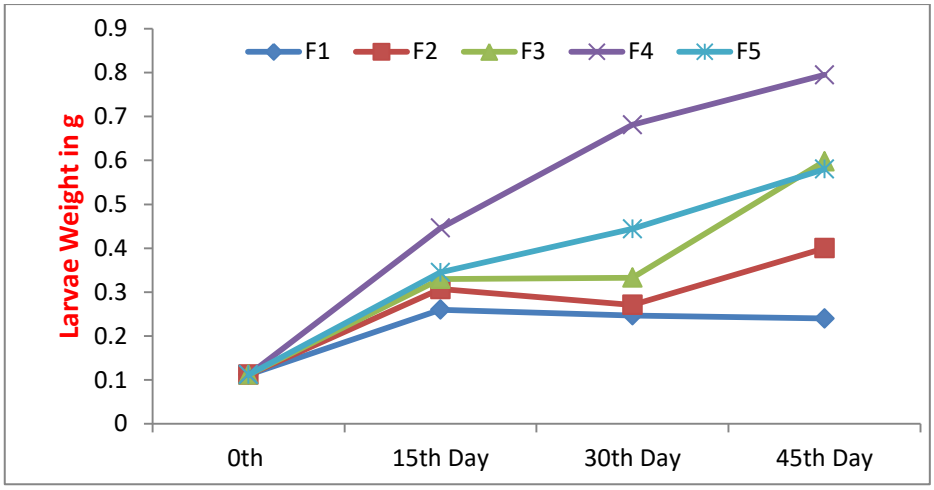
1000–2000 mg/kg showed a poor growth performance and survival. Broken-line regression analysis revealed that the dietary vitamin C requirement for the growth of *C. chanos* larvae was estimated to be in the range of 183–204 mg ascorbic acid per kg. The results will be helpful for the formulation of cost-effective ascorbic acid incorporated diets for milkfish, *C. chanos* larvae.



Estimation of dietary vitamin C requirement for growth of *C. chanos* larvae using broken-line regression analysis

Dietary fish oil and lecithin ratio on growth performance, survival and fatty acid composition of milkfish (*Chanos chanos*) larvae

The influence of five different ratios of fish oil (F) and lecithin (L) on growth and survival of milkfish, *Chanos chanos* larvae (0.112g), was evaluated in a 6-weeks experimental trial. Fish oil was gradually replaced with lecithin F1 (F100/L0), F2 (F75/L25), F3 (F50/L50), F4 (F25/L75) and F5 (F0/L100) in each treatment. A 30 day feeding trail was conducted in in triplicate following a completely randomized design. The results revealed that milkfish larvae fed F50/L50 and F25/L75 ratio of fish oil and lecithin showed highest ($P < 0.05$) growth performance and survival rate. *C. chanos* fed with F50/L50 and F25/L75 ratio of fish oil and lecithin diets achieved significant ($P < 0.05$) improvement in growth performance and muscle biochemical compositions while milkfish fed with F25/L75 showed enhanced performance. Diet fatty acid composition was affected by phospholipid incorporation, dietary n − 3 HUFA concentration decreasing with the incorporation of PL. The growth and survival of milkfish was positively related to the dietary PL concentration.



Pattern of growth in milkfish larvae fed feed F1 (F100/L0), F2 (F75/L25), F3 (F50/L50), F4 (F25/L75) and F5 (F0/L100)

Optimization of lipid requirement of *M. gulio* fry

A 42 day's feeding experiment was conducted to evaluate dietary fat requirement of *M. gulio* (ABW 1.05 g) Five practical diets containing five graded levels of fat (3%, 6%, 9%, 12% and 15%) with 25 % protein were fed to *M. gulio* fry. The experiment was conducted in 100 l FRP tank with five treatments and three replicates containing ten *M. gulio* fry in each. It was found that 6% dietary fat with 25 % protein is optimum. Body composition didn't show any difference with different level of fat in the diet.

Performance *M. gulio* fed different level of fat in diet

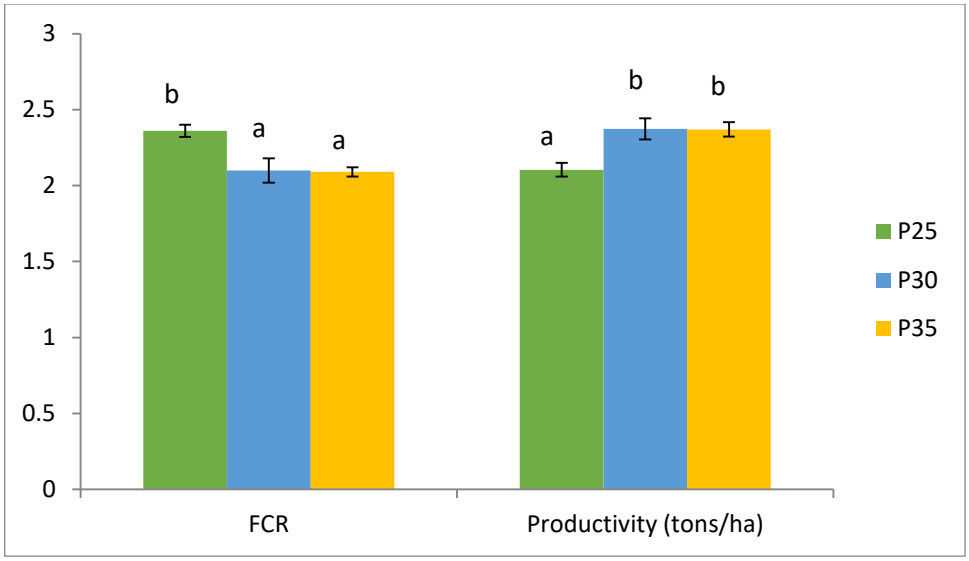
Parameter	Control	T1	T2	T3	T4
Final body weight (g)	2.09±0.03	3.64±0.05b	2.47±0.01	2.34±0.01	2.18±0.30
FCR	2.76±0.04	1.14±0.03	1.86±0.19	1.63±0.08	2.52±0.16
Survival (%)	70.00±00	93.33±3.33	83.33±3.33	80.00±00 b	66.67±3.33
PER	1.43±0.02	3.50±0.09	2.18±0.25	2.40±0.11	1.58±0.10

Control, (EE-3%), T1 (EE-6%), T2, (EE-9%), T3, (EE-12%), T4, (EE-15%)

Study on growth and production of *P. vannamei* fed varying level of protein in low saline pond culture system at KRC

Pond trial was conducted at Kakdwip Research Centre to evaluate the performance of shrimp feed with varying level of protein (25%, 30% & 35%) in *P. vannamei*. Shrimp were stocked @28 nos/sqm in triplicate ponds and duration of culture was 94 days. Result showed that *P. vannamei* fed diet with 30 and 35 % protein attained 23.02 and 22.22 g after 94 days of culture in low saline pond culture system. Production (2.37 t/ha) and FCR (2.09-2.10) were similar in *P. vannamei* fed diet with 30 and 35 % protein. Growth, production and FCR were affected in shrimps fed diet with 25 % protein.

Results revealed that 30% protein is optimum for *P. vannamei* in low saline pond culture system.



Effect of varying level of protein on production performance of *P. vannamei* in low saline pond culture system

Feed management options

Utilization of periphyton biomass for partial replacement of feed in milkfish culture

Periphyton based culture systems have been found provide better natural feed as well as as act as a *in situ* biological filter in the rearing system. Milkfish being an herbivore fish, it can reared using this periphyton biomass by reducing the feed inputs. To study this milkfish (ABW 14.68 g) grow-out culture was undertaken in four different feeding regimes, (P0) control with total feeding, (P75) periphyton grown in 75% surface area (SA) + partial feeding, (P100) periphyton grown in 100% SA + partial feeding and (P125) periphyton grown in 125% SA + partial feeding with stocking density of 15000/ ha in 50 m^2 pond enclosures. After 180 days, fish growth (242.29±5.22 g) was significantly highest (P<0.05) with lowest FCR of 1.17±0.02 in P125. This trial indicated that periphyton can be utilized to reduce FCR (up to 46%) in monoculture of milkfish for better productivity.

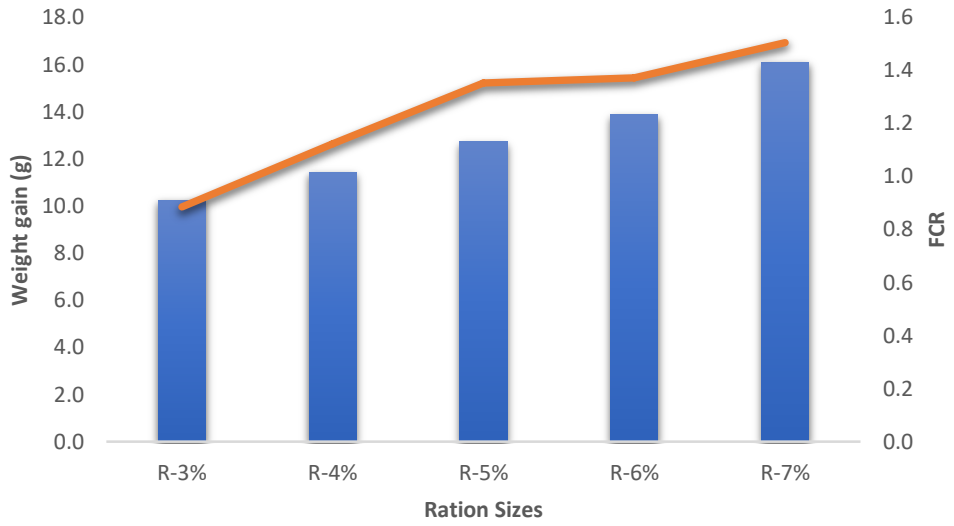
Production performance, FCR and economic return of milkfish monoculture under four different systems

Parameter	**P0**	**P75**	**P100**	**P125**
Final ABW (g)	132.24±2.32^{d}	214.89±7.75^{c}	237.18±4.25^{b}	242.29±5.22^{a}
Survival (%)	76±2.7^{d}	79.1±0.5^{c}	83.1±0.9^{b}	86.7±3.4^{a}
Productivity (kg/ ha)	1509±79^{d}	2549±77^{c}	2844±71^{b}	3146±60^{a}
FCR	2.15±0.11^{d}	1.63±0.05^{c}	1.34±0.03^{b}	1.17±0.02^{a}

Means with different superscripts in a row differ significantly (P<0.05); values are mean ± SD of three replicates; total feeding and no periphyton (P0), and partial feeding with periphyton grown on 75 (P75), 100 (P100) and 125 (P125) % of pond surface area.

Optimum daily feed ration for grow-out rearing of fish, Pearlspot

Pearlspot being a omnivorous fish they prefers to eat plant based foods in nature. Considering this we developed a grow-feed to contain more of plant-based agriculture by-products as ingredients. Feed management which involves provisioning feed in right quantity in right time and intervals is a critical component for better utilization of nutrients. In this study we tested the different ration levels such as 3, 4, 5, 6 and 7% per day in indoor clear water systems. In the tanks juveniles of 4 g reached ABW of 110 g in 155 days and 133 g in same duration in cages. Feed ration of 5% was found to be optimum for the juvenile pearlspot, in which better utilization of feed was found based on the growth and FCR. Survival was obtained 100% irrespective of the ration size. Nursery rearing in microcosm produced 1080 juveniles of 1.22 g in 57 days and 2.34 g in 84 days from 22 mg initial weight with 90% survival on practical CIBA's microbound feeds.

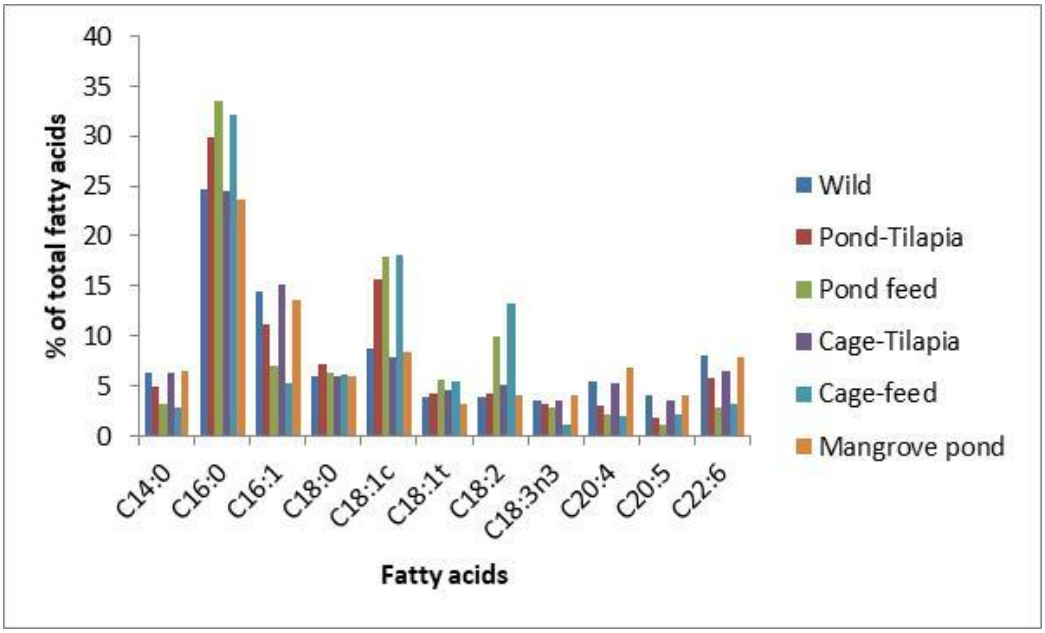


Weight gain and FCR of juvenile pearlspot fed varying daily rations

Influence feed on the final nutritional quality of the seafood

Effect of rearing system on fatty acid profiles of Asian Seabass, *Lates calcarifer*

Asian seabass, *Lates calcarifer* is a high value finfish species widely farmed in brackishwater. There were assumptions and evidences in other farmed fishes on the variation in nutritional quality and taste. In this study, Asian seabass were collected from wild and five different farming systems, viz., pond (fed Tilapia), pond (fed formulated pelleted feed), open water cages (fed Tilapia) open water cages (fed formulated pelleted feed) and extensive culture in mangrove ecosystem to study the effect of culture system on fatty acids profile. The fatty acid profiles varied significantly (P<0.05) between rearing systems. Though the proportion of n-3 fatty acids, are reduced in fishes fed on pellet feed in both the systems, the absolute quantity of n-3 fatty acids are higher due to the higher lipid content.

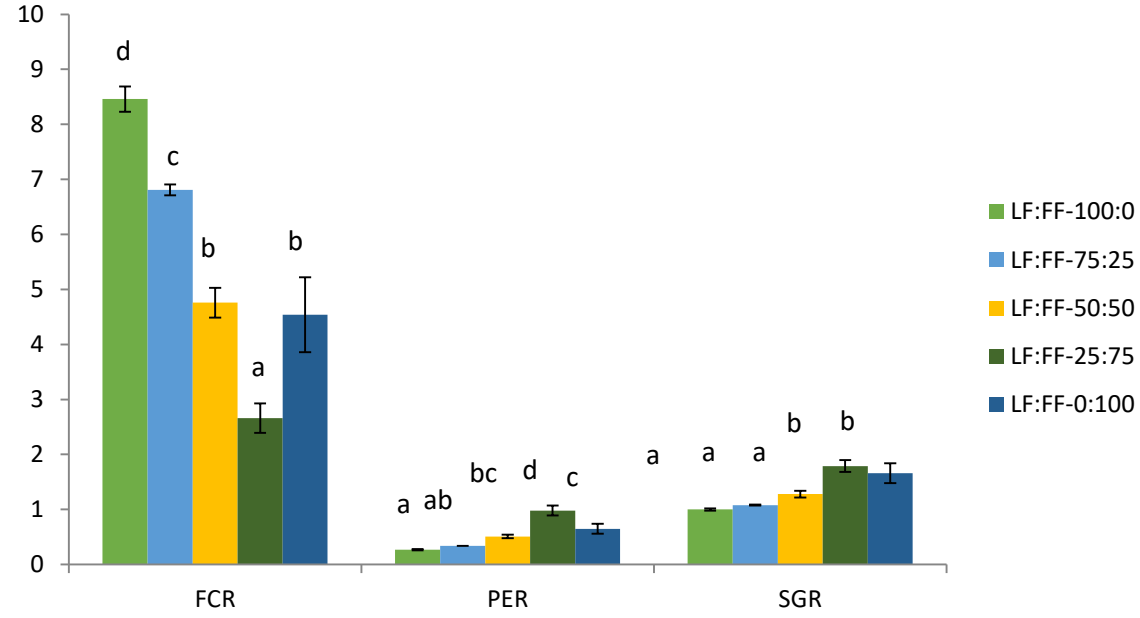


Fatty acid profiles of Asian Seabass reared in different rearing systems

Live feeds: key element in hatchery seed production of fish and shellfish

Optimum combination of formulated and live feed for hilsa juveniles

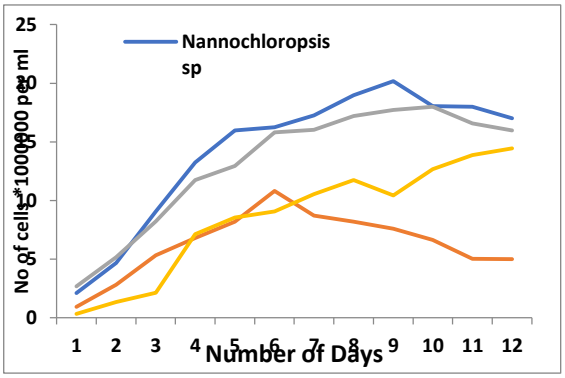
Hilsa juveniles are filter feeders in nature, which filters the live feeds in the water while to flows through the gill rakers. Under captive rearing feeding the filter feeders is challenging. In this study, to optimize the proportion of live feed and formulated feed in diet of hilsa juveniles an indoor experiment was conducted with different proportion of live feed (LF) and formulated feed (FF) i.e., LF:FF-100:0; LF:FF-75:25; LF:FF-50:50; LF:FF-25:75; LF:FF-0:100. Trial was conducted for 30 days. Hilsa fry performed better in terms of weight gain, growth rate and nutrient utilization efficiency when offered with 25% Live Feed and 75 % formulated feed in their diet in indoor experiment.



Growth and feed utilization efficiency of hilsa fry with different proportion of live feed (LF) and formulated feed (FF)

Potential microalgal species and their growth kinetics

Apart from the common microalgae used in aquaculture, many other potential unexploited microalgal species occur in backwaters and estuaries, which may have unique values for use in hatchery production finfishes and shellfishes and human nutraceutical properties. Using the standard isolation and culture methods, microalgae strains such as *Tetraselmis* sp (2 strains), *Nannochloropsis* sp, *Chlorella* sp, *Navicula* sp, (from high saline waters) and *Isochrysis galbana* sp (from seawater) were isolated. The growth kinetics of these isolates is studied and it was observed that *Chlorella* sp and *Nannochloropsis* sp were fast growing compared to *Tetraselmis* and *Isochrysis* sp. The *Tetraselmis* sp was showing extended exponential growth in its growth cycle (>12 days).



Growth cycle of microalgal isolates

Microalgae facility at Muttukadu Experimental Station

Downstream processing of locally isolated *Arthrospira maxima*

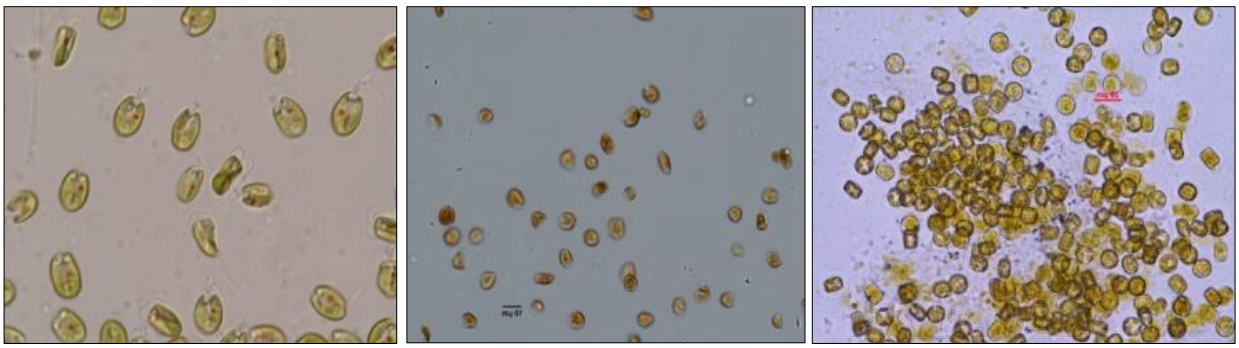
The cyanobacterium; spirulina (*Arthrospira* sp) has unique set of biological characteristics which are highly useful for a broad range of applications in food, feed nutraceuticals, pharmaceuticals etc. In India, the commercial culture and production of spirulina is mostly depending on the imported strains. A potential strain of spirulina (*Arthrospira maxima*) was isolated from Muttukadu waters for the first time, and its mass culture was optimized for both indoor and outdoor a cost effective urea based medium. The biomass obtained was used to produce a high value pigment phycocyanin. A three-stage extraction procedure was standardized to get crude form of phycocyanin. By this process the purity (A620/A280) of about 1.14 is been achieved. The yield of phycocyanin

was 15 % of the dry weight. The yield of purity and phycocyanin was compared in each stage with commercially available spirulina a powder (*Arthrospira platensis*). The purity of crude extract was on par with commercially available spirulina.

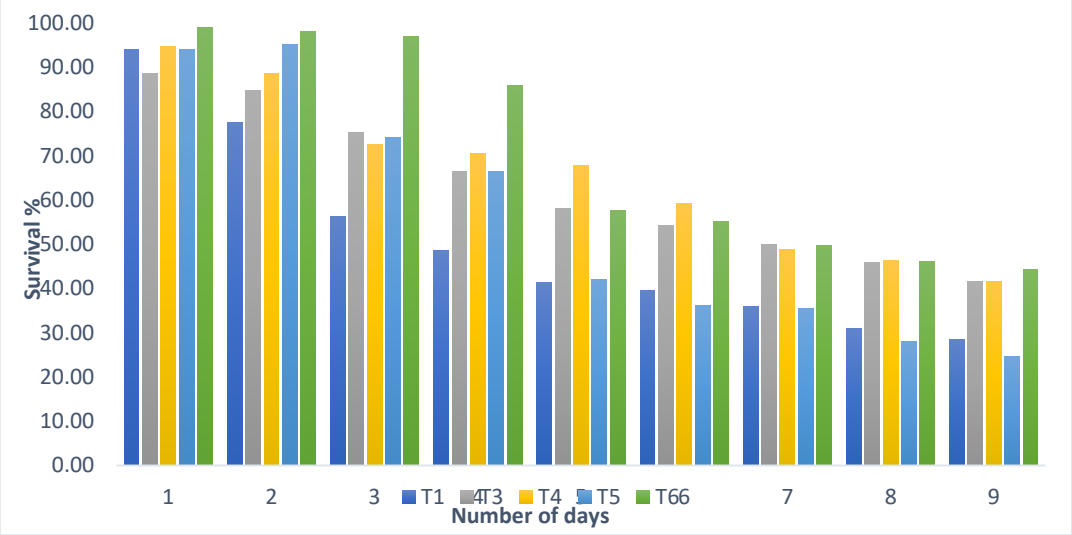
Harvested spirulina and phycocyanin extract

Efficiency of different microalgae in shrimp larval rearing

Over the years, shrimp hatcheries were using different microalgae for larval rearing. Microalgae were selected only based on the practical constrains and without much scientific background. We conducted experiments to find out the best microalgae for penaeid shrimp larval rearing with relevance to its nutrient value as well as ease for mass cultivation. First experiment was with *Penaeus indicus* larvae. Based on the easy nature of mass culture micro algae such as *Tetraselmis* sp, *Chaetoceros* sp and *Thalassiosira* sp were selected and tested individually as well as in combinations. The results showed that the highest survival, growth and fast conversion shrimp larvae was obtained in combination of *Thalassiosira*: *Tetraselmis* (1:1) followed by *Thalssisosira* : *Chaetoceros* and *Thalassiosira*.



Microscopic images of *Tetraselmis* sp, *Chaetoceros* sp and *Thalassiosira* sp

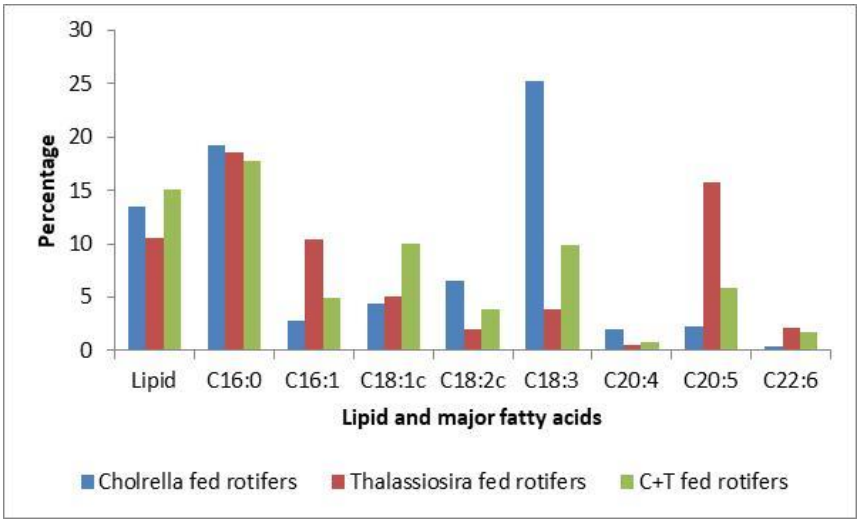


Effect of different microalgae in shrimp larval survival

T1: Tetraselmis sp, T2: Chaetoceros sp, T3: Thalassiosira sp, T4: Thalassiosira: Chaetoceros (1:1), T5: Chaetoceros : Tetraselmis (1:1), T6: Thalassiosira: Tetraselmis

Fatty acid profile of rotifer fed different micro algae

Micro algae are primary producers of the PUFA and HUFA in aquatic food chain. In order to increase the survival and better performance of mud crab larvae, the larvae were fed with rotifers which were fed on three different microalgae. The rotifers were fed with Chlorella, Thalassiosira and both Chlorella + Thalassiosira in combination. The nutrient profiling of these rotifers has indicated that highest lipid in rotifers which were fed on Chlorella +Thalassiosira together. The better performance of crab larvae when fed rotifers which were fed on Chlorella + Thalassiosira in combination might be due to the better balancing of the fatty acid profiles.



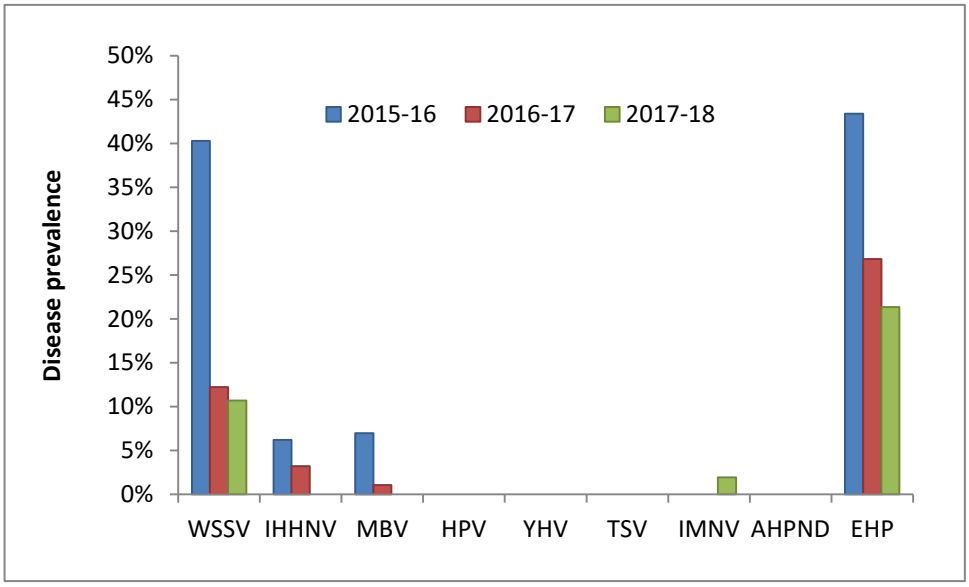
Fatty acid profiles of rotifers fed with different micro algae

AQUATIC ANIMAL HEALTH

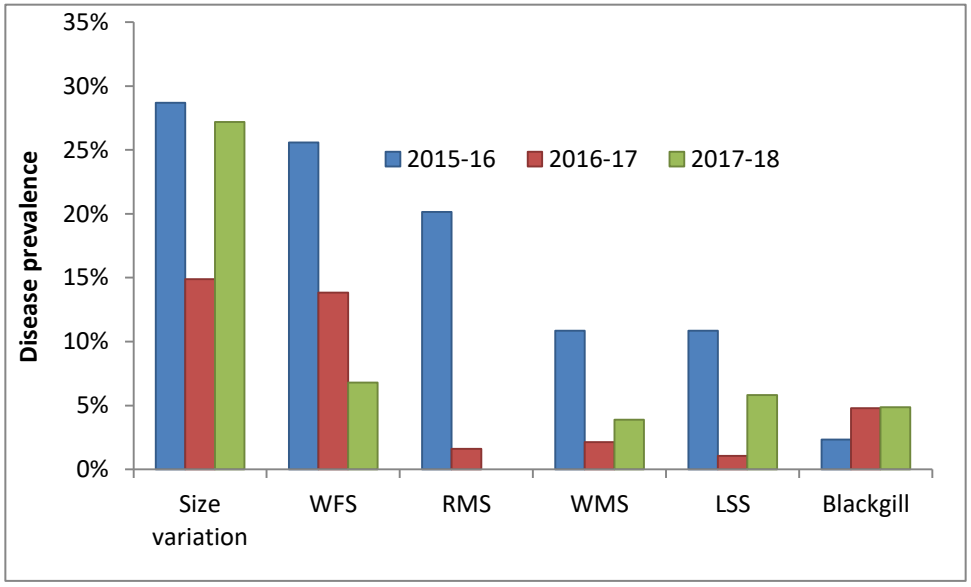
Outbreaks of White spot syndrome declining over the past three years

Diseases are the biggest threat in shrimp aquaculture growth and sustainability. As part of the on-going active shrimp disease surveillance programme since the year 2014, a total of over 420 shrimp farms were screened for OIE listed pathogens in three maritime states viz., Tamil Nadu, Andhra Pradesh and West Bengal. Over a period of three years, the disease prevalence has been showing decreasing trends. The hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) had the highest prevalence rate of 43% during 2015. However, the prevalence has come down to 21% during the last year. The prevalence of the most dreaded white spot syndrome (WSD), caused by white spot syndrome virus (WSSV) was 40% during 2015 and has declined in the previous year to 11%. The prevalence of infectious hypodermal and haematopoietic necrosis (IHHN) disease also show declining trend from 6 to 3%, over the last three years. The other disease syndromes, attributable to poor farm management such as stunted growth, white faeces syndrome (WFS), loose shell syndrome (LSS) and black gill were observed in 27, 7, 4, 6% and 5% of the farms, respectively during 2017-18, out of 120 farms investigated.

The Indian brackishwater aquaculture was free from other OIE listed diseases such as taura syndrome (TS), yellow head disease (YHD), acute hepatopancreatic necrosis disease (AHPND) and necrotising hepatopancreatitis (NHP). However, during February- March 2017, infectious myonecrosis (IMN) was detected in two *P. vannamei* farms in East Godavari, Andhra Pradesh and at Nagapattinam, Tamilnadu.



Prevalence of viral, bacterial and fungal diseases in AP, TN and WB during 2015 – 18 (420 farms)



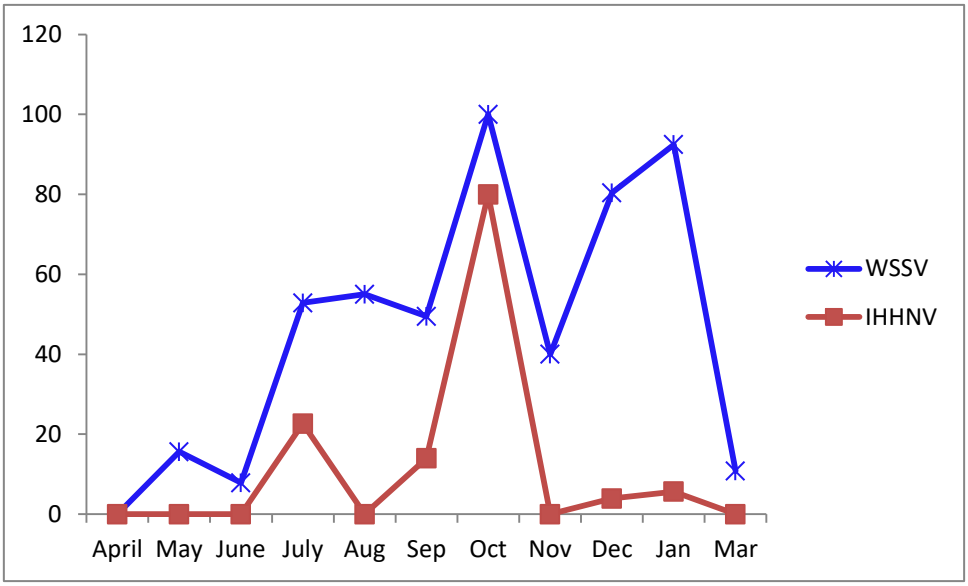
Occurrence of disease syndromes in AP, TN and WB during 2015-18 (420 farms)

Prevalence of WSSV in Indian shrimp broodstock

A successful breeding program depends upon the supply and maintenance of healthy, disease free brooders. A round the year surveillance of 661 brooders of Indian shrimp species (*P. indicus, P. monodon* and *P. japonicus)* was carried out for major shrimp pathogens such as WSSV and IHHNV. *P. indicus* brooders sourced from three locations in Tamil Nadu (Muthukadu, Kalpakkam and Nainarkuppam), Orissa (Puri) and Kerala (Kollam) indicated that the prevalence of WSSV was significantly high (38.4%). The WSSV prevalence was 37% in *P. japonicus* and 31% in *P. monodon*. The IHHNV prevalence was mostly associated with WSSV and found to be more in *P. monodon* (25.4%) compared to *P. japonicus* (6.7%) and *P. indicus* (6.0%). The incidence of WSSV was minimal during March to June (0-16%), started increasing from July (52.8%) and reached peak in October (100%). The data indicates that summer and pre-monsoon season (March to June), are ideal period for collection of wild brooders of *P. indicus* for seed production.

Prevalence of WSSV and IHHNV in brooders of major Indian species (*P. indicus, P. monodon* and *P. japonicus*)

Species	No. of samples screened	WSSV I	WSSV II	WSSV	IHHNV	WSSV + IHHNV	IHHNV
P. monodon	51	7	16	6	13	10	3
P. indicus	565	47	217	183	34	32	2
P. japonicus	45	4	17	14	3	3	0
Total	661	58	250	203	50	45	5

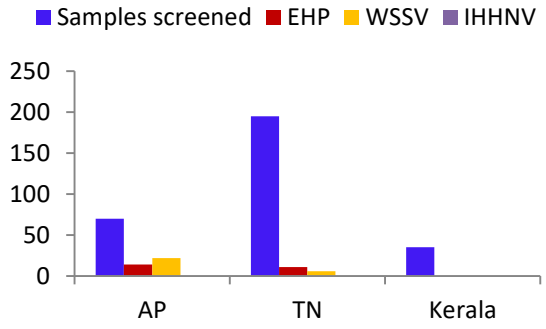


Prevalence of WSSV and IHHNV in *Penaeus indicus* brooders

Polychaete worms (*Marphysia* sp.) carry shrimp pathogens

Polychaete worms were examined as agents of pathogen transmission in aquaculture. Small, medium and large sized polychaete (*Marphysia* sp.) worms of 4 - 45 cm length from Tamil Nadu (TN), Andhra Pradesh (AP) and Kerala were screened for important shrimp pathogens *viz*., WSSV, IHHNV and EHP by PCR. Polychaete samples from shrimp farming areas of AP and TN revealed a high prevalence of WSSV (34.2%) and EHP (21%). Moreover, 14.6% of polychaetes carried both WSSV and EHP infection. While in non- shrimp farming area of AP and TN, a very low incidence of EHP (3.2%) was recorded. Overall, 72% of the PCR positive polychaete sample showed infection detectable only by nested PCR and hence unlikely to be a natural host for EHP. However, it is certain that the wild polychaete worms serve as carriers of shrimp pathogens and should be screened while using them as maturation diet for shrimp broodstock.

Polychete worm collected from Palar river



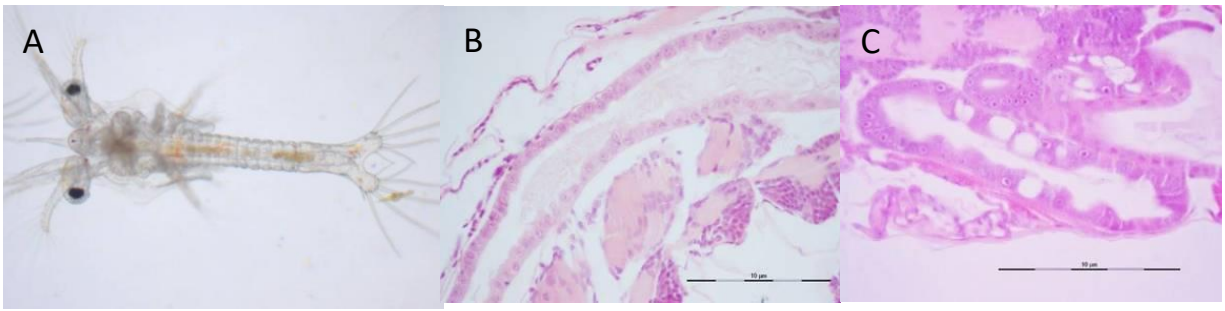
Occurrence of EHP, WSSV and IHHNV in wild Polychaetes worms

Zoea II syndrome associated with cycle of larval stocking and reduced cholesterol level in *P. vannamei*

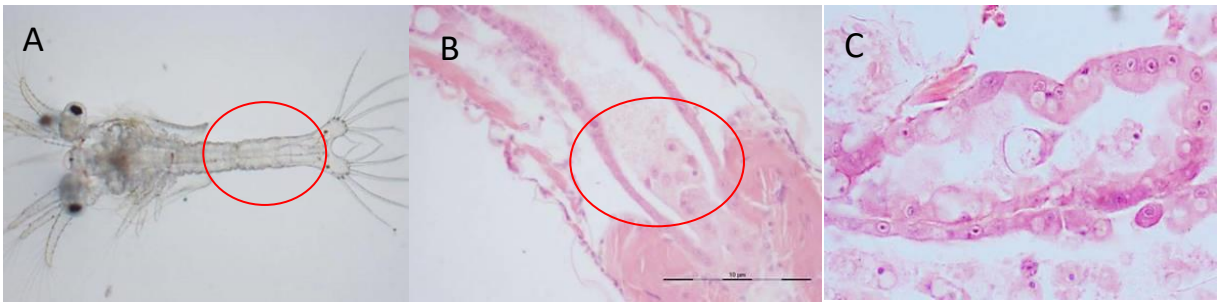
Zoea II syndrome has emerged as a serious threat to Indian shrimp hatcheries, especially after introduction of *P. vannamei*. It causes delayed molting or impairment of metamorphosis into larval stages followed by mass mortality at zoea II stage. Our study revealed that zoea II syndrome was always associated after 3-4 days of stocking in the

same larval rearing units while the other previous batches of the same hatchery did not have any incidences of zoea II syndrome. The cumulative mortality rate in the affected larval batches was up to 90% compared to 20% in healthy larval batches. The gut of the affected larvae was empty with impaired peristaltic movement and no faecal strands. The microscopic examination revealed inflammation, necrosis and whitish ball-like structure in the intestinal lumen. Histological examination showed detachment of hepatopancreatic tubular epithelial cells. The intestinal epithelium showed vacuolization, disintegration of peritrophic membrane with sloughing of epithelial cells from the basement membrane.

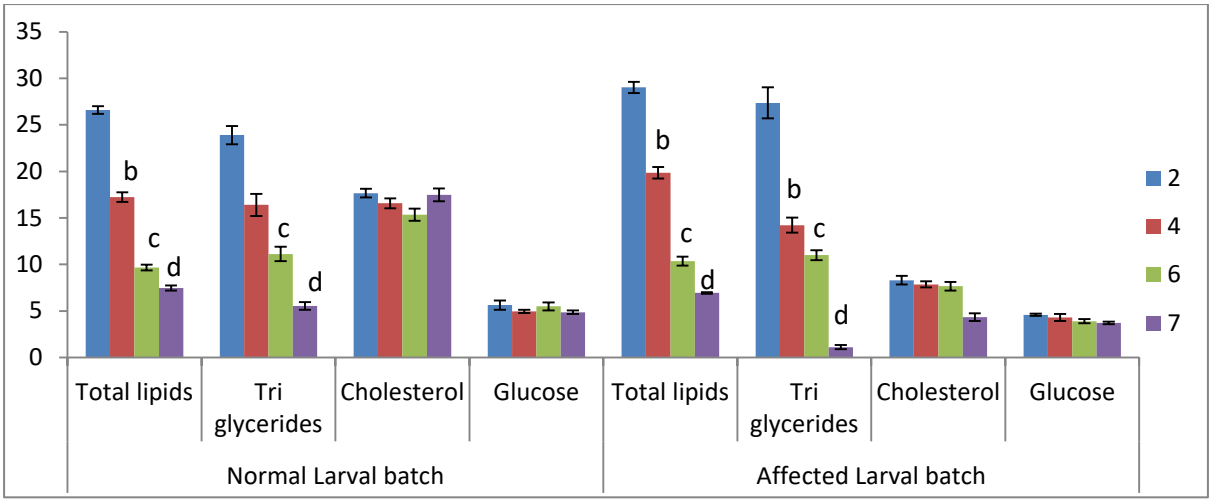
The biochemical profiling suggested that total lipids and triglycerides decreased over the larval cycles in both healthy and zoea II syndrome affected larval batches. In contrast, the cholesterol level was significantly lower in the affected larval batches compared to healthy larvae. Cholesterol is the precursor of molting hormone and hence, its lower level indicates the possibility of delayed molting. Mortality of zoea in affected larval tanks was more than 80% by 7th day of stocking. Denaturing gradient gel electrophoresis (DGGE) of normal zoea, affected zoea and larval samples from 2nd day, 6th day and 7th day of affected larval batch revealed association of an uncultured bacteria of *Flavobacterium* (*Nonlabens* sp) with zoea-2 syndrome.



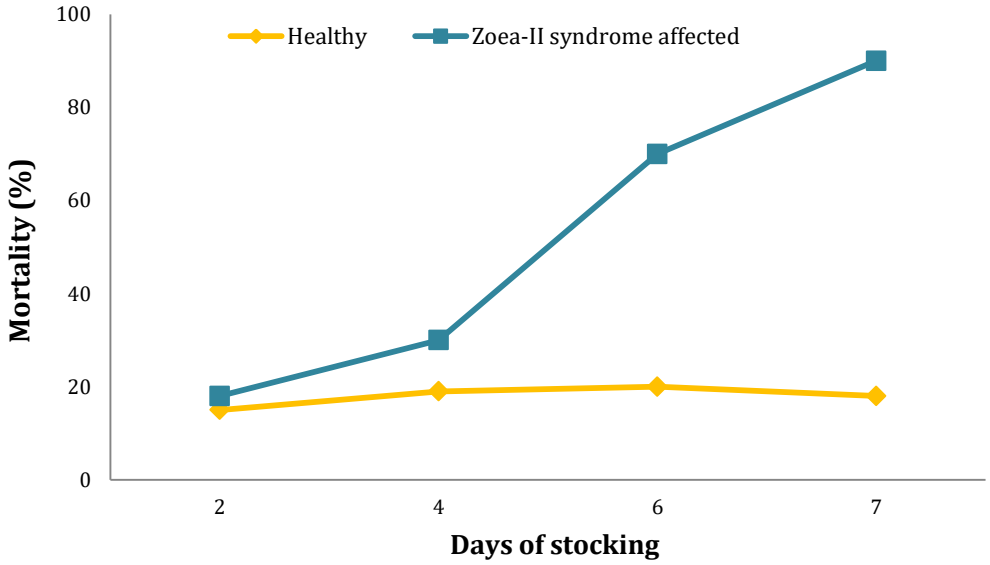
(A)Normal protozoea-2 with full gut; (B) longitudinal histological section of normal protozoea showing intact intestinal epithelial cells; (C) longitudinal histological section of nomal protozoea showing hepatopancreas with intact B cells, F cells and E cells



(A) Zoea syndrome affected larvae with empty gut and inflammation; (B) longitudinal histological section of affected protozoeal intestine showing with ball like structures in the lumen; (C) longitudinal histological section of affected protozoea showing necrosis and sloughing of E cells and B cells of the hepatopancreas



Biochemical parameters of normal and zoea syndrome affected larval batches on 2nd, 4th, 6th and 7th days of stocking



Percentage of mortality during normal and zoea syndrome affected larval production cycles on 2nd, 4th, 6th, 7th days of stocking

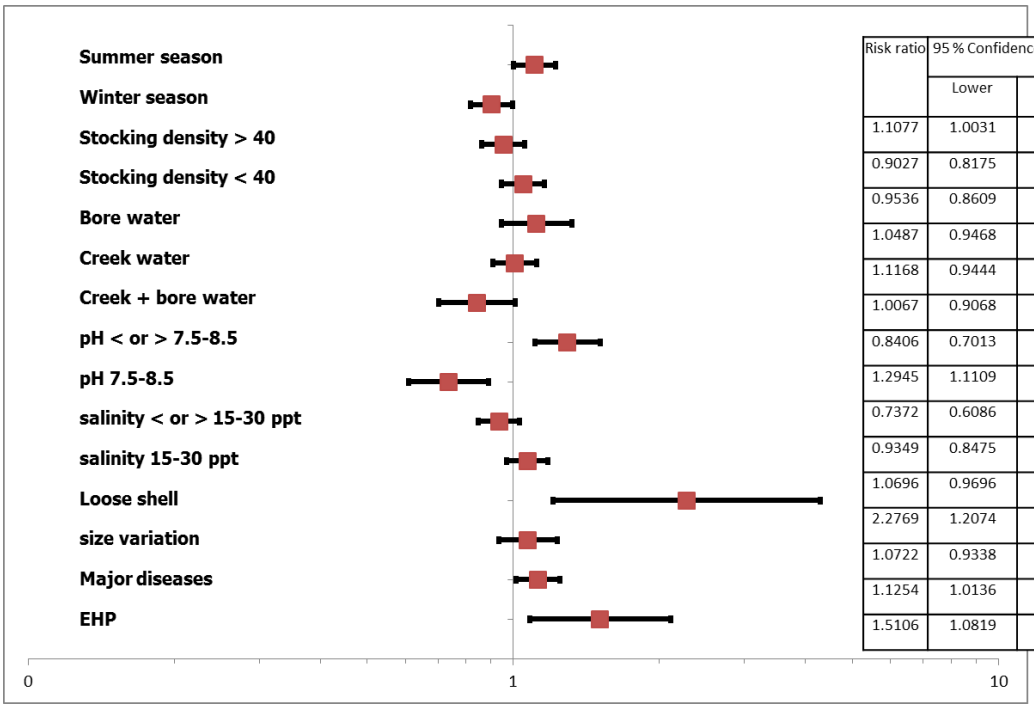
Bacteria associated with zoea syndrome on the 2nd, 4th, 6th, 7th days of stocking using DGGE

Bacteria associated with normal and zoea syndrome on the 2nd, 4th, 6th, 7th days of stocking revealed by DGGE

Days of Stocking	Identified sp
Zoea normal	*Rhodobacterium, V. alginolyticus*
Second day	*Roseavarius* sp (*Rhodobacterium*), Alpha proteobacterium (Proteobacter), *Rhodobacteracea*, *V. proteolyticus*
Sixth day	*Shimia* sp (Roseobacter), *Nonlabens* sp (Flavobacterium), *Rhodobacterium*, *V. alginolyticus*, *V. proteolyticus*
Seventh day	*Nonlabens* sp (Flavobacterium), Rhodobacteracea
Zoea Affected	*Nonlabens* sp (Flavobacterium)

White faeces syndrome of *P. vannamei* shows strong epidemiological association with EHP

White faeces syndrome (WFS), chronic/running mortality syndrome (CMS/RMS), and white muscle syndrome (WMS) have been prevalent in vannamei farms since 2011. The WFS alone is responsible for up to 20-30% reduction in production of farmed shrimp. Out of 317 farms investigated during 2015 – 17, 17% of the farms were affected with white faeces syndrome. Among the WFS affected farms, 30% of the cases were positive for EHP, 20% had size variation, 16% showed symptoms of white muscle, another 20% had loose shells and 16% cases were affected with WSSV. Bacteriological studies indicated the presence of *V. proteolyticus*, *V. corallayticus* and *V. alginolyticus* in a few of the affected farms. The pH range of 7.5-8.5 was found optimal for maintaining a healthy pond. The pH beyond 7.5-8.5 was significantly associated with white faeces syndrome. Interestingly, 100% epidemiological association between the incidences of EHP and loose shell were associated with WFS. All other risk factors such as season, stocking density, source of water, salinity were not significantly associated with WFS.

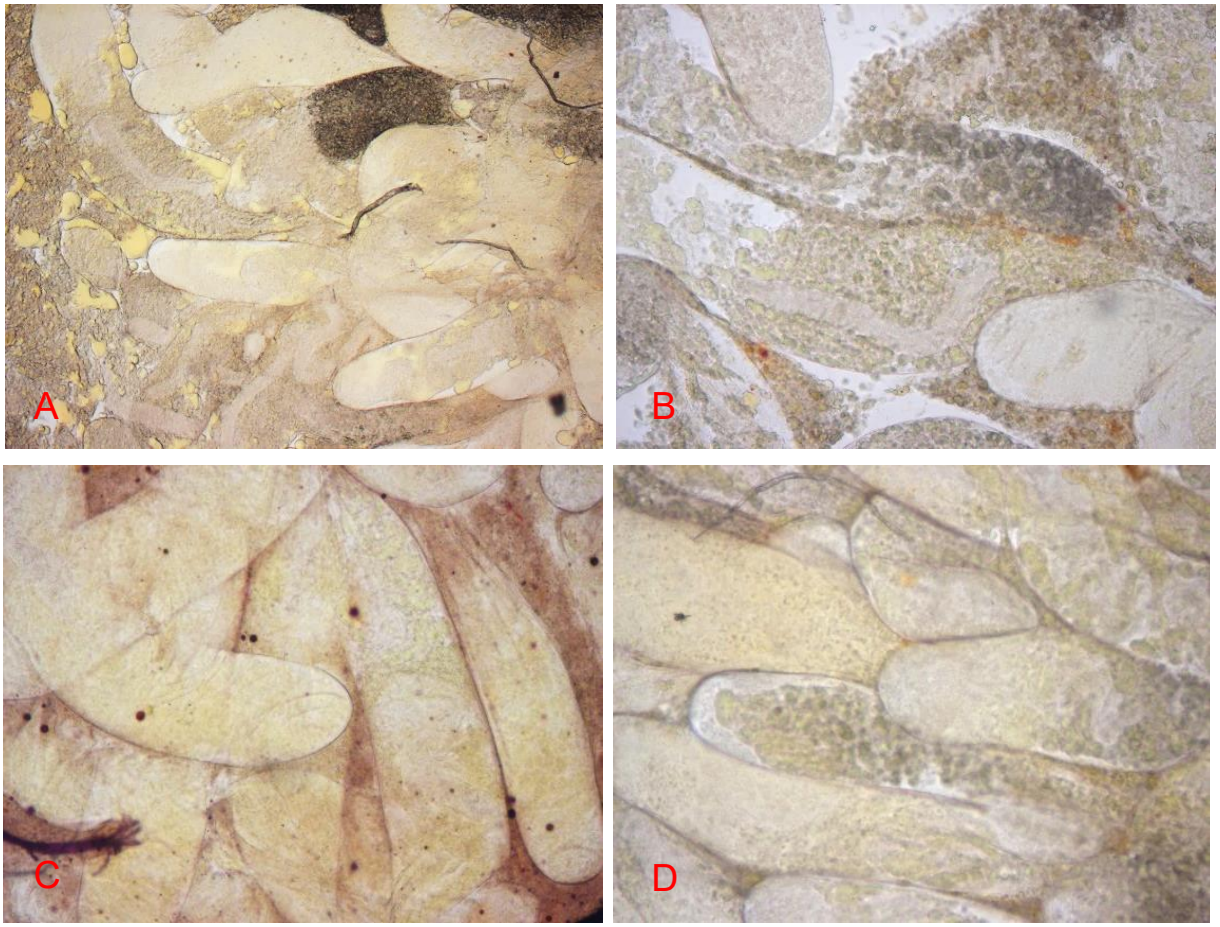


Risk ratio	95 % Confidence interval		P value
	Lower	Higher	
1.1077	1.0031	1.2233	0.05193
0.9027	0.8175	0.9969	0.05193
0.9536	0.8609	1.0562	0.42288
1.0487	0.9468	1.1616	0.42288
1.1168	0.9444	1.3206	0.14811
1.0067	0.9068	1.1177	1
0.8406	0.7013	1.0075	0.06845
1.2945	1.1109	1.5113	0.01326
0.7372	0.6086	0.8892	0.01326
0.9349	0.8475	1.0313	0.22558
1.0696	0.9696	1.1799	0.22558
2.2769	1.2074	4.2935	0.00003
1.0722	0.9338	1.2311	0.27256
1.1254	1.0136	1.2495	0.02463
1.5106	1.0819	2.1093	0.00375

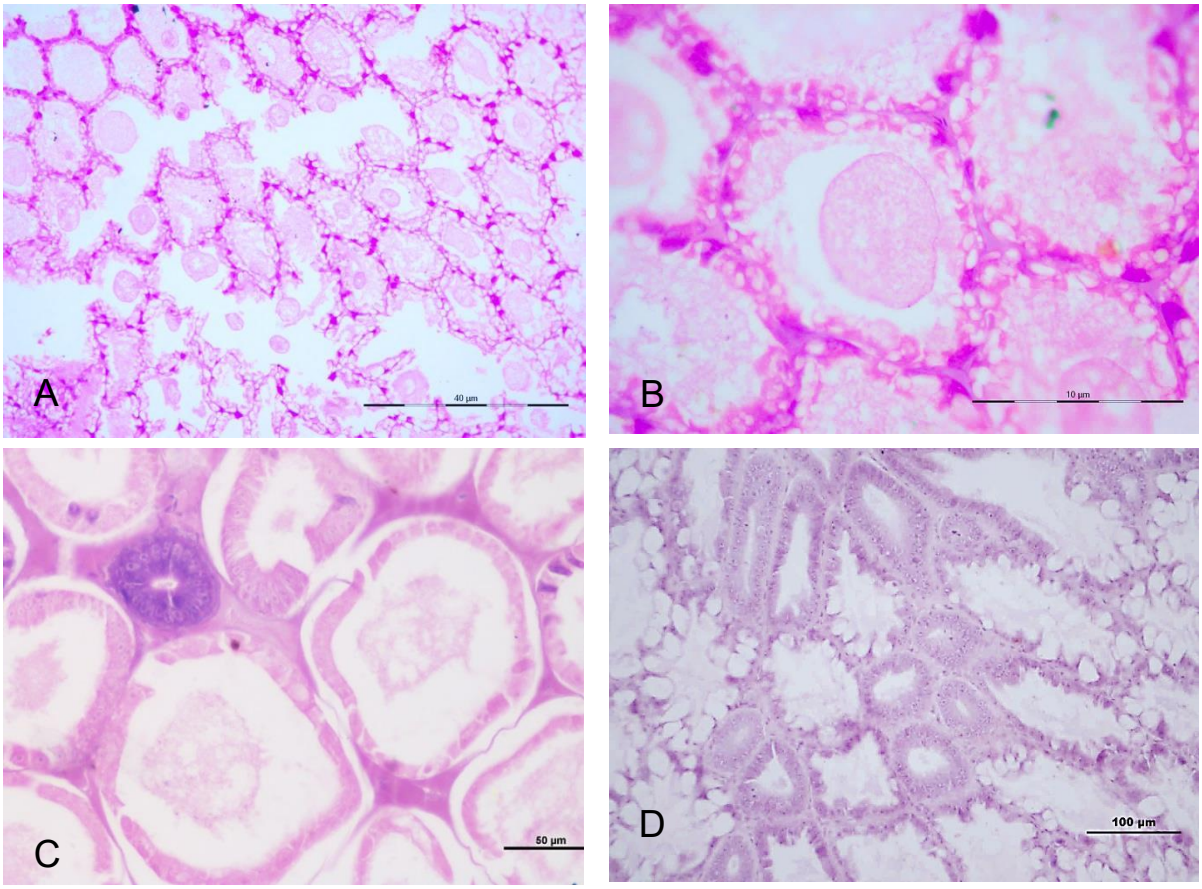
Association of EHP with loose shell syndrome and white faces syndrome in famed *P. vannamei*

White faeces syndrome affected *P. vannamei* recover when good water quality conditions are restored in the laboratory

The symptomatic examination suggested that WFS affected shrimp regained normalcy in 7-10 days under laboratory conditions when good water quality conditions were restored. The hepatopancreas of WFS affected shrimp revealed severe necrosis of the epithelial cells along with the presence of aggregated transformed microvilli (ATM) like structures inside the lumen. In comparison, the recovered shrimp showed the regeneration and proliferation of epithelial cells (E cells or embryonic cells) in the proximal region of the hepatopancreas. Thus the recovery of shrimp could be histologically demonstrated when good water quality conditions are restored.



Wet mount preparations of WFS affected shrimp with hepatopancreas showing aggregated transformed microvilli (ATM) structures (A & B); Normal hepatopancreatic tubules (C & D)

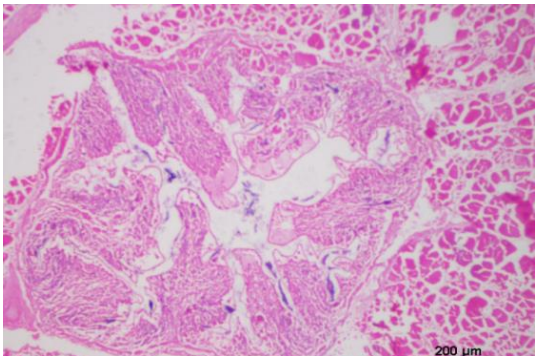


Histological section of WFS affected shrimp with hepatopancreas showing degenerative epithelial cells and ATM structures (A & B); Histological section of WFS recovered shrimp hepatopancreas with regeneration and proliferation of epithelial cells (C & D).

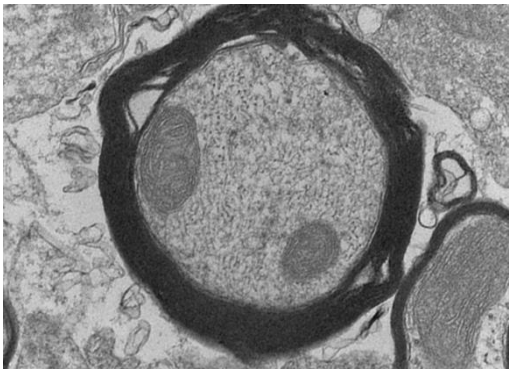
Infectious Myonecrosis Virus (IMNV) is an emerging threat to shrimp aquaculture

Infectious Myonecrosis Virus (IMNV) till recently was restricted to Brazil in South America and Indonesia in Asia. CIBA disease surveillance study revealed the presence of Infectious Myonecrosis Virus (IMNV) in 2017 at two shrimp farms (DOC: 60), one each from AP and TN. The affected *P. vannamei* (~16 ±2 g at 70-120 DOC) appeared dark red with white extensive necrosis in the distal abdominal muscle. A 70 - 90 % mortalities and emergency harvest was reported from the affected farm. The bioassay study was carried out to reproduce the disease in *P. vannamei* (n: 30; ABW: 15±2 g) using IMNV infected muscle of shrimp collected from AP outbreak. The challenged *P. vannamei* developed typical whitish necrotic lesions in abdominal segments. Challenge trials by intramuscular injection of healthy shrimp with viral preparation and co-habitation of healthy shrimp with infected animals, produced 80% and 70% mortalities respectively. Histo-pathologically coagulative necrosis of skeletal muscle with haemocytic infiltration, fibrosis and vacuolation of muscle tissue was observed in IMNV challenged *P. vannamei* shrimp. The TEM analysis further revealed ultrastructural changes such as fibrosis and vacuolation in the muscle of experimentally challenged shrimp.

Reproduction of IMNV in *P. vannamei* through experimental challenge



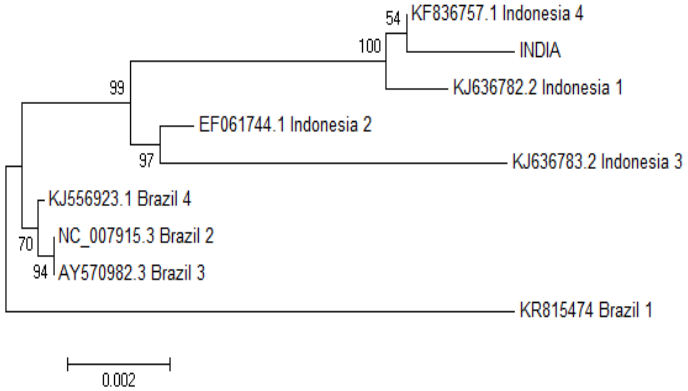
Fibrosis of skeletal muscle due to IMNV in experimentally challenged *P. vannamei*



Fibrosis and vacuolation of skeletal muscle in IMNV challenged *P. vannamei* revealed by TEM

Whole genome sequencing of Infectious myonecrosis virus (IMNV) showed highest similarity to Indonesian strain

ICAR-CIBA sequenced the IMNV genome using 8 sets of primers from the conserved region, covering the entire genome. A total 8266 bp was sequenced. The Indian isolate showed maximum identity with Indonesian IMNV strain KF836757.1. The phylogenetic analysis clustered the Indian isolate with four Indonesian strains whereas the four Brazil strain formed a separate cluster. The study signifies that recently emerged Infectious myonecrosis virus in India probably entered through Indonesia.



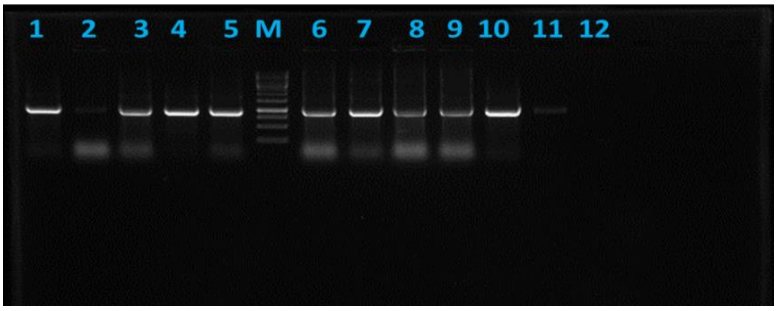
Phylogenetic analysis of Indian IMNV strain vs. Brazilian and Indonesian strains

Tilapia Lake Virus (TiLV) infection recorded for the first time in GIFT Tilapia

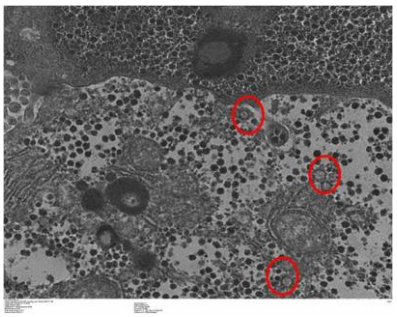
Tilapia Lake Virus (TiLV) is an orthomyxovirus characterised with segmented RNA genome. It was first time reported in 2014 from Israel. The GIFT tilapia with history of mortality, skin erosion, ulcers, lesion in the eye, opacity of the lens, haemorrhages on body and caudal fins were collected from Vijayanagaram district, Andhra Pradesh and Kolavai Lake, Chengalpet, Tamilnadu. The affected fishes also had

multifocal areas of necrosis with syncytia and haemorrhages in liver, brain, spleen, and heart. These samples were found negative for viral nervous necrosis (VNN) and Iridovirus infection, the two most commonly reported viral infections from brackishwater and marine fishes in India. Further investigation found the presence of emerging Tilapia Lake Virus (TiLV) by semi-nested RT-PCR. The transmission electron microscopy (TEM) of affected liver showed icosahedral particles of 60–100 nm diameter, with a central electron-dense core and several electron-dense projection of ~10–15 nm width at regular intervals. Histological examination of liver of TiLV infected fish revealed haemorrhages and loss of architecture of hepatocytes. The TiLV was adapted in primary tilapia brain cell culture. The cytopathic effect (CPE) was observed in confluent monolayers after infection with liver or brain tissue homogenate of affected tilapia. The disease was re-established in tilapia by bioassay experiments with 86.67 % and 66.67 % cumulative mortality by intraperitoneal injection of primary culture supernatants and cohabitation study respectively. The study confirms the presence of tilapia lake virus in India which has the potential to cause high level of mortality.

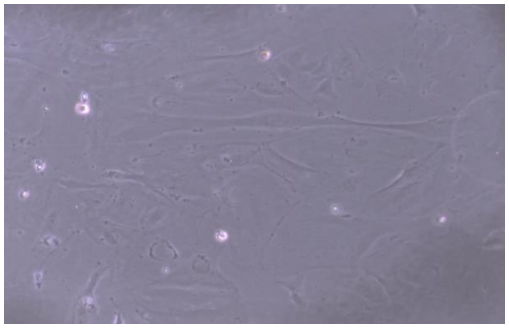
Sunken eyes with deep ulcers in moribund tilapia infected with TiLV



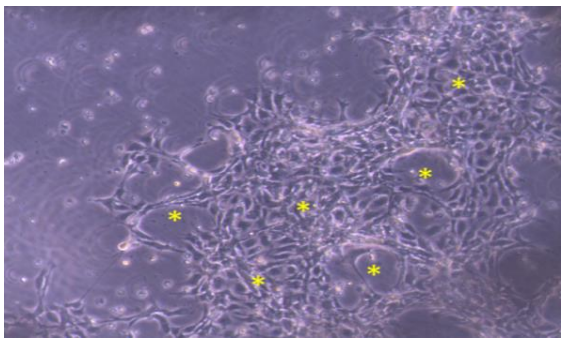
Screening of fish samples for TiLV by Semi nested RT- PCR (Dong et al., 2017): Lane M: 100bp marker. Lane 12: Negative control, Lanes 1-5: Liver samples found first step positive for TiLV, Lane 7-11: Brain samples first step positive for TiLV



Tilapia lake viurs in liver of infected fish observed by TEM



Primary tilapia brain culture

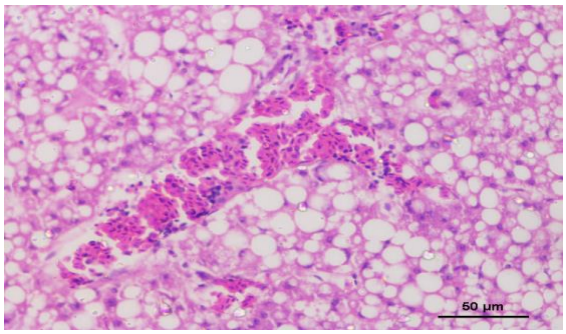


Syncytia formation in tilapia brain culture by TiLV

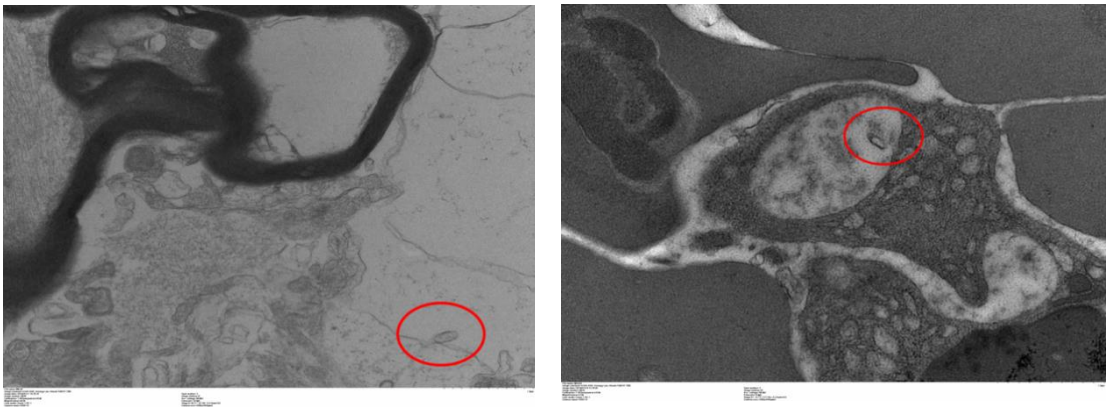
Virus like particles detected in TEM in pearlspot associated with mortalities

Mortalities of Pearlspot brooders (100±5 g) maintained at the Institute's Muthukadu experimental station exhibiting haemorrhages was investigated. The affected pearlspot brooders showed hepatomegaly, spleenomegaly and empty guts. Histological examination showed vacuolation and haemorrhages in liver, gills, spleen and heart of affected fish. The transmission electron microscopy (TEM) analysis of affected spleen and brain showed the presence of putative virus like particles of ~200nm.

Haemorrhages on the skin of diseased Pearlspot



Haemorrhages and vacuolation in liver of infected Pearlspot (H&E 40 X)



Putative virus like particles (bullet shaped) in brain and spleen of infected Pearlspot (TEM)

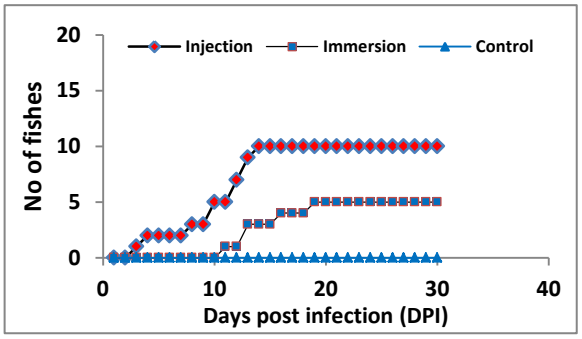
Orange chromide, *Etroplus maculatus* as model fish for experimental infection of *Betanodavirus*

Viral nervous necrosis (VNN) is an acute viral disease of fish causing high mortalities in larval and early juvenile stages. For developing therapeutics and vaccines, a model fish highly susceptible to nervous necrosis virus (NNV) is desired. Hence, a brackishwater cichilid, orange chromide (*Etroplus maculatus*) was examined as a model fish for VNN infection. The susceptibility of *E. maculatus* to NNV was tested by two different modes of challenge using RGNNV strain of NNV. The fingerlings of *E. maculatus* (n=60) were equally divided into three groups; Group 1 (immersed in seawater containing 10^5 viral particles ml^{-1} for one hour); Group 2 (i/m injected with 10 µl of 10^5 viral particles ml^{-1}); Group 3 (control fish without the viral inoculum).

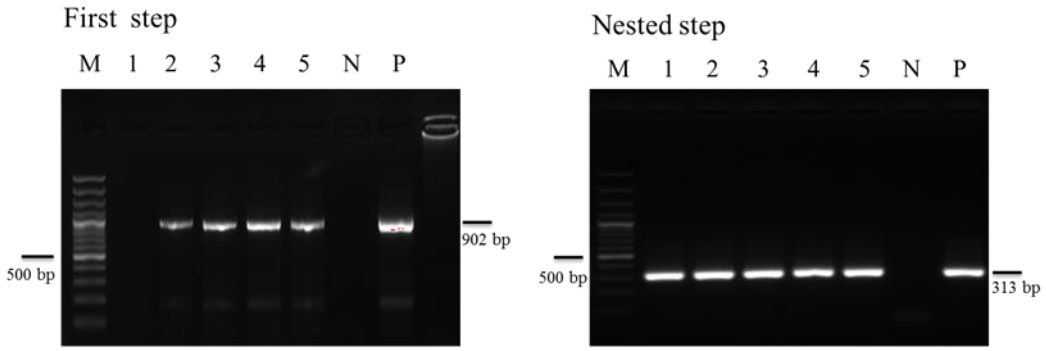
All the experimentally infected fish were positive for NNV, amplifying 903 bp PCR product. Morbidity and mortality rate was significantly higher by injection route compared to immersion. This resembled to natural infection in juvenile of marine fishes. Mortality started in injected group by 3 dpi and almost 50% mortality recorded by 15

dpi. The affected fishes exhibited cork screw movement before succumbing to death. These fishes showed severe neurological disorders accompanied by extensive vacuolar degeneration and mild to moderate neuronal necrosis of the brain. However, most of the larger fishes in the group survived without showing any signs. *E. maculatus* inhabits both fresh and brackish water systems, hence this fish species can be used as a model to study the age related resistance to NNV and developing potential NNV vaccine.

Infected fish showing dark pigmentation and reddish dorsal fins after infection



Cumulative mortality in experimentally infected *E. maculatus* by different mode of transmission

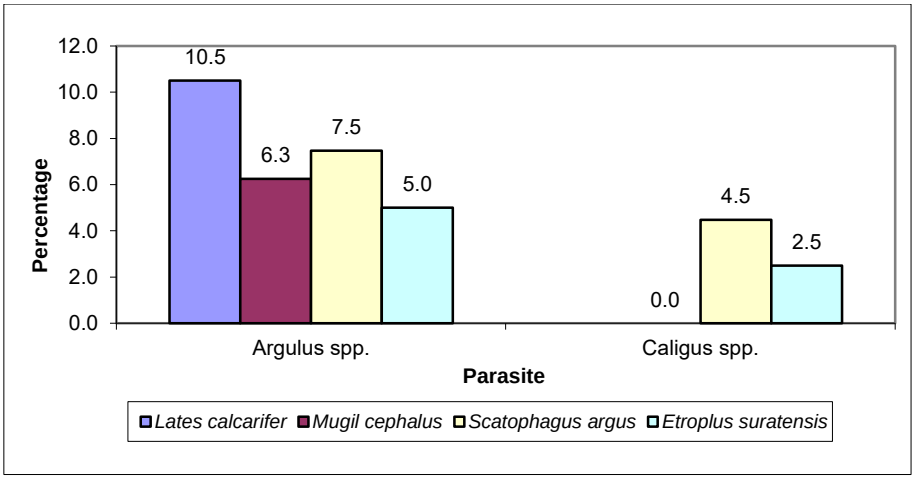


M- Marker (100 bp), Lane 1-1 dpi, Lane 2- 7 dpi, Lane 3- 14 dpi, Lane 4- 21 dpi, Lane 5- 30 dpi, N- Negative control, P- Positive control.

Confirmation of NNV infection byrt-PCR amplification of 903 bp product

Fish lice *Argulus* is the predominant parasite infesting seabass

Intensification in aquaculture parallels with increase in disease outbreaks. Parasitic infestations are one of the major issues in finfishe aquaculture. Studying the prevalence of such infection will help in formulating the control measures against parasitic diseases. Hence, profiling of parasites was carried out in 588 fishes of five candidate species including *Lates calcarifer* (352 nos), *Mugil cephalus* (112 nos), *Chanos chanos* (17 nos), *Scatophagus argus* (67 nos) and *Etroplus suratensis* (40 nos). These fishes were collected mainly from Muttukadu experimental station (MES). *Argulus* and *Caligus* were found to infect majority of the brackishwater finfishes. The percentage of *Argulus* spp. infection in *L. calcarifer*, *M. cephalus, S. argus* and *E. suratensis* were 10.5, 6.3, 7.5 and 5.0%, respectively. *Caligus* spp. infection was found only in *S. argus* (4.5%) and *E. suratensis* (2.5%). Interestingly, no parasitic infection was recorded in milk fish, *C. chanos*. The fish lice, *Argulus* spp. infection was most predominantly observed in *L. calcarifer* broodstock. The parasite was identified as *A. quadristriatus,* based on the morphological characterization by transmission electron microscopy and molecular characterization targeting cytochrome oxidase I and hemocyanin genes.

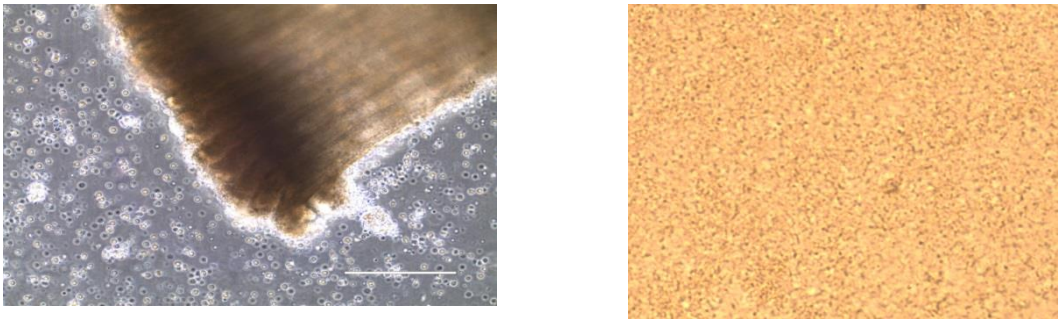


Prevalence of parasitic infections in brackishwater finfishes

***Argulus* under transmission electron microscopy (A) Male (B) Female**

Explant culture from gill and heart of Green mussel, *Perna viridis*

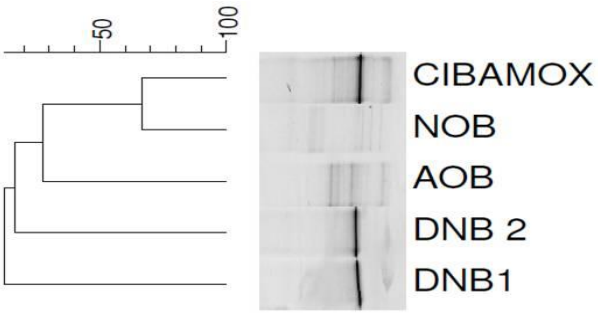
The explant culture from gill and heart of Asian Green mussel, *Perna viridis* was carried out in L15 medium augmented with salt and incubated at 26 to 28 °C. Explant cultures of both organs showed the migration of epithelial cells at 24 h. The gill epithelial cells had both ciliated and non-ciliated cells and measured 11.54±1.94µm and 15.30±5.84µm at 24 and 48h, respectively. The heart epithelial cells were somewhat smaller and measured 8.68±2.58µm and 11.61±4.31µm after 24h and 48h. Eight passages of these epithelial cells were successfully carried out. These explant cultures could be used for environmental toxicants study and shrimp virus propagation.



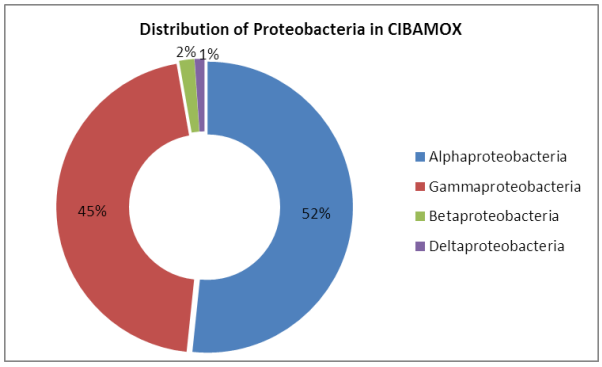
Green mussel, *Perna viridis* gill explant culture and gill epithelial monolayer

Microbial Profiling of nitrifying and denitrifying bacterial product 'CIBAMOX'

CIBAMOX, a product of CIBA, containing enrichments of ammonia oxidising bacteria (AOB), nitrite oxidising bacteria (NOB) and denitrifying bacteria (DNB) was analysed for the associated microbial composition by PCR-DGGE. The product contained two DNB, eight AOB and 11 NOB groups. Metagenomic analysis recovered 199 operational taxonomic units (OTUs) covering 21 phyla, consisting of proteobacteria (62%) which includes Alphaproteobacteria (32.4%), Gammaproteobacteria (28.6%), Betaproteobacteria (1.0%) and Deltaproteobacteria (0.7%). Patent for unique consortia and manufacturing methodology was filed (Patent No. 201841010230, Priority date March 20, 2018).



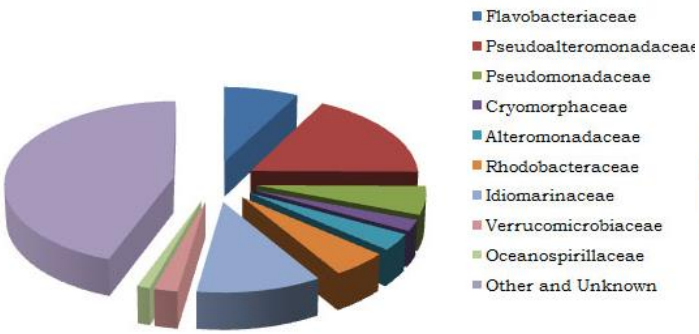
PCR-DGGE analysis of AOB, NOB, DNB and CIBAMOX



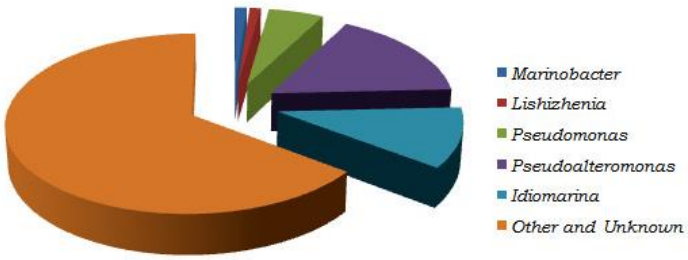
Microbial composition of CIBAMOX

Metagenomic analysis of EHP and white faecal syndrome (WFS) affected shrimp pond

Enterocytozoon hepatopenaei (EHP) infection and white faecal syndrome (WFS) are the emerging threats in shrimp culture. To understand the disease process, microbial profiling through metagenomic approach was carried out in a shrimp culture pond affected with EHP and WFS syndrome at Bhadrak, Odisha. The high throughput DNA sequencing at Illumina Miseq platform was carried out using V3-V4 regions of 16S rRNA gene. The dominant bacterial families found in the water sample were Pseudoalteromonadaceae (17.44%), Idiomarinaceae (11.12%), Flavobacteriaceae (7.71%), Pseudomonadaceae (5.58%), Rhodobacteraceae (5.03%), Alteromonadaceae (3.31%), Cryomorphaceae (2.20%), Verrucomicrobiaceae (2.09%) and Oceanospirillaceae (1.14%). Among dominant bacterial genus, the presence of *Pseudoalteromonas* (16.54%), *Idiomarina* (10.99%), *Pseudomonas* (5.45%), *Marinobacter* (1.17%) and *Lishizhenia* (1.09%) were prominent. Only 0.12% of the total OTUs belong to *Vibrio* spp.



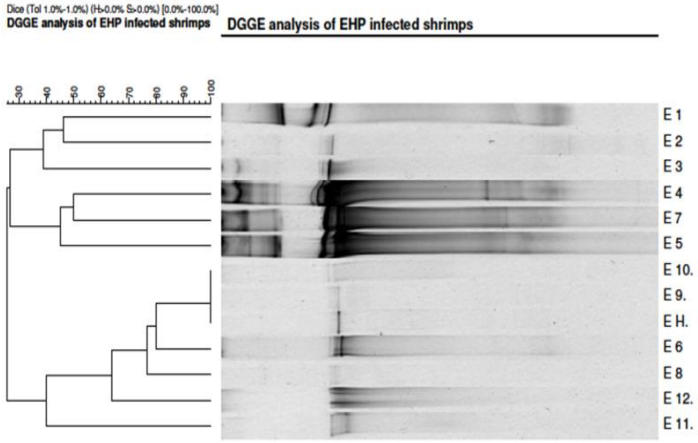
Family-wise microbial diversity in EHP affected shrimp pond



Microbial genera in EHP affected shrimp pond

EHP affected hepatopancreas showed higher microbial diversity

The culture dependant and culture independent bacteriological profiling of EHP infected shrimp hepatopancreas was carried out to assess the role of bacteria in EHP disease progression. A total of 22 hepatopancreas samples; 12 EHP infected and 10 uninfected were processed by culture independent PCR- DGGE method. The EHP infected hepatopancreas showed increased microbial diversity compared to normal healthy hepatopancreas. Further, the microbial diversity in I-step positive EHP cases (n=5) were higher than II-step positive EHP cases (n=7). The higher bacterial count witnessed the progression of secondary bacterial infection with increase in EHP infection of shrimp.



PCR-DGGE analysis of EHP affected shrimp samples

Using culture dependant method, 37 bacterial isolates from 18 EHP positive cases were characterized and further confirmed by 16S rRNA gene sequencing. The analysis revealed 58% prevalence of *Vibrio* species such as *V. alginolyticus, V. parahaemolyticus, V. azureus* and other vibrios followed by 42 % of miscellaneous bacteria such as *Shewanella sps, Staphylococcus epidermididis, S. sciuri, Exquo bacterium, Rothia terrae* and unidentified bacterial sps. The pathogenicity of vibrios was tested using immersion based challenge trial and were found to be non-pathogenic to shrimp post larvae. The study confirms the bacterial isolates from the hepatopancreas of EHP infected shrimp are of secondary pathogens gained entry due to disruption of hepatopancreatic tubules.

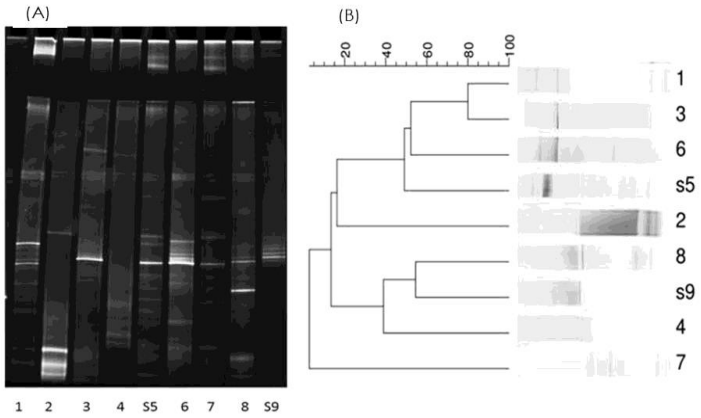
Microbial profiling in milkfish (*Chanos chanos*) larval rearing systems

Milkfish (*Chanos chanos*) is a herbivorous euryhaline fish known for its relative resistance to disease and infections. Through rigorous effort, ICAR-CIBA has succeeded in breeding of milk fish. Understanding the normal microbiota is essential for devising the strategies for upscaling the seed production and promoting the health. Taking initiative in this direction, study on microbiota associated to milk fish larvae and culture water was carried out by culture-dependent and culture-independent methods. Further, microbial association from the day of spawning to post weaning period was carried out to ascertain the beneficial nature and any relation to larval survival and productivity. The maximum heterotrophic and *Vibrio* population in the larval rearing system reached to 10^4 to 10^5 cfu ml^{-1} with no significant effect on survival. Gram-positive bacteria, especially, *B. polymyxa, B. brevis and B. circulans* were predominantly present in rearing water and larvae. Among Vibrios, *Vibrio fisheri*, *V. coralliilyticus, V. superstes and V. hepatarius* were common in rearing water and fish larvae. However, presences of *V. mimicus* and *V. metchnikovii* were not established in fish larvae. The culture-independent analysis using density gradient gel electrophoresis (DGGE) suggested the maximum microbial diversity during the pre-weaning period. Further, microbiota of

pre-weaning and post-weaning period clustered separately. The study clearly indicates the feeding and spawning has significant contribution to bacterial profiles of milk fish and gram positive bacteria *Bacillus* were more prominent in rearing water and fish larvae.

Bacteria associated with milkfish larval rearing cycle

Bacteria	Rearing Water	Milkfish Larvae
Gram positive	*Bacillus polymyxa* *Bacillus brevis* *Bacillus circulans*	*Bacillus polymyxa* *Bacillus brevis* *Bacillus circulans*
	Vibrio fisheri *Vibrio coralliilyticus, Vibrio superstes* *Vibrio hepatarius*	*Vibrio fisheri* *Vibrio coralliilyticus, Vibrio superstes* *Vibrio hepatarius*
Gram negative	*Vibrio mimicus*	Not established
	Vibrio metschnikovii	Not established
	Not established	*V. mytilli*

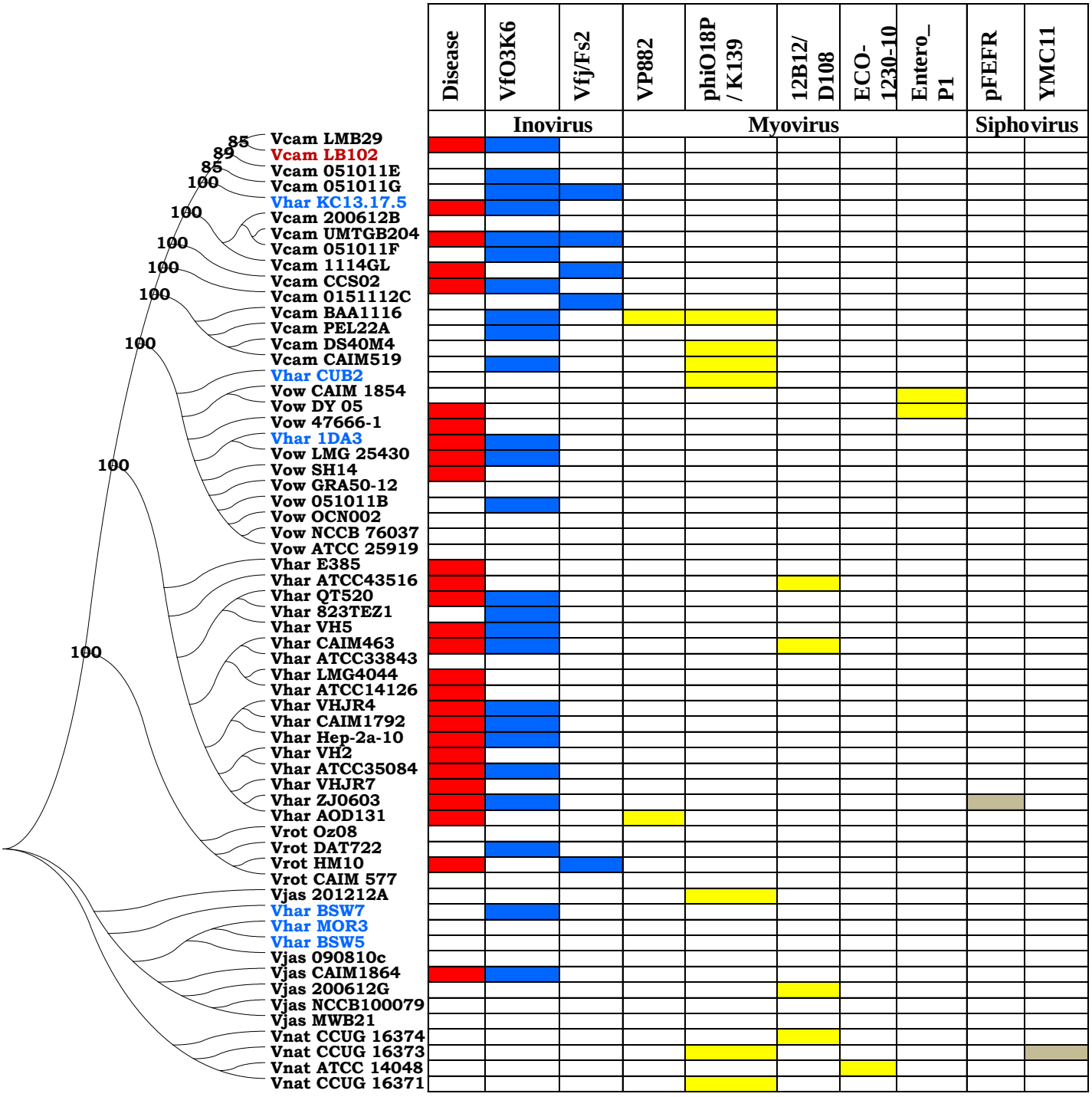


Profiling of microbiota from milkfish larvae using DGGE PCR (A) and dendrogram analysis using UPGMA algorithm (B), Lane 1, 2, 3, and 6 were profiles of microbiota during pre-weaning period, 4, 7 and 8 were post-weaning , S5 and S9 were on first day of spawning.

Virulence of Vibrio

Lysogenic filamentous phages are widely distributed among Indian isolates of *Vibrio campbellii*

Lysogenic phages play major role in virulence of many *Vibrio* species such as *V. cholerae* and pandemic strains of *V. parahaemolyticus*. To understand the role of lysogenic phages in Harveyi clade species, 60 isolates within six Harveyi clade including *V. campbellii* and *V. harveyi* were examined using bioinformatic tools. The results indicated that an inovirus, a filamentous phage was present in as many as 29 isolates. Other phages such as myovirus was found in 15 isolates and siphovirus in two isolates. The PCR analysis revealed the presence of inovirus phages in 33% *V. campbellii* isolates maintained at CIBA. The role of these phages on the virulence of vibrios is under investigation.



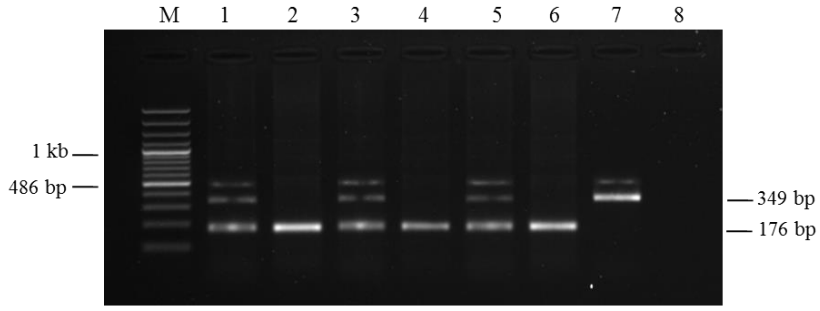
Distribution of lysogenic phages in harveyi clade. The phylogeny of harveyi clade is based upon the consensus of 1710 core genes

Development of diagnostics

A semi-nested PCR protocol for the detection of EHP in shrimp

Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) is an emerging microsporidian parasitic disease in *P.*

vannamei and *P. monodon.* It is often associated with severe growth retardation and/or white faeces syndrome resulting considerable economic loss to shrimp aquaculture. A number of diagnostic tools such as PCR, isothermal loop-mediated amplification (LAMP), real time PCR and *in situ* hybridization have been described for the detection of EHP parasite in post larvae, shrimp hepatopancreas and faeces. A new sensitive nested PCR method based on a gene encoding spore wall protein (SWP) of EHP spore was reported to be more than the other techniques. At CIBA, a new semi-nested PCR protocol targeting spore wall protein (SWP-PCR) gene of EHP in shrimp was developed. The PCR products of 486 bp (first step) and 349 bp (nested) were generated by an optimized amplification cycle. This kit includes β-actin house-keeping gene with the amplicon size of 176 bp to ensure the perfectness of the nucleic acid extraction. The detection of EHP was accurate in experimentally infected *P. vannamei* (n=20) without false positives in healthy (n=20) shrimp. The detection limit of the kit is 20 copies of plasmid DNA. The developed semi-nested PCR protocol was found sensitive and specific to detect EHP in different species of shrimps, artemia, polychaetes, bivalves and environmental samples such as faeces, soil, water *etc*. from shrimp ponds.



M-marker (100 bp), 1- PL (EHP +ve), 2- PL (EHP -ve), 3- hepatopancreas (EHP +ve), 4- hepatopancreas (EHP -ve), 5- faecal thread (EHP +ve), 6- faecal thread (EHP -ve), 7- Positive control (plasmid) , 8- Negative control.

Detection of EHP in different types of samples from shrimp using Single tube nested PCR

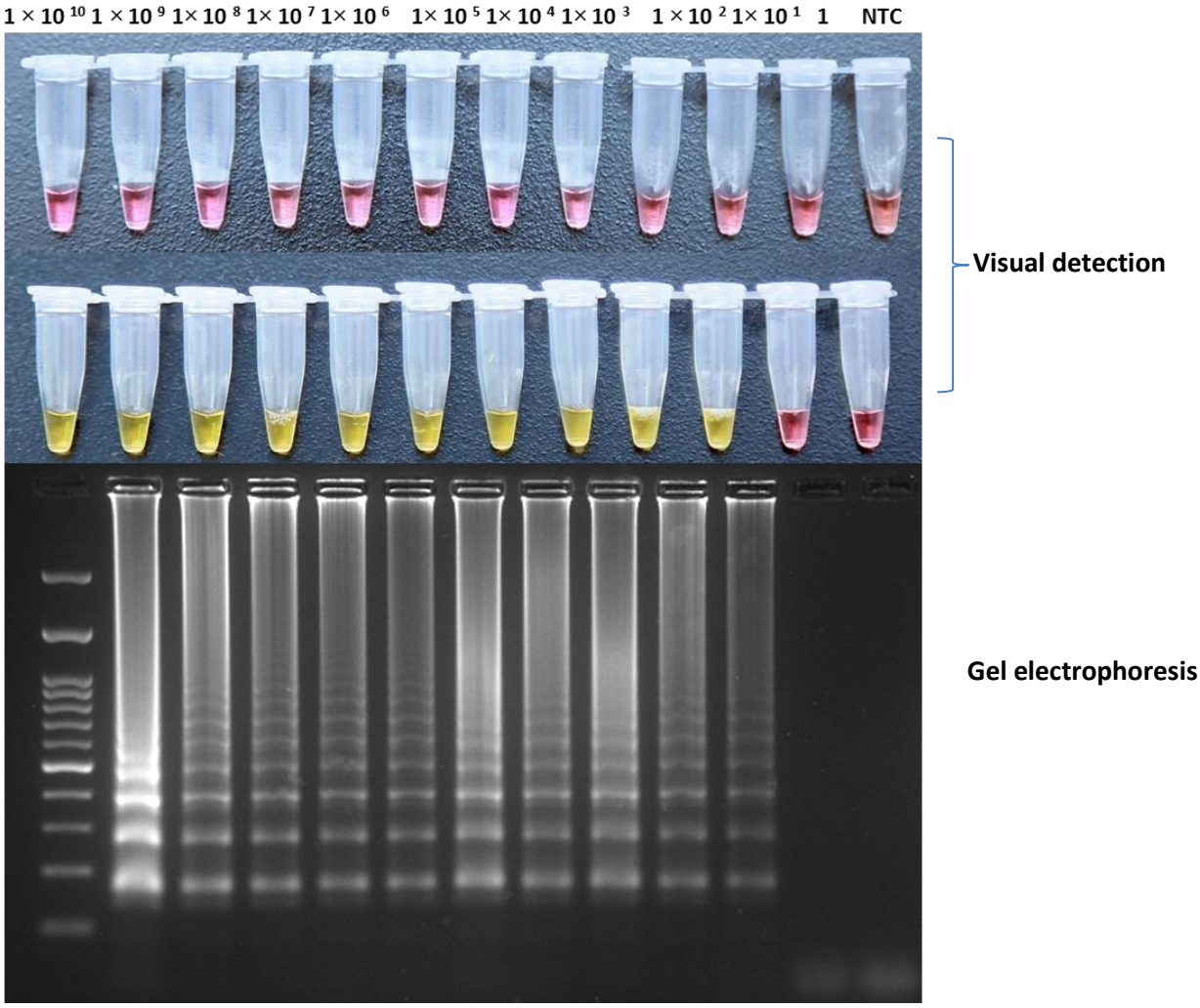
Quantitative detection of EHP using TaqMan probe based real-time PCR

A real-time PCR assay was developed for the quantitative detection of *E. hepatopenaei* (EHP). A TaqMan probe and a pair of specific primers were designed based on the small subunit ribosomal RNA (SSU rRNA) gene sequences. It showed a good linearity in detecting positive control plasmid (pGEM-SSU) containing the target sequences for EHP SSU rRNA gene as standards (10^2 to 10^6 copies/reaction) using the optimized protocol. The detection limit of the qPCR method was 40 copies per reaction, which was superior in sensitivity than the conventional PCR and nested PCR. The protocol was found suitable to quantify EHP in slow-growing *P. vannamei* collected from shrimp ponds and experimentally infected shrimps. Overall, the test was found sensitive, specific and easy to perform (96 tests in<3 h) for detecting EHP.

LAMP assay for field level detection of *EHP*

Currently existing diagnostics of EHP is based on the microscopic demonstration of spores in hepatopancreas and faecal samples and by PCR targeting 18 s small subunit (SSU) rRNA gene (SSU-PCR) or spore wall protein gene (SWP-PCR). A rapid, sensitive and specific, loop mediated isothermal amplification (LAMP) test for the field level diagnosis of EHP was developed. The reaction was set-up using primers targeting spore wall protein at constant temperature of 65°C for 60 min. The amplified LAMP products were visually detected without opening the PCR tube. The sensitivity of thee developed assay was 10 copies. Field and clinical applicability of the assay was demonstrated using 60 field samples including 40 hepatopancreas and 20 faecal samples. The EHP was detected in 41 samples including 21 hepatopancreas and 15 faecal samples. This LAMP

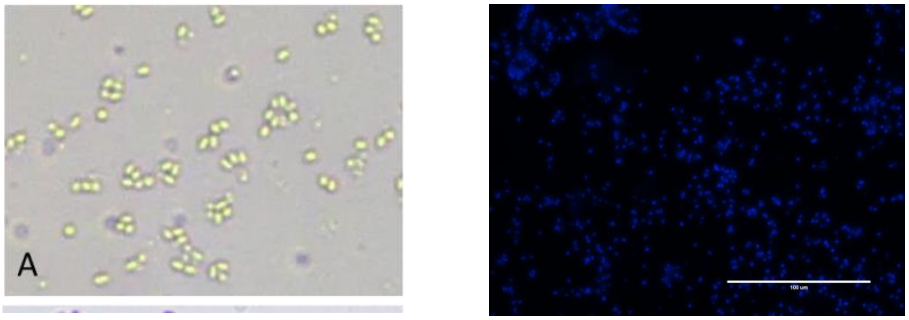
assay is rapid, sensitive and more specific diagnostic procedure than SSU-PCR and equivalent to nested SWP-PCR. The test has great potential for diagnosing EHP at the farm level, particularly under low resource circumstances.



Visual detection of LAMP products of EHP and gel electrophoresis

Rapid detection of viable EHP spore using chemoflourescent staining in fresh tissues

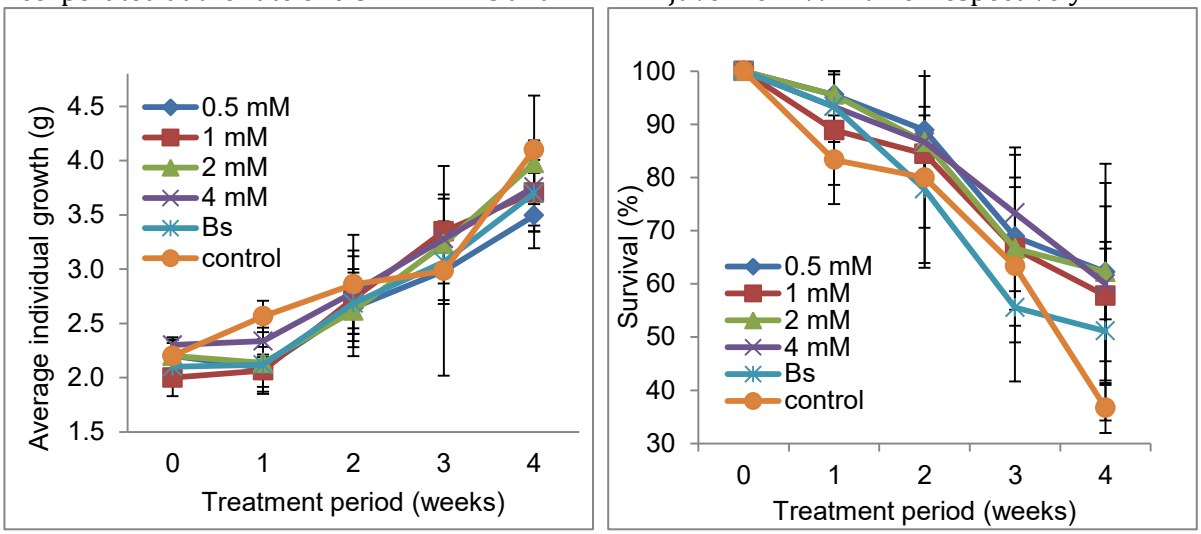
The PCR based assays detect DNA and not necessarily a viable pathogen. Therefore, to confirm the presence of a viable pathogen, Calcofluor White, a fluorescent dye, was tested for quick identification of EHP spores and their localisation in hepatopancreatic tissue. Calcofluor White is a non-specific fluorochrome that binds with cellulose and chitin present in the cell wall. The microsporidian spores appeared as bluish-white or turquoise oval halos when viewed through EVOS FL Auto Cell Imaging System at wave length between 345 455 nm of DPAI illumination light cube. The Calcofluor staining protocol is sensitive, fast and require ~15 min to perform.



Microscopic detection of *Enterocytozoon hepatopenaei* spores from *Penaeus vannamei:* A: Fresh spores; B- Calcoflour stain. 1000x

Fortification of probiotics with Selenium nanoparticles for enhanced activity

Probiotics has become the integral part of farm inputs to enhance aquaculture productivity. Selenium is an essential dietary nutrient and plays an important role in the functioning of the immune system and promoting cellular immune response. In addition, selenium in the bioavailable form has been shown to promote growth and may improve health of the shrimp because of its anti-microbial property. To harness its beneficial effects, selenium nanoparticles (SeNP) were synthesised in probiotic bacterium and examined for its potentiality to enhance shrimp immunity and larval survival. Wet lab experiments showed 35% and 25% higher survival over control when SeNP incorporated at the rate of 0.5mM in PLs and 2 mM in juvenile *P. vannamei* respectively.



Average growth and survival of shrimp juvenile fed with selenium nanoparticles (SeNPs)

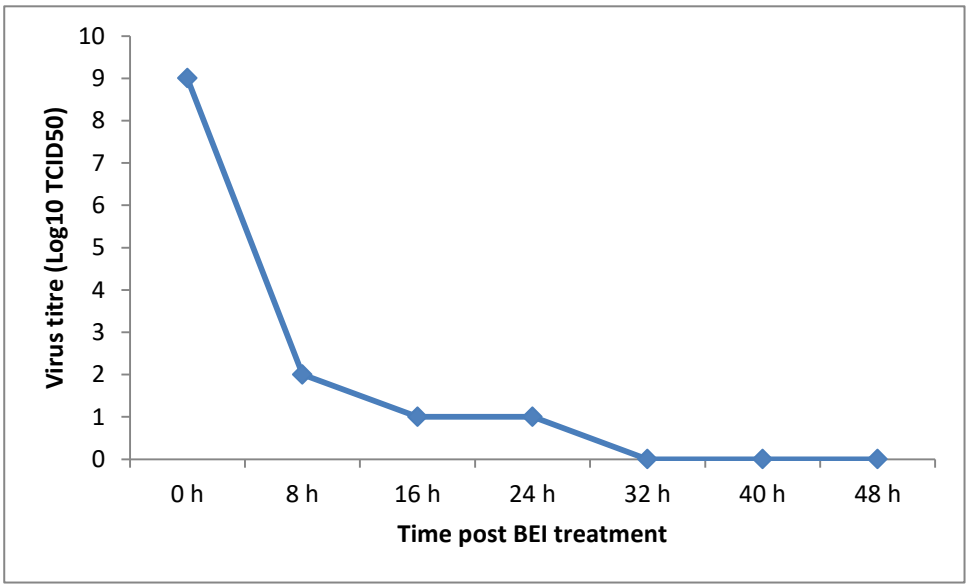
Lactic acid bacteria (LAB) isolated from shrimp gut inhibited the growth of *V. parahaemolyticus*

Lactic acid bacteria (LAB) is known for their ability to inhibit bacterial pathogens, stimulate growth and immunity of cultured species. To develop effective probiotics, a number of lactic acid bacteria (n=52) LAB was isolated from the gut of wild shrimp (*Penaeus monodon*, *P. indicus* and *P. penicillatus)* from Kakdwip and Sagar island of Sundarban, India. Out of tested 52 isolates, 29 isolates inhibited the growth of *V. parahaemolyticus* below 1.0 Log_{10} CFU/mL from ≥ 9 Log_{10} (control). The growth of *V. parahaemolyticus* was also inhibited by the cell free culture supernatant of 21 LAB isolates. The further characterisation by 16S rRNA gene sequencing identified two of the potential LAB probiotic strain as *Lactococcus lactis* subsp. *lactis* and *Lactobacillus casei*.

***Lactococcus lactis subsp. lactis* on Lactobacillus MRS agar**

Development of inactivated vaccine against nervous necrosis virus (NNV)

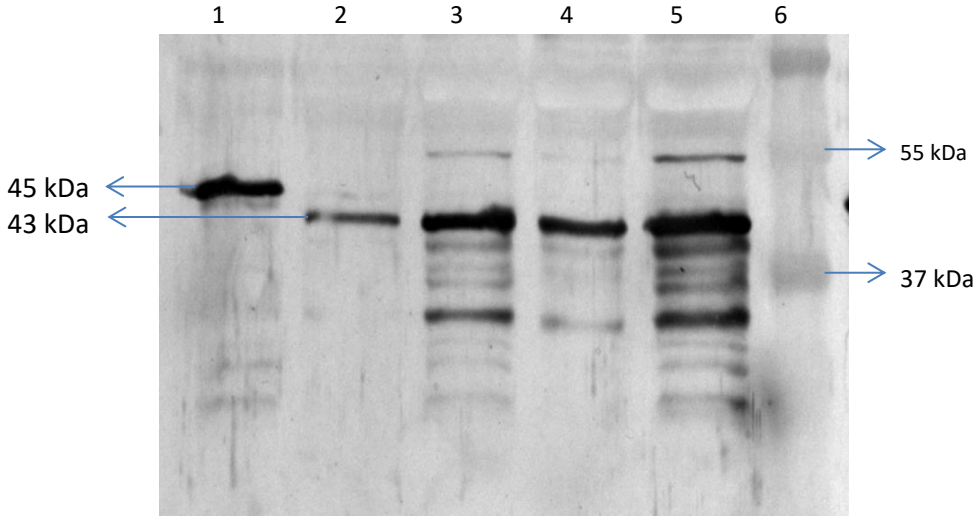
Viral encephalopathy and retinopathy (VER) also called as viral nervous necrosis (VNN) is an acute viral infection of brackishwater and freshwater fishes. It affects 120 fish species and causes up to 100% mortality in Asian seabass fry. The virus is also transmitted vertically through infected broodstock, eggs and ovarian fluid. One of the best possible control measures against VNN is by vaccinating the broodstock, fry and fingerlings. The NNV isolated from infected seabass was plaque purified and propagated in SSN-1 cell line. The virus was inactivated using binary ethylenimine (BEI) for 72 h. The inactivation kinetics suggests that virus could be 100% inactivated by 32 h after addition of BEI. Oral and immersion vaccine was produced by mixing the inactivated cell culture supernatant with Montanide Essai GR01 PR and Montanide IMS 1312 VG NPR adjuvants. The vaccine was orally administered to 30 days old seabass seeds. Twenty eight days post vaccination, the vaccinated and control fish were challenged with virulent NNV through intraperitoneal route. The vaccinated group produced 60% relative percent survival (RPS) suggesting the possibility of developing effective vaccine against NNV.



Inactivation kinetics of nervous necrosis virus (NNV) using binary ethylenimine as inactivation agent

Development of polyclonal antibodies against NNV

The gene encoding the capsid protein of NNV was amplified using specific primers. The amplified product was initially cloned into pTZ57R/T vector and sequenced. The capsid gene in the recombinant plasmid was purified by double digestion and cloned into pET28b vector. The recombinant plasmid was transformed in to BL21 DE3 cells and a pilot expression was carried out. Bulk protein was produced by IPTG induction and the expressed protein was purified using nickel affinity chromatography. The purified protein was characterized by SDS-PAGE analysis and quantified. The recombinant protein was used to immunize New Zealand white rabbits to produce polyclonal antibodies against NNV. The antibody titre was estimated by ELISA. The specificity of the antibodies was confirmed by western blot against the recombinant coat protein and NNV. The recombinant NNV coat protein and NNV infected cell culture supernatant was electrophoresed on a 12% SDS-PAGE gel and blotted on to a PVDF membrane. After blocking, the membrane was incubated with polyclonal antibodies and secondary antibodies. The TMB substrate was used to detect the specific binding of the antibodies. The antibodies reacted with both whole virus and recombinant coat protein. The antibody developed against capsid protein could be used for developing diagnostics and testing the efficacy of vaccine.



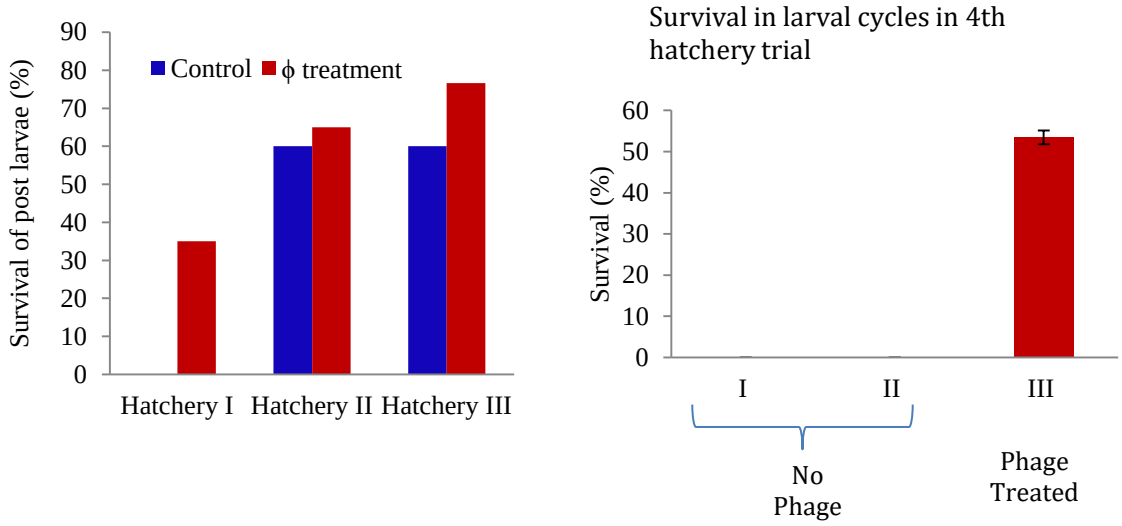
Western blot for NNV using polyclonal antibodies against recombinant capsid protein of different concentrations.

Prophylactics

Biocontrol of vibrios in shrimp hatcheries using bacteriophages

Luminescent bacterial disease is one of the biggest threats in shrimp hatcheries. To control bacterial infection, hatchery operators often apply large quantity of antibiotic. In recent times, bacteriophage therapy is emerging as an effective biocontrol measure to control bacterial infections. CIBA has a stock of well-characterised bacteriophages. Based upon the lytic spectrum, a consortium of four bacteriophages was formulated for prophylactic and therapeutic application. The growth conditions of these bacteriophages along with their host bacterium were standardised in fermenter. The yield of phages ranged between 10^{10} pfu ml^{-1} to 10^{12} pfu ml^{-1}. Before applying in the hatchery, the traces of bacterial contamination were removed by filtration and its biosafety and efficacy were further tested in the laboratory conditions. As therapeutic measure, the phage consortium was tested at five multiplicity of infection (MOI) with 35% survival (hatchery I) against 100% mortality in non-treated larval unit. As prophylactic measure at one MOI, a higher production of 15% (hatchery II) and 17% (hatchery III) was obtained compared to control. Bacteriophage application in these hatcheries caused one to two logs reduction in *Vibrio* and luminescent *Vibrio* counts. The

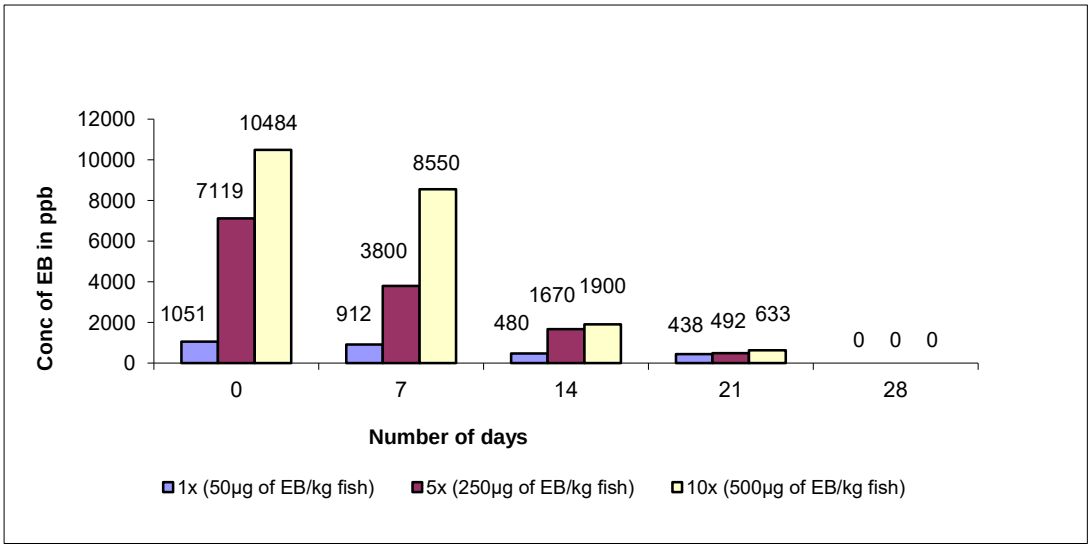
hatchery IV had history of severe luminescent vibriosis with complete loss of stock for two consecutive cycles. The phage therapy resulted in 53% production of shrimp post larvae and no luminescent bacteria were detected during the treatment. These field trials established the potential of phage therapy for treating luminescent bacterial disease in shrimp hatchery. A provisional patent for consortia of four bacteriophages was filed (# 201841010229).



Survival of *P. vannamei* larvae in commercial shrimp hatchery during bacteriophage trial

Withdrawal periods and degradation of drugs and chemicals used in aquaculture

Study was conducted to evaluate the safety and withdrawal period of emamectin benzoate an effective antiparasitic agent in Asian seabass, *Lates calcarifer* fingerlings (7.69±0.03g). The drug administered at the therapeutic dose of 50µg of EB kg^{-1} fish BW d^{-1} for 7 d was found to be safe and no residue of the drug could be identified in LC-MS/MS analysis 28 days after the withdrawal of administration. Studies on the degradation of oxytetracycline indicated the positive role of salinity, temperature and photoperiod. 98% of OTC was degraded in 2 days at 36°C compared to 5 days at 25°C. Similarly, the degradation was faster in lower salinity at 5 ppt compared to that of 25 ppt.



Withdrawal period of emamectin benzoate (EB) in Asian seabass, *Lates calcarifer*

Services to the sector

National Referral Laboratory for Brackishwater Aquatic Animal Diseases

CIBA's Aquatic Animal Health and Environment Division is serving as National Referral Laboratory for brackishwater aquatic animal diseases (NRLD) and serving the stakeholders including Aquatic Quarantine and Certification Services (AQCS), Southern region, Aquatic Quarantine Facility (AQF), Chennai, shrimp hatcheries and shrimp farmers. During April 2017 to March 2018, a total of 53 samples including imported Artemia cyst, frozen tissue and feed samples were tested for OIE listed shrimp and fish pathogens for the AQCS, Chennai. Apart from one positive Artemia cyst sample for EHP, other samples were tested negative for OIE listed pathogens. From disease diagnostic services CIBA generated revenue of Rs. 9,56,060/-.

Screening of samples for OIE listed pathogens

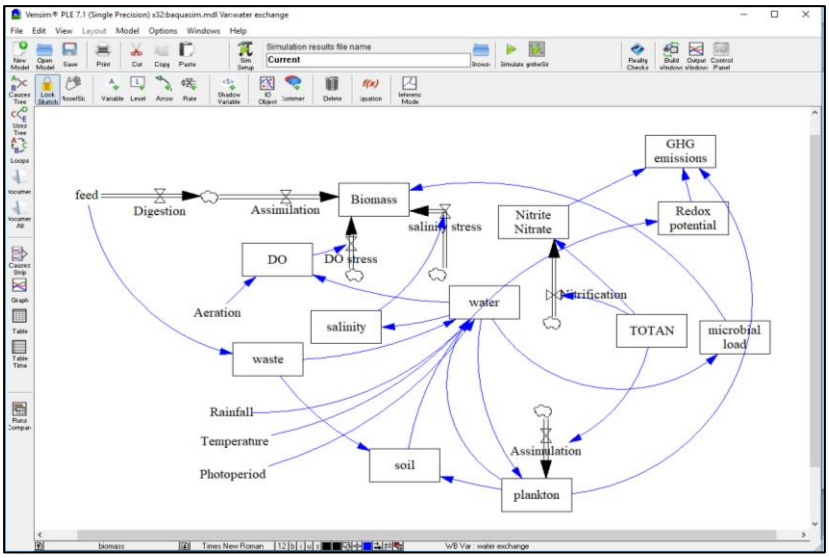
Sl.No.			DNA viruses		RNA viruses			Bacteria		Parasite
	Sample	No Tested	WSSV	IHHNV	IMNV	TSV	YHV	AHPND	NHPB	EHP
1	Reimported frozen tissue samples	1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	Imported Artemia cyst	39	-ve	-ve	-ve	-ve	-ve	-ve	-ve	1
3	Imported Fish feed	2	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
4	Imported Prawn feed	9	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
5	Imported Krill Oil	2	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
6	Total samples Tested	53	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve

AQUACULTURE ENVIRONMENT AND CLIMATE CHANGE

Thematic area: Production Systems Research

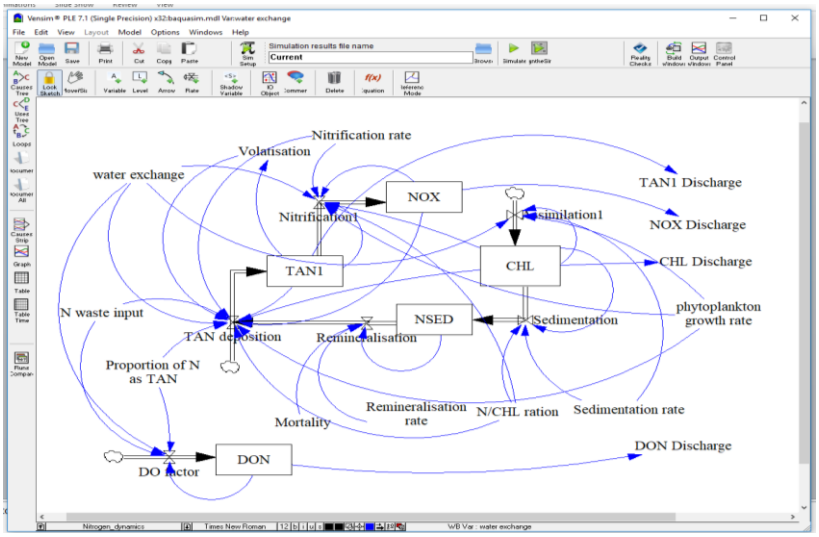
Modelling shrimp growth

In order to develop dynamic simulation models for shrimp aquaculture stocks rates and flows were set based on the relational diagram prepared covering all the processes of shrimp farming. Major output parameter of the model is biomass produced from the shrimp culture system. Systems dynamics software Vensim was used to build the model.



Shrimp biomass model using Vensim software

Main model outputs include total biomass, climate effects on growth, greenhouse gas emissions. There are several sub-processes of the model which needs to be addressed first. To start with, nitrogen dynamics sub-process was built at first. TAN, NOX, DO, sedimentation, phytoplankton are the five key state variables of the model. This model assesses the discharges into the system which will directly or indirectly affect the shrimp growth. Calibration of the model and parameter estimation is being done with farm level data.



N dynamics sub-process model

Integrated freshwater (low saline) shrimp and paddy farming model

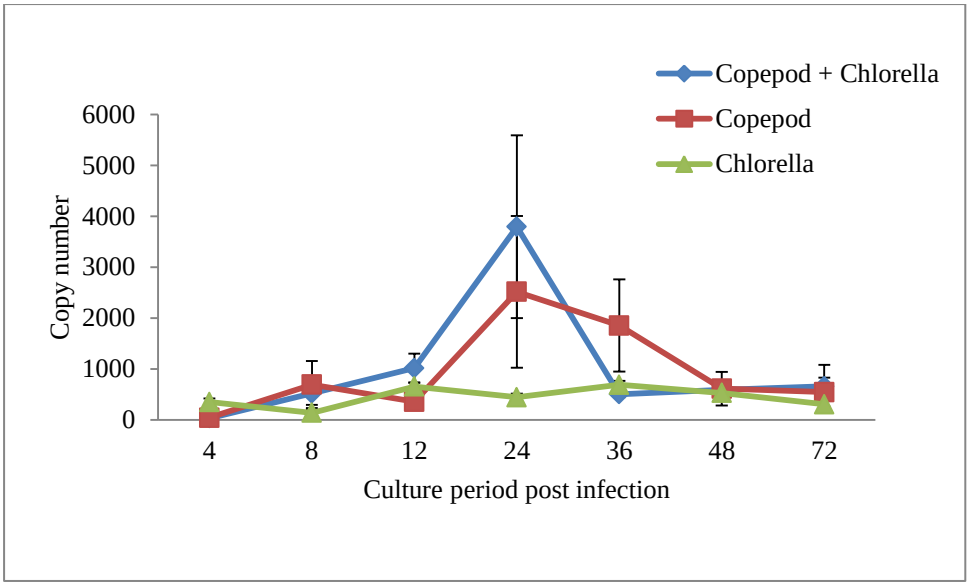
In order to assess the environmental impacts of freshwater/low saline shrimp aquaculture, case studies were conducted in Orthanadu, Thanjavur District, Tamil Nadu since last two years. Most of the low saline (0 to 1 ppt) shrimp farms are surrounded by rice fields. The shrimp species *P. vannamei* is being cultured in 0 to a maximum of 1 ppt salinity. Vannamei is well adapted to low salinities due to its osmoregulatory capacity. Salt was not added in the ponds and minerals were applied to mitigate the imbalance in minerals. The discharge water from these farms is being used by the neighbouring agriculture farmers for irrigating paddy crop (Variety: ADT-43, Duration: 100 days) during Kharif and Black gram in Rabi since last five to six years. Even without paddy crop also, farmers are taking water and ploughing the fields to enrich the fertility status of soil. Paddy crop irrigated with nutrients rich shrimp farm discharge water resulted in additional paddy production of 8 to 10 bags/ac compared to irrigation with normal water, regularly being followed. Farmers are getting an additional income of about Rs. 15,000 and Rs.25,000/- for paddy and back gram respectively per acre due to increase in production and also by decreasing the fertilisers application compared to the recommended dose. The sediment from the shrimp culture ponds has been applied as manure for the tree crops within the farm. Better height growth and diameter growth of Teak trees with the use of harvested low saline shrimp pond sediment compared to control showed its potential as manure for horticultural crops.

Teak tress growth supplemented with and without harvested pond sediment

<u>Thematic area: Animal Health</u>

Influence of planktons (Zoo and phyto) in transmission of WSSV in *Penaeus vannamei*

Experiment on effect of zooplankton (copepod) and phytoplankton (*Chlorella* sp) on WSSV infection in shrimp (*Penaeus vannamei*) was checked by in-vivo study. Different concentration of copepod (250,500 and 1000 number/L) with or without chlorella (10^5 cells/ml) was infected with WSSV (10^8 copy number/ml) and added to 30L tubs containing juvenile shrimp. The shrimp infected with WSSV through copepod (1000/L) along with chlorella caused 100% mortality compared to no mortality in the group with copepod only. The shrimp with chlorella only experienced partial mortality, indicating chlorella may act as carrier of WSSV and the virus amplify in copepod enhancing shrimp mortality. Viral kinetics was checked in the copepod by quantitative PCR. Viral copy number increased in copepod with or without chlorella and peaked at 24 hpi, but the copepod with chlorella carried higher number than copepod alone group. The experiment indicates phytoplankton like *Chlorella* may act as a carrier and upon feeding on such phytoplankton, copepod amplify the WSSV infection to reach disease causing level in the farming systems.

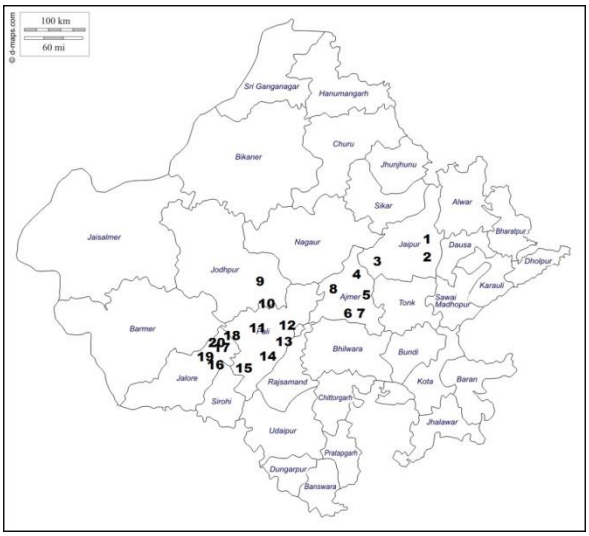


Influence of plankton on WSSV kinetics

Thematic area: Environment

Suitable sites for inland saline aquaculture in Rajasthan

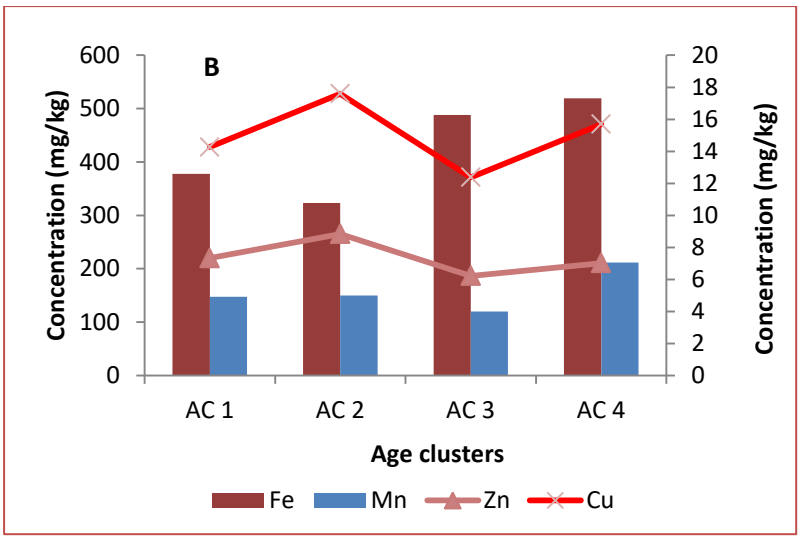
Rajasthan poses vast lands of inland saline areas with varying subsurface water salinity and a survey was undertaken to assess the suitability of sites for aquaculture. Soil and water samples were collected from villages in Jaipur, Ajmer, Jodhpur, Pali and Jalore districts to study the suitability of the areas for inland saline aquaculture. The salinity, pH, alkalinity and hardness of the surface and subsurface water varied from 0-22 ppt, 7.06-9.15, 49-1415 ppm and 84-3480 ppm, respectively. Highly alkaline areas such as Kishangarh and Kanpura were not suitable for aquaculture. Variable productivity of water sources as indicated by nitrate and phosphate concentration of 0.001 to 1.505 ppm and 0.008 to 0.599 ppm, respectively. Ca: Mg ratio range of 0.6 to 28.4, and sodium and potassium concentration of 16 to 27055 ppm and 1 to 254 ppm respectively indicates the variation in mineral profile and the necessity for minerals manipulation. Based on the suitability criteria for farming and willingness of farmers, Jetpura of Jalore district were selected to start aquaculture.



Sampling points in inland saline areas of Rajasthan

Database on minerals status of shrimp culture ponds and source waters

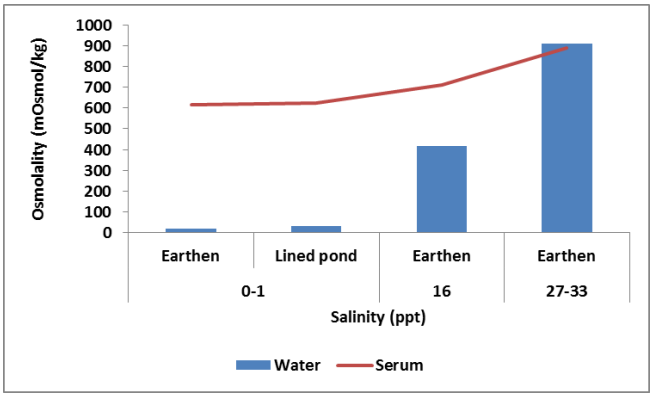
Collection of soil samples from shrimp culture ponds varying in age [age clusters of <5 (AC1), 6 to 10 (AC2), 11 to 15 (AC3) and 16 to 20 years (AC4)], and source waters was continued from different geographical locations and analysed for major minerals (calcium, magnesium sodium, potassium, chloride and sulphate) and trace minerals (iron, manganese, zinc and copper) concentration along with fertility (physico-chemical parameters) in shrimp pond soils varying in age and mineral composition of source waters being used for shrimp farms (creeks and bore wells) was assessed in different geographical locations viz., Andhra Pradesh, Tamil Nadu and Gujarat to understand the changes in soil nutrients and minerals over a period of time. Among the age clusters, soil quality parameters pH, OC, $CaCO_3$, Av. P, Ca, K, Mg, SO_4, Zn and Cu were not significantly varied with pond age. Significantly high concentration of available N, Na, Cl, Fe and Mn concentration were observed in AC 4 ponds. Creek and bore well waters from different locations, even with similar salinity varied in their mineral composition and ionic ratios.



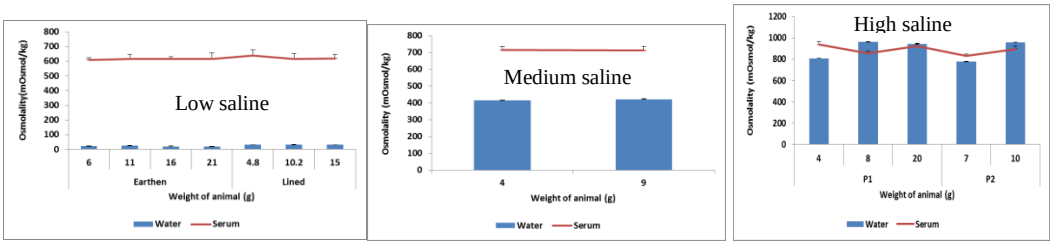
Variation in trace minerals concentration

Adaptability of *P. vannamei* culture under low salinities

There is a growing trend to culture *P. vannamei* in low saline areas. In order to evaluate the adaptability of *P. vannamei* under different salinities, field samples were collected throughout the culture from shrimp ponds of different salinities 0 (earthen and lined), 16 and 32 ppt. The mean water osmolality varied from 21, 419 and 909 mOsmol/kg under 0, 16 and 32 ppt salinity respectively. However, there was not much change in serum osmolality (614, 713 and 888 mOsmol/kg at 0, 16 and 32 ppt), indicating that *P. vannamei* adapts to varying salinities. Shrimp serum osmolality did not vary during culture period and is independent of animal weight in all salinities. During the culture, calcium and magnesium concentration in whole shrimp and water ranged from 30-60, 240-241, 362-724; and 47-83, 703-704, 1067-1690 ppm for low, medium and high saline pond water respectively.



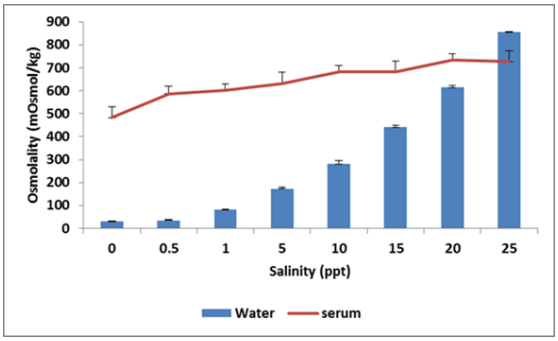
Variation in water and serum osmolality under different salinities



Water and serum osmolality of shrimp during culture period (indicated by increase in animal weight) at different salinities

Influence of steady salinity variation on water and serum osmolality

In order to test the adaptability of *P.vannamei* under the conditions of gradual decrease in salinity, yard experiment was conducted wherein salinity was reduced by 5 ppt from 25 ppt to 1 ppt and by 0.5 ppt from 1 ppt to 0 ppt at every 24 h interval and samples were analyzed for osmolality and mineral content. Water and serum osmolality varied from 855 to 29 and 727 to 484 mOsmol/kg from 25 ppt to 0 ppt. It is quite visible that the osmotic point lies near to 700 mOsmol/kg at 25 ppt of salinity. No major differences in haemolymph osmolality and above 90% survival rate in all salinities indicate that *P. vannamei* shrimp rapidly adapts to drastic changes in the mineral content of water.

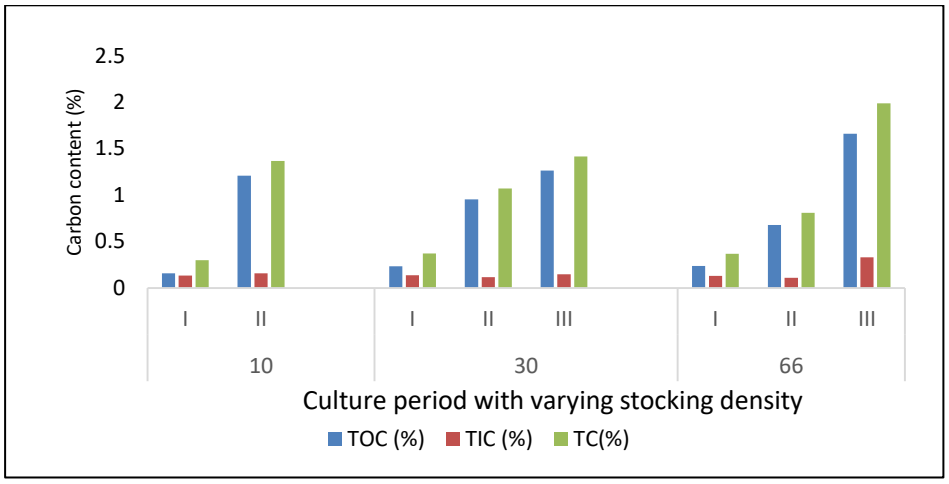


Osmolality of water and serum under gradual decrease in salinity

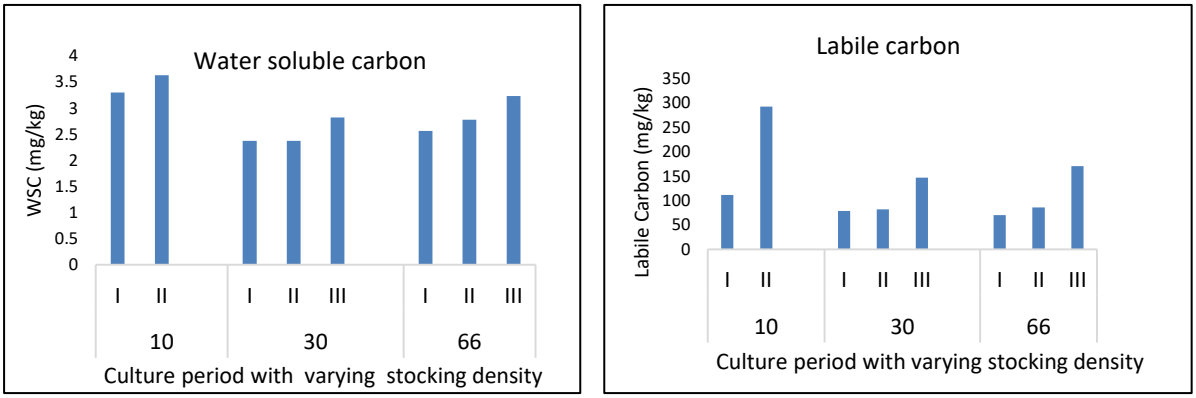
Carbon fractions in pond sediment of shrimp farms varying in stocking density

Investigations on carbon fractions in pond sediment will give indication of pond bottom soil deteriorating condition. Carbon fractions were analysed in high saline shrimp culture ponds (55 ppt at start of culture to 35 ppt during culture period) varying in stocking density (10, 30 and 66 nos./m^2) at Mahabalipuram, Tamil Nadu. The pond with 10 no./m^2 had emergency harvest within 70 DOC. Total organic carbon (TOC) content in sediment increased from 0.16 to 1.21%, 0.2 to 1.27 % and 0.2 to 1.7 % respectively in the ponds with increasing order of stocking density and total inorganic

carbon (TIC) content was comparatively low ranged from 0.1 to 0.3%. TOC content in pond waters ranged from 5 to 9 ppm in the surface layer and from 9 to 15 ppm in the bottom layer. The TIC content was comparatively higher and varied from 19 to 40 ppm in the surface and from 17 to 51 ppm in the bottom layer. The labile carbon and water-soluble carbon **(**WSC) fractions in pond sediment increased linearly during the culture period in all the stocking densities. High labile carbon content in pond with 10 no./m^2 indicates the poor pond bottom condition, the predisposal for emergency harvest.



Carbon fractions in pond sediments varying in stocking density during the culture period



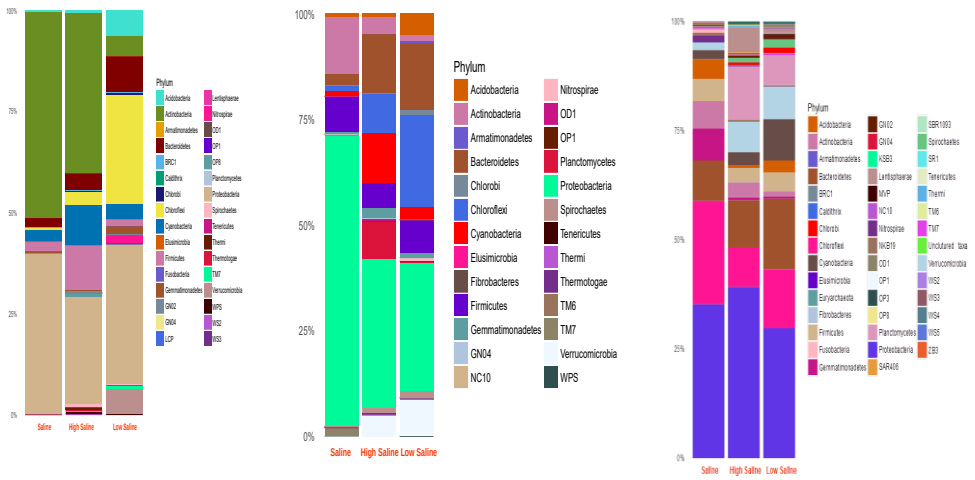
Labile and water soluble carbon in sediments varying in stocking density

Bacterial diversity in shrimp culture ponds by metagenomics

Metagenomics approach was used to understand the diversity of bacterial communities in *P. vannnamei* culture ponds of varying salinity 0-1ppt (low saline - 1ppt), 14-16 ppt (saline - 15 ppt) and 42-47 ppt (high saline - 45 ppt). Soil samples were collected at sediment-water interface (SWI) during 30, 60 and 90 days of culture (DOC). More diverse microbial communities were observed towards the end compared to early days of culture in all salinities. Actinobacteria were dominant at 30 DOC and Proteobacteria at 60 and 90 DOC in saline and high saline culture ponds, whereas in low saline Proteobacteria was dominant during the whole culture period. The predominance of sulfur-reducing bacteria from 60 DOC in low saline, throughout the cropping period in high saline, and at 90 DOC in saline culture ponds indicates the possibility of build-up of sulphide and reduced condition in the pond and requirement for microbial manipulation with the beneficial microbes in improving the pond bottom condition.

Beneficial bacterial communities reported in the culture ponds were Acidomicrobiales, Commondaceae, Myxococcales, Rhizobiales, Sphingomonadales, Rhodospiralles,

Thiotrichales, Chromatiales Cytophagia, Saprospirae, Flavobacteria, Bacilli, Chloroflexi, Synechococcus, Pirellulales, Phycisphaerales, Verrucomicrobia, Acidomicrobia, Nitropspirae, Lentispharae and Chlorobi. Harmful bacterial communities reported were Actionmycetales, Alkaligenacaee, Desulfobacterales, Desulfovibrionales, Syntrophobacterales, Desulfuromonadales, Rhodobacterales, Xanthomonadales, Enterobacteriales, Vibrionales, Alteromonadales, Psuedomonadales, Bacteroidia, Sphingobacteria, Clostridiales, Planctomycetales, Gemmatimonadetes and Spirochaetes.

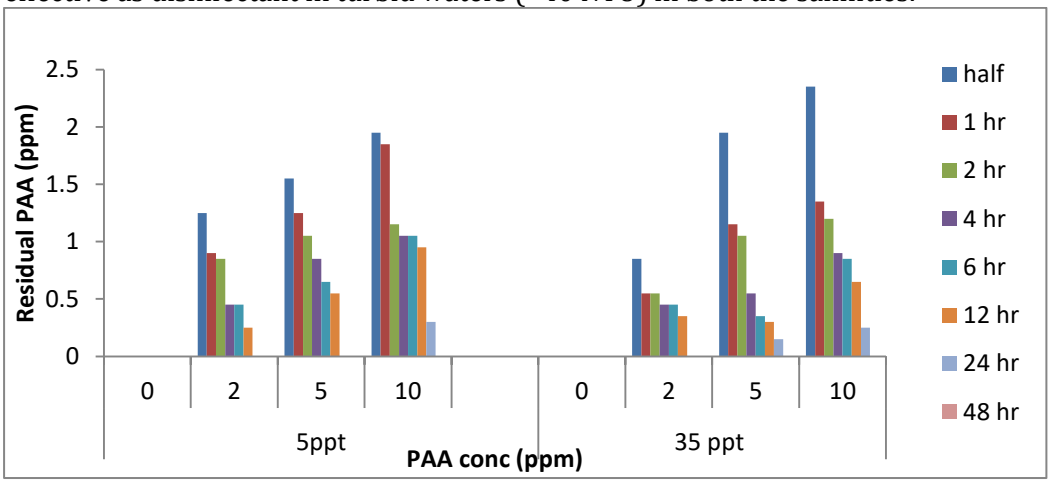


30 DOC 60 DOC 90 DOC

Bacteria phyla at different DOC in *P.vannamei* ponds under varying salinities

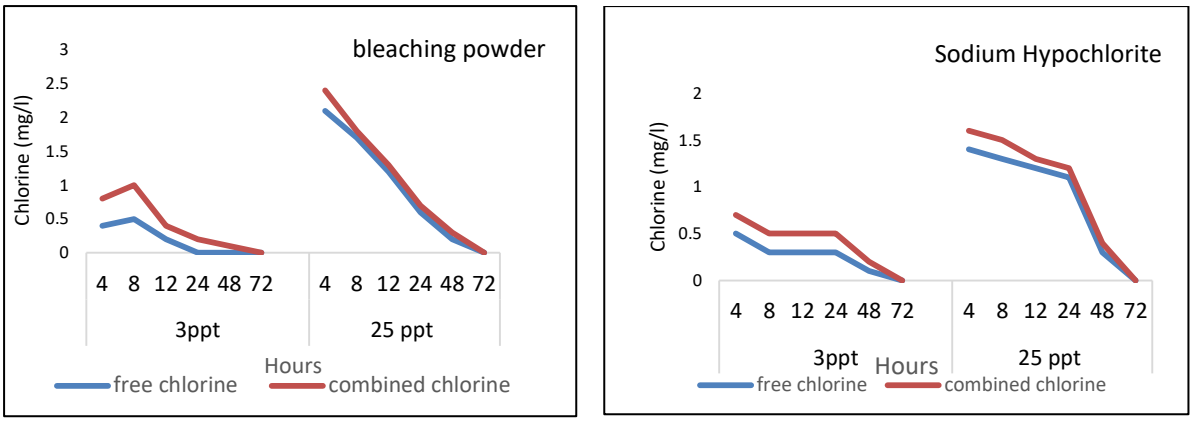
Efficiency of per acetic acid as a disinfectant and ccomparison with other disinfectants

The efficiency of peracetic acid (PAA) at 0, 2, 5 and 10 ppm as disinfectant in 5 and 25 ppt salinities revealed that the residuals of PAA, viz., hydrogen peroxide and acetic acid, reduced to zero after 24 h of application in 2 and 5 ppm and after 40 h at 10 ppm in both the salinities. However, the degradation was faster at lower salinity. The heterotrophic bacterial count 24 h after treatment reduced from 10^7 CFU in control to 10^4 CFU in low saline and 10^3 CFU in high saline water. The disinfection efficiency of PAA on luminescent *Vibrio* sp. by microbial inhibition study conducted from 2 to 100 ppm showed that concentration of 10 ppm inhibited the *Vibrio* growth. PAA wasn't effective as disinfectant in turbid waters (>40 NTU) in both the salinities.



Residual effect of peracetic acid in different salinities

Total residual chlorine (TRC) content was 2.4 and 1.6 mg Cl_2/L compared to 0.8 and 0.7 mg Cl_2/L in high (25 ppt) and low saline (3 ppt) waters after 4 h of application with bleaching powder and sodium hypochlorite at the rate of 10 ppm Cl, respectively. The TRC reduced to zero after 72 h of application in both the cases. Both the disinfectants reduced the heterotrophic bacterial count from 8.3 x 10^4 cfu/ml in low saline and 38 x 10^4 cfu/ml in high saline waters to nil and remained same after 24, 48 and 72 h of treatment. The results indicated that peracetic acid is effective and has a shorter residual effect, and can be used as an alternative disinfectant.

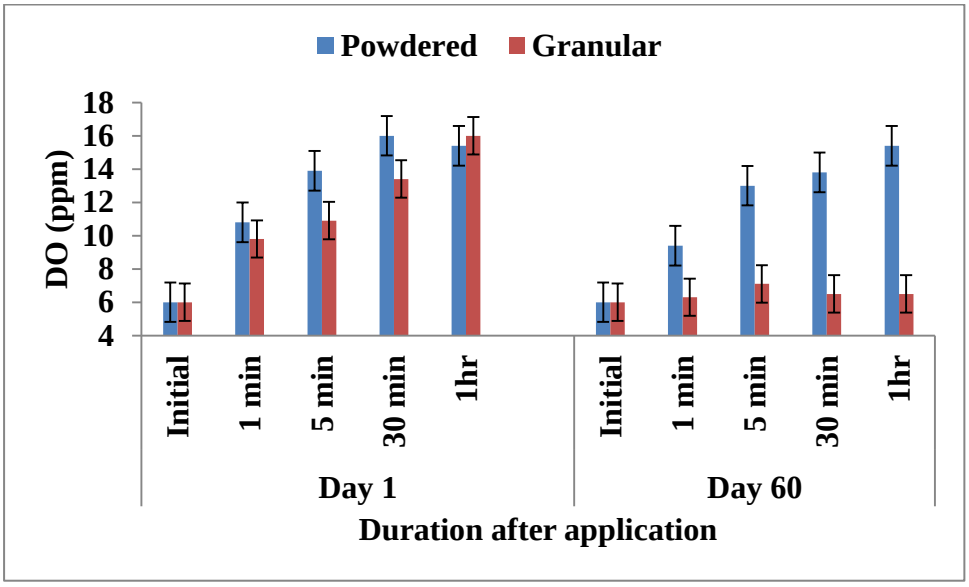


Residual effect of bleaching powder and sodium hypochlorite at different salinities

Enhanced stability of prototype Oxygen Releasing Compound (ORC)

Even though mechanical aerators are commonly used for better aeration, under emergency situation oxygen releasing compounds are applied by the farmers to increase oxygen levels in pond water. Sodium per carbonate-based oxygen releasing compounds were synthesized in granular as well as powder form and their stability was evaluated by their dissolved oxygen release efficiency at different time intervals. The granular form was synthesized by physically mixing the active ingredients, activators, and stabilizers. Powder formulation was synthesized by pulverizing active components individually and mixing the powdered components with each other. The prototype powder form ORC was more stable, attained DO level of 15.4 ppm compared to 7.1 ppm with granular form ORC after two months from an initial value of 16 ppm observed with both the forms immediately after preparation. The DO level in control was 4.8 ppm indicating the efficiency of product to increase DO levels in an emergency situation.

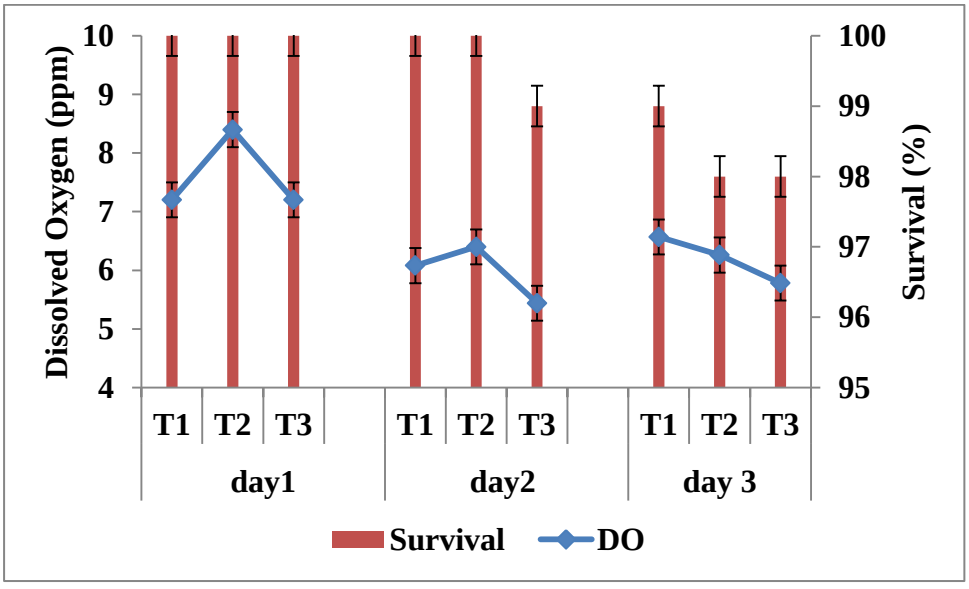
Granular and powder formulation of prototype ORC



Effect of storage period on the stability of the ORC formulations

Efficiency of prototype ORC in comparison to aeration

With the objective of studying the effectiveness of ORC in comparison to mechanical aeration a yard experiment was conducted with three treatments namely complete aeration (T_1), partial aeration and ORC (T_2) and ORC alone (T_3). *P. vannamei* was stocked at 45 no./m^2 and ORC was applied twice a day (1g/100 litre). Application of ORC was statistically on par with the aeration with respect to survival and water quality parameters for three days and later decrease in survival with only ORC. The survival was 99, 98 and 98% in T_1, T_2, and T_3, respectively on third day. The study revealed that ORC could be utilised as a supplement/ replacement to mechanical aeration under emergency condition for three days.

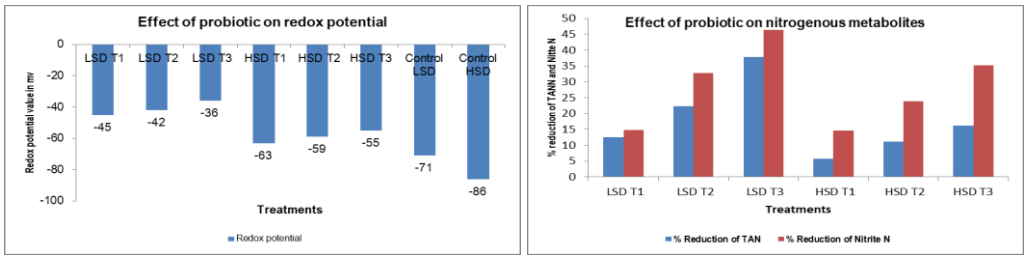


Effect of aeration and ORC on DO levels and shrimp survival

Prototype probiotic for soil and water quality improvement

Prototype probiotic with bacterial consortium @ 10^7, 10^9 and 10^{11} cfu/g (T1, T2 and T3), applied at weekly intervals in zero water exchange system of *P. vannamei* (0.65 g) culture with two stocking densities 30/m^2 (LSD) and 60/m^2 (HSD) for 30 days

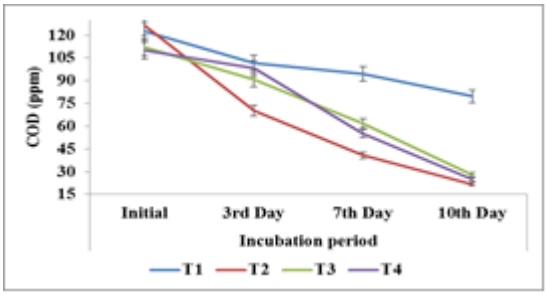
indicated that 10^{11} cfu/g showed better reduction in total ammonia N by 38 & 16%, nitrite N by 46% & 35%, decrease in soil redox potential (E_h) towards oxidation state by 42 & 36 % and increase in shrimp growth by 15 & 17%, in low and high SD treatments, respectively. Treating the post-harvest shrimp culture pond bottom sediment collected from a shrimp farm in Tamil Nadu with probiotic showed an improvement in redox potential by 9, 12 and 15% with 10^7, 10^9 and 10^{11} cfu/g, respectively compared to 4% decrease in control from an initial value of -263 mV.



Evaluation of prototype probiotic for soil and water quality improvement

Treatment of discharge water rich in chemical oxygen demand

According to the Coastal Aquaculture Authority regulations, the chemical oxygen demand (COD) of the discharge water should be less than 100 and 75 ppm if the final discharge point is coastal marine waters and creek/estuary, respectively. In order to decrease the COD of the discharge water, calcium peroxide (T_2), ORC (T_3) and potassium nitrate (T_4) were applied at 5g/ 100 litre. The COD was measured at different time intervals and the results indicated that application of CaO_2, ORC and KNO_3 reduced the COD of discharge water by 83, 78 and 80%, respectively on 10^{th} day compared to 37% reduction in control (T_1). ORC and other treatments could be utilized for decreasing COD.



Effect of chemical treatments on COD of discharge water

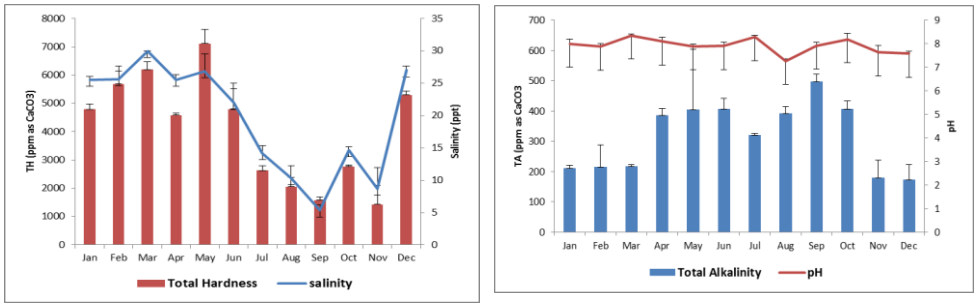
Improved accuracy of portable water analysis kits

A continual improvement was made in the water analysis kits developed by the Institute and commercialised (DO, pH, ammonia and nitrite). The accuracy was checked and the modifications were made in the concentration of reagents, improving the storage stability of reagents, quality of colour charts etc. CIBA kits were proved to be more accurate than the counterpart kits available in the market. The packing of calcium, magnesium and total hardness analysis kit ($CMH_{Mineral}$ kit) was done and is ready for commercialization as well as sale from the Institute.

Calcium, Magnesium and Hardness ($CMH_{Mineral}$) kit

Suitability of restored Adyar creek waters for brackishwater cage culture

Monthly monitoring of environmental parameters from six sampling stations in restored Adyar creek and estuary area near Srinivasapuram, Chennai from sea mouth to 1.5 km stretch showed the salinity variation from 22-30 ppt during December to June and 5-15 ppt during July to November. Salinity, metabolites and nutrients concentration at each sampling station varied based on the tidal influx. Based on the variation in the key water parameters over a period, suitable sites were identified for cage culture of finfishes and crab.



Seasonal changes in water quality parameters of Adyar creek and estuary

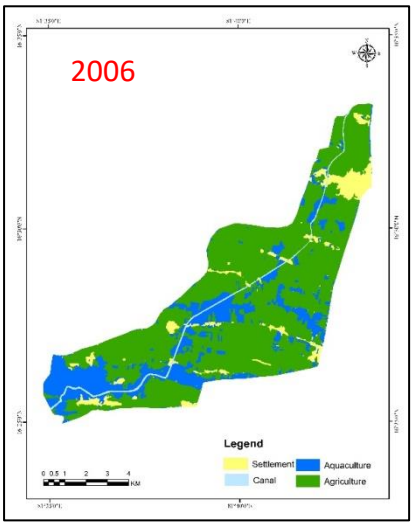
Adyar creek-full view

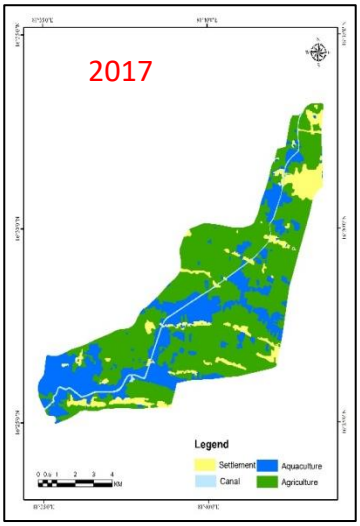
Sampling stations on Adyar Creek

Comparison of carrying capacity of estimations of brackishwater sources for *P. vannamei* and *P. monodon* farming

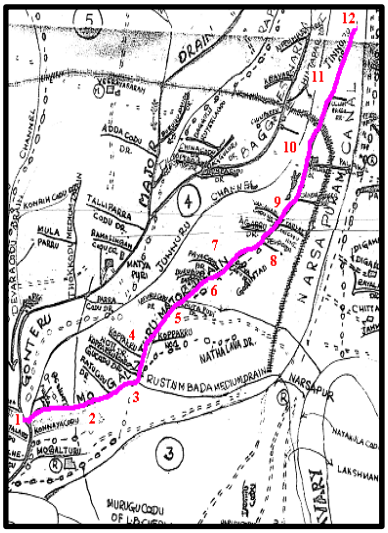
In West Godavari District, Andhra Pradesh, there was not much increase in vannamei farming area compared to earlier monodon farming, except for the intensification in brackishwater mandals, whereas the increase in area was enormous in freshwater mandals. Investigations were carried out to assess the carrying capacity of Mogalthur Drain, brackishwater source pertaining to vannamei farming and compared the earlier estimation for monodon farming. The drain was divided into three zones and water samples were collected from 12 sampling stations on the drain shrimp culture ponds and water bodies. Based on bathymetry details of source waters and nutrients

loading from both shrimp culture ponds and paddy fields into source waters, carrying capacity was estimated. An increase in shrimp farming area of 277 ha was observed in 2017 compared to 2006. The nitrogen loading into the drain was more than the carrying capacity and it is advised to reduce the stocking density in zone 3. The scope for increased area for vannamei is due to the scattered harvest over different months during the year unlike monodon, where maximum biomass harvest was in July and Nov/Dec months.





Land use around Mogalthur drain in 2006 and 2017



Sampling points on drain

EIA of crab farming and carrying capacity estimation of brackishwater creeks for crab farming in Sindhudurg District, Maharashtra

Environmental impact assessment and monitoring of water and soil quality from source water, crab culture pens and ponds, discharge water and receiving water body prior to culture, during culture period and harvest time for two crops in Malwan, Davgad and Vengurula taluks of Sindhudurg District showed no negative environmental impacts of crab farming on the receiving water bodies. There are no obvious sources of pollution nearby the crab farming sites which would negatively affect crab framing, either directly or indirectly. Virgin mangrove forest was not been affected nor will regenerating mangrove forests be impacted to any significant degree. The probable impacts were identified and mitigation measures were recommended for sustainable crab farming in pond/pens.

Crab pens in mangrove area

Carrying capacity assessment of three water bodies in the district was estimated based on the bathymetry details of the creeks, nutrients concentration from crab ponds and pens and their load in water bodies. A maximum area of 256 ha on Mandavi creek in Vengurla, 471 ha on Achara creek in Malvan and 475 ha on Naringree creek in Devgad can be recommended for crab farming.

Carrying capacity (CC) of creeks and area recommended for crab farming

Source water	CC of source water for N (Kg/day)	Total N load (kg/day)	N loading (kg/day) that can be accommodated	Area recommended for crab farming (ha)
Achara creek,	673	3.43	669	471

Malvan				
Mandavi creek, Vengurla	72	0.86	71	256
Naringree creek, Devgad	293	3.26	290	475

Soil and water health cards distribution for aquaculture farmers in PPP mode

Soil and water health cards (SWHCs) were prepared for aquaculture farms in coastal districts of Tamil Nadu and Andhra Pradesh and distributed to farmers in the programs organized by the Institute. As it is not possible to issue the SWHCs to a large no. of farmers throughout the country by the Institute, a working model in PPP mode was developed in collaboration with three private laboratories viz., Alpha Biologicals Pvt. Ltd., KCT Group and Blue Shell Aqua Analytical Lab and Fisheries College in Nellore District, Andhra Pradesh. Initially Awareness was created among the farmers about the importance of SWHC through media. About 190 and 37 SWHCs were distributed to aqua farmers from Kota Mandal and Allur Mandals, in Nellore District, AP and Elavur, Tamil Nadu respectively. The information provided in the cards is useful to farmers in understanding the nutrients status of the soils and water quality which will help in managing the pond soil and water parameters in optimum levels. The database from SWHCs captures the geographical variation and helps in framing

Model Soil and Water Health Card

Thematic area: Climate Change

Greenhouse gases emission from cage culture systems

GHGs flux was collected from cage/pen culture systems and open water bodies of *L.calcarifer (*4 X 5 X 2 m), *C.chanos* (10 X 11 m) at Venangapattu, and *M.cephalus* (2 X 1 X 1 m) at Srinivasapuram with biomass of 80, 3.7 and 0.75 tons, respectively. GHGs emission in CO_2 eq. emission kg/ha was 341, 508 and 220, respectively from the three culture systems, whereas the emission from open waters from Venangapattu and Srinivasapuram was 623 and 853 respectively indicating the sustainability of cage aquaculture systems.

Collection of GHGs from cage culture systems and open waters at Venagapattu

Collection of GHGs from cage culture systems and open waters at Srinivasapuram

Influence of pond drying on GHG emissions from shrimp ponds

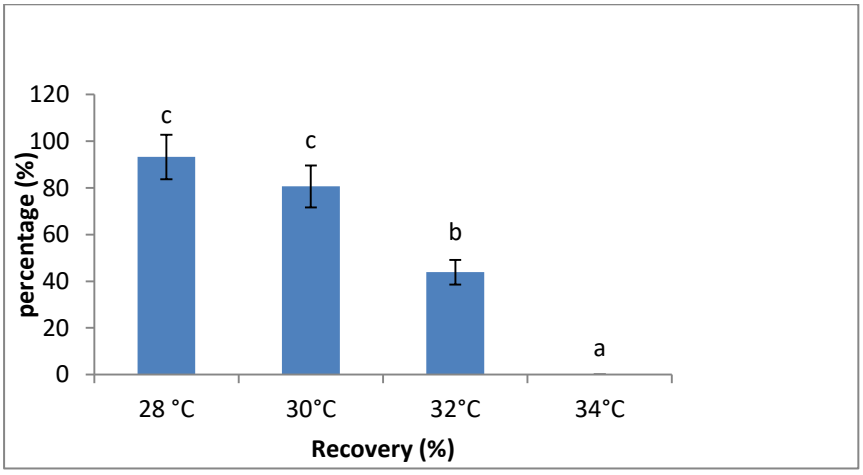
GHGs flux was collected during culture period of *P.vannamei* (56 to 60 nos./m^2) and *P.indicus* (36 to 54 nos./m^2), two days after harvest and, 30 and 46 days after drying from pond bottom sediment. The pond bottom emitted higher amount of CO_2 during the drying process (2245 – 4142 g/ha/d), compared to the emission during culture period (640 – 2942 g/ha/d), whereas CH_4 emission was high during culture period, and N_2O emission trend was not significant.

Collection of GHGs flux from the harvest pond bottom

Facility for thermal stress experiments

Environmental manipulation unit for temperature controlled recirculation system was fabricated. Investigations on thermal stress tolerance on recovery of Asian seabass fry (0.15 g body weight & 18- 22 mm length) showed that seabass fry can tolerate acute temperature stress for a period of 72 h till 30 ^oC with minimum mortality. Beyond 32^oC water temperature, mortality was high and is not advisable for seabass nursery rearing. 24 h recovery was high in control temperature of 28 ^oC.

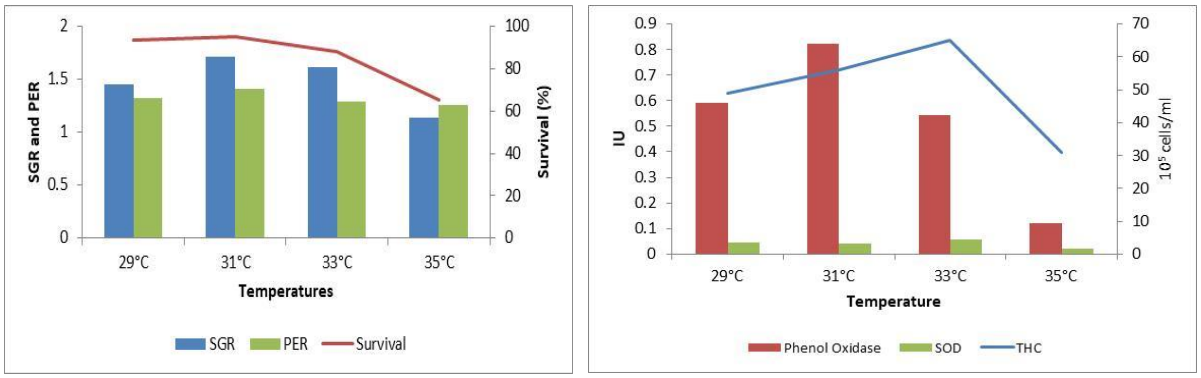
***In situ* environment manipulation unit**



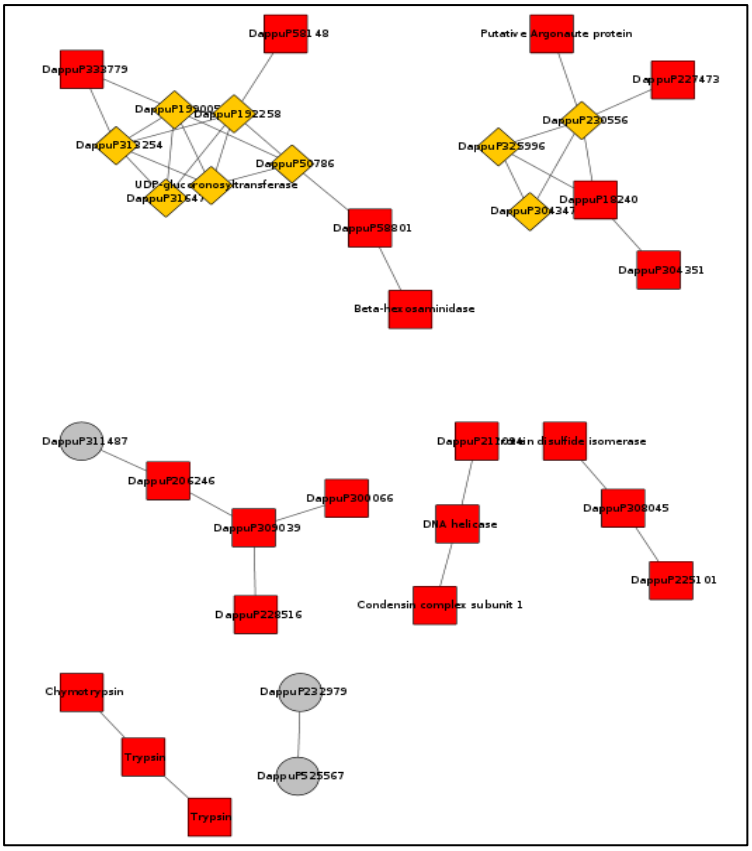
Percentage of recovery of Seabass after thermal stress

Effect of temperature stress on growth, fatty acids, stress indices and transcriptome profiling in *P.vannamei*

Effect of temperature (9, 31, 33 and 35 ^{0}C) on *P. vannamei* juveniles in thermostatically controlled RAS system showed better survival and growth of shrimp between 31 and 33 ^{o}C. Total lipid and fatty acid content increased in hepatopancreas shrimp reared in 31 and 33 but not at 35 ^{o}C. Transcript expression results (KEGG pathways) also indicated the increased fatty acid biosynthesis, pentose phoshphate pathway and biotin metabolism at 31 and 33 ^{o}C and not at 35 ^{o}C. The hepatopancreas of shrimp were utilized for RNA-seq experiments and finding of differentially expressed transcripts in temperature-stressed shrimp. Out of the down-regulated transcripts at 33 ^{o}C, six interacting protein networks could be documented with searches made in STRING database and using cytoscape tool. One of the networks has enzymes involved in breakdown of proteins which indicate that *P. vannamei* shrimp might lose ability to digest protein at higher temperatures. Results led to the increased understanding on preparation of functional feeds for temperature stress



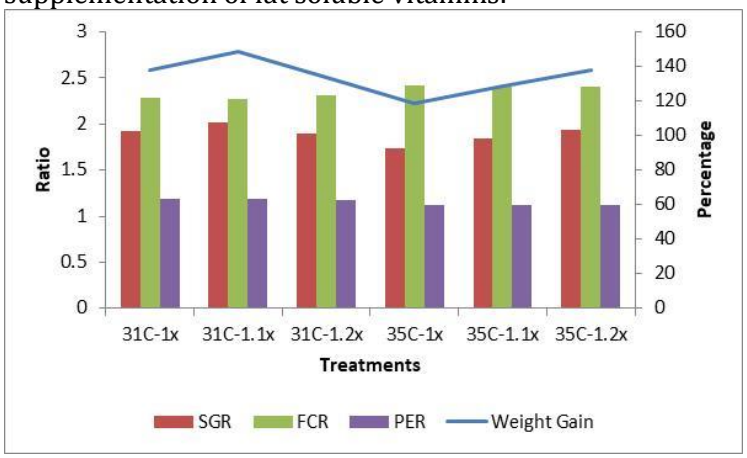
Growth, survival and immune parameters of *P. vannamei* reared in different temperatures



Interacting protein networks among down-regulated transcripts in temperature-stressed *P. vannamei.*

Effect of supplementation of fat soluble vitamins for amelioration of temperature stress in *P. vannamei*

Based on the results of experiment on the effect of temperature on growth and nutrient utilization the effect of supplementation of fat soluble vitamins was studied at 31 and 35 ^{o}C. Three practical diets with varying levels of fat soluble vitamins (1x, 1.1x and 1.2x) were prepared and tested in the juveniles (2.42±0.15 g) of *P.vannamei*. The results showed significant (P<0.05) increase in the weight gain at 31^{0}C with10% higher supplementation of fat soluble vitamins.



Effect of supplementation of fat soluble vitamins for amelioration of temperature stress in *P. vannamei* on growth and nutrient utilization

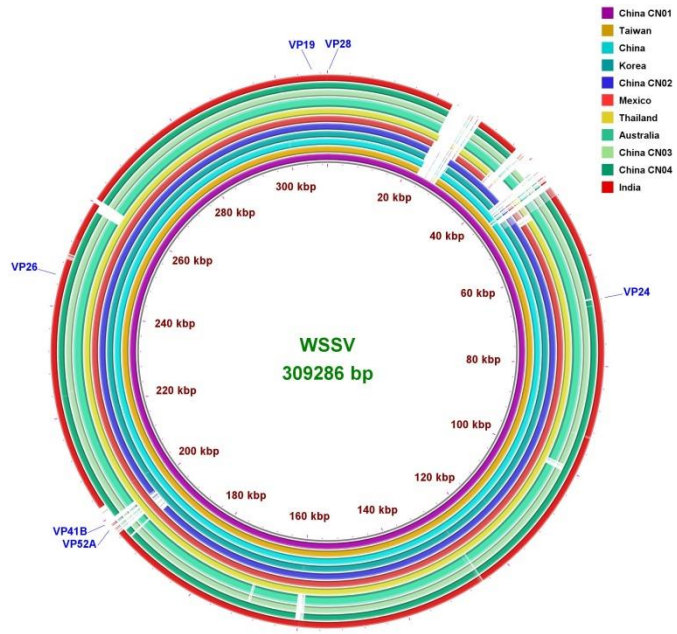
GENETICS & BIOTECHNOLOGY

First report on the complete genome of an Indian isolate of White Spot Syndrome Virus (WSSV)

White Spot Syndrome Virus is a major pathogen of shrimps causing economic loss to the aquaculture industry. For the first time, the complete *de novo* genome of an Indian isolate of this virus has been deciphered using Illumina and Nanopore sequencing technologies. The genome has 280,591 bp with 442 predicted coding genes.

An isolate of WSSV, IN_AP4RU was obtained from the pleopods of infected *Penaeus vannamei* samples that were collected from a shrimp culture pond located in Andhra Pradesh in 2014. The presence of virus was confirmed through PCR. Two sequencing technologies were used to build the complete genome of this virus. The assembly was principally built with long nanopore reads which were corrected for error bases using short Illumina reads. Initially, about 14 million Illumina and 170,475 Nanopore reads were separately aligned on to a WSSV reference genome (GenBank accession KT995472) using BWA tool to separate out virus-specific DNA reads. About 771,852 Illumina paired reads were used to correct 27,883 Nanopore reads that originated from viral DNA. These nanopore reads were used for *de novo* assembly using CANU v1.1. The assembly generated a single contig of 280,591 bp.

This is the smallest genome reported so far for WSSV and akin to a Chinese WSSV isolate of 281054 bp. The genome fragment was analyzed at Rapid Annotation using Sub-system Technology (RAST) server specifying 'Virus' domain which predicted about 442 coding sequences. The annotation of coding sequences was obtained through a local blast search against Uniprot Virus database using blast2go tool with an e-value of 1e-5. The complete genome sequence has been submitted to the GenBank database with the accession number, MG702567. The complete genome of Indian isolate was compared with genomes of other WSSV isolates available at GenBank to identify the missing regions in Indian isolate as depicted in Figure 1.



Comparative map of available WSSV genomes against the longest isolate of China, as the inner circle. The map clearly indicates the missing regions in shorter WSSV isolates. Few envelope proteins missing in some genomes are also plotted

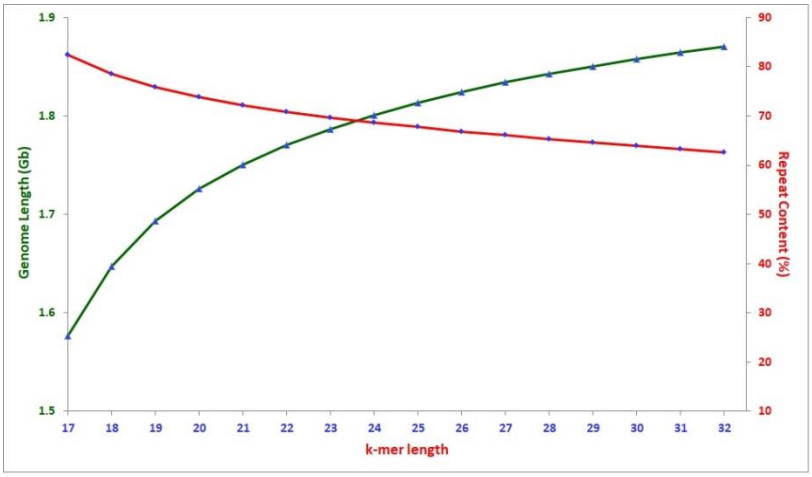
Transcriptome profiling of WSSV-infected Penaeus vannamei

P. vannamei shrimps (n=106) weighing between 15-20g were infected with WSSV virus by intramuscular injection. The gill samples from three individual shrimps were collected at 1.5, 3, 6, 9, 12, 18, 24, 30, 36, 48 and 56 hour time points post-challenge. The collected tissue samples were immediately frozen in liquid nitrogen and stored in a deep freezer. The infected samples tested positive for WSSV by PCR. The viral copy number at 11 different time points post-infection was calculated using qPCR and it was observed that there was a spike at 18 hours. Hence gill tissues collected from control and infected shrimp at 18 hour were taken up for RNA-seq to build transcriptome assembly and conduct differential gene expression studies.

A single assembly was made with RNA-seq data of six shrimp, 3 control and 3 infected in Trinity software. The assembly generated 7,92,385 transcripts with N50 of 493 bases. The transcripts were subjected to differential gene expression studies to document those transcripts that are up-regulated in infected shrimp based on read counts. The criteria used to find significantly up-regulated transcripts were log fold change of 4 and FDR value of less than 0.001. About 1987 transcripts were found to be up-regulated in infected shrimp. Out of these, 86 were mapped in 43 KEGG pathways. Efforts are in progress to unravel interactions among significantly up-regulated transcripts for documenting interacting protein networks.

Genome size of P. indicus based on Jellyfish k-mers

Earlier, the DNA of Indian White Shrimp (IWS) had been sequenced on Illumina platform to generate about 2.66 billion reads. These sequence reads are to be used for building the complete genome of Indian White Shrimp. After performing quality control that involves removal of contaminating adapter content from reads, discarding poor quality reads, trimming of poor quality ends at 3' ends of reads and removal of shorter reads, about 1.97 billion reads of 225 Gb length were available. These good quality sequence reads were used to estimate the genome length of IWS based on Jellyfish k-mer principle. Different lengths of k-mer ranging from 17 and 32 were used to estimate the genome length and repeat content. As observed in Fig 2, the genome length varies between 1.57 to 1.87 Gb. The repeat content of the genome varied between 62.7 to 82.5 %. As the length of k-mer increased, there is an increase in estimated genome length and a decrease in estimated repeat content. This could be due to resolution of some repeat regions as the k-mer length increased.



Estimated genome length (primary Y-axis) and repeat content (secondary Y-axis) of *P. indicus* genome at different k-mer lengths (X-axis) of Illumina sequence data

Assembly of complete genome of *P. indicus*

The genome of *P. indicus* was built with three assemblers namely Soap *denovo*, CLC genomics workbench and Platanus using 1.97 billion Illumina sequence reads (Table 1). A common observation with all three assemblers is that the assembly is broken to several fragments. This could be due to high repeat content of the shrimp genome and high heterozygosity of the specimen used.

When the number of contigs assembled by various assemblers was examined, we find very high numbers to the tune of about 9 million. These several fragments would not indicate anything about the genome except for high repeat content and high heterozygosity. However, to extract useful information, we had also summarized the number of contigs that are equal to or longer than 1000 bp. These longer contigs are about 1.86 to 15.05 % of the total number of contigs and represent about 11 to 22 % of complete genome (assuming 2.47 Gb as genome size from flow cytometer reading). The efforts indicate that an assembly of shrimp genome cannot be built with short Illumina reads. It is planned to build the *P. indicus* genome with long sequence reads obtained on Pacbio sequencing platform.

Statistics of assembled genome of *P. indicus* based on short reads sequence data

	Soap *denovo*	CLC Genomics workbench	Platanus
No. of contigs,	7654919	2149684	9931046
No. of contigs, ≥1000 bp	212121	323453	185169
% of contigs of ≥1000 bp to the total no of contigs	2.77	15.05	1.86
Total length, bp	298 118 791	548 973 115	272 512 812
% of genome represented by contigs of ≥1000 bp	12.07	22.23	11.03
Longest contig, bp	12399	108009	22336
GC (%)	37.90	38.91	38.35
N50, bp	1346	1685	1421
L50	81460	107511	68592

Estimation of genome size of brackishwater fishes and shrimp by flow cytometry

Various fish and shellfish species are being cultured globally, amongst them brackishwater fishes and shrimp constitutes an important food resource. With the rapid advancement in NGS techniques, there is a concerted research effort worldwide to

decipher whole genome sequence of various aquaculture fish and shellfish species including the non-model organisms to understand the organization and evolutionary pattern of their genomes. Prior estimation of the genome size is therefore essential in comprehending the genome content of the species. The genome size estimation was performed using BD Accuri™ C6 plus flow cytometer (BD Biosciences, USA) and was estimated with the corresponding mean value of the unknown and with the known genome size of chicken (*Gallus domesticus*).

The mean estimated genome size from five individuals each of six fish species is shown in Table 2. On comparison, *Etroplus suratensis* showed the largest genome size of 1.71 ± 0.16 (pg) whereas *Lates calcarifer* showed the least genome size of 0.44 ± 0.02 (pg). The less genome size of *Lates calcarifer* (0.44 ± 0.02 pg) as compared to the reported larger size of this fish indicates variation due to distinct species found in the Indian subcontinent.

Estimated genome size for six fish species

Species	Genome size (pg)
Chanos chanos	0.72 ± 0.01
Lutjanus argentimaculatus	0.95 ± 0.10
Etroplus suratensis	1.71 ± 0.16
Scatophagus argus	0.79 ± 0.01
Liza macrolepis	0.87 ± 0.02
Lates calcarifer	0.44 ± 0.02

Estimated genome size of four shrimp species

Species	Genome size in male (pg)	Genome size in female (pg)
Penaeus monodon	2.86 ± 0.06	2.91 ± 0.03
Penaeus japonicus*	2.30 ± 0.04	2.14 ± 0.02
Penaeus vannamei*	2.32 ± 0.13	2.19 ± 0.03
Penaeus indicus*	2.19 ± 0.02	2.47 ± 0.04

* The genome size varies significantly ($P < 0.05$) between sexes.

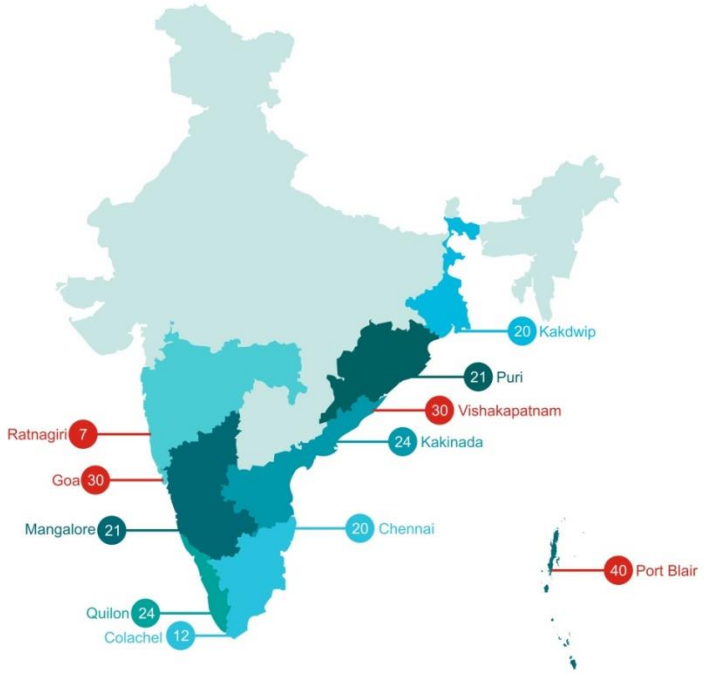
The estimated genome size from three individuals each of either sex of four shrimp species is shown in Table 3. Significant difference was observed in the genome size between male and female shrimp of all species except in *P. monodon*.

Population structure of Indian White shrimp

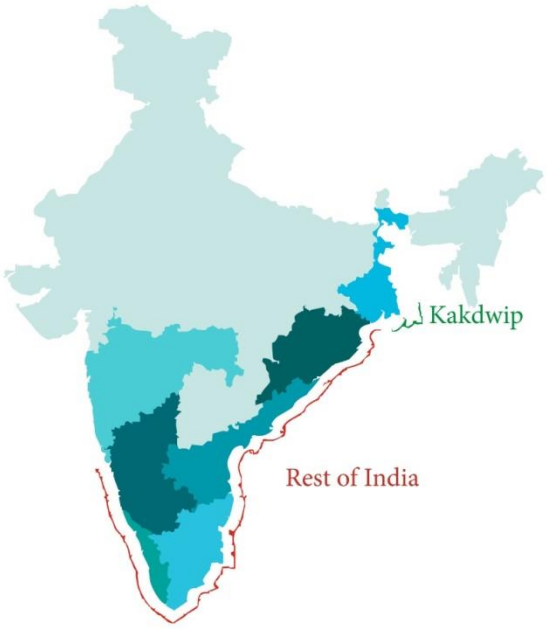
Penaeus indicus is a commercially important shrimp in our country after *Penaeus vannamei* and *Penaeus monodon*. Identification and evaluation of growth performance of these stocks of existing stocks in culture are preliminary steps for domestication and selective breeding. The genetic diversity, population structure and phylogenetics of *P. indicus* from the Indian coast using partial sequence data analysis of the 16S rRNA gene was carried out.

P. indicus samples from 11 locations along the coastal states of India *viz.* Kakdwip (20), Puri (21), Vishakapatnam (30), Kakinada (30), Chennai (30), Colachel (27), Kollam (24), Mangalore (21), Goa (30), Ratnagiri (7) and Port Blair (40) were collected. The species of the samples was confirmed using COI gene sequences (Fig.3). Mitochondrial 16S rRNA gene sequence data was generated and 121 gene sequences were submitted in GENBANK with accession numbers MH094288-MH094408. Sequence

data analyses of mitochondrial 16S rRNA gene using Arlequin software revealed that there are only two different stocks of *P. indicus:* West Bengal (Kakdwip) stock and Rest of India (Mangalore, Kollam, Kanyakumari, Chennai, Kakinada and Puri) stock (Fig. 4).



Sampling sites of Indian white shrimp. Places in red indicate that samples did not conform to the species



Diversity of Indian white shrimp along the coast

Succesful breeding of Rice fish Oryzias sp .in captivity for the first time

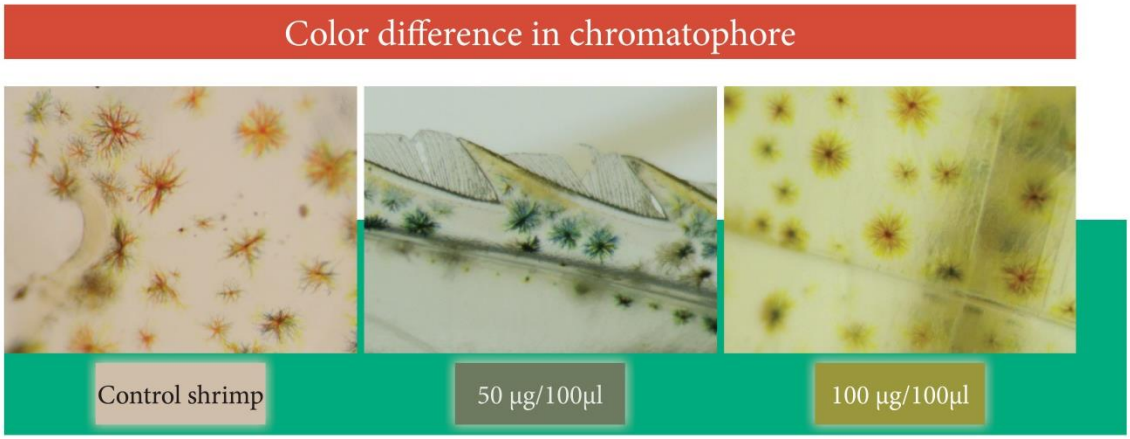
An unidentified rice fish, *Oryzias sp.* was collected from Muttukadu lagoon. They were found to be highly adaptable to brackishwater as well as seawater and could become a model organism for studies in brackishwater and marine fishes. Some of the rice fishes belonging to Adrianichthyidae and genus *Oryzias* are considered to be well-established experimental organisms for developmental biology, ecology, molecular biology and genetics. The fishes were reared in 250L circular tanks for a fortnight and were fed with commercial pellet feed. The sexes were distinct and mating appeared to be polygamous. Two males and three females (all mature) of 4-5 cm size were selected and reared together in 30 L tank at 30 ppt salinity. The fishes were fed twice daily with freeze-dried tubifex worms during the day and adult Artemia in the evening hours. The fish bred within ten days of rearing in captivity. Eggs were seen hanging in a cluster from the vent areas of the females, the eggs being highly adhesive with hard chorion possessing numerous short villi. The eggs after external fertilization by males were brushed off by the female which swam past fine-leaved plants that acted as a spawning mop. The fertilized eggs hatched by 10-14 days with 100% survival, the inconsistency in hatching could partly be attributed to the difference in water temperature. Some of the embryonic development stages have been documented.

Embryonic stages of rice fish

Transgenic studies

Experiments were conducted to produce novel transgenic *Penaeus vannamei* with highly vivid fluorescent phenotype through transgenesis of a Green Fluorescent protein gene (GFP). Efforts were also taken to construct a green fluorescent protein (GFP) reporter construct regulated by an endogenous β-actin promoter in *P. vannamei*. The β-actin promote gene from *P. vannamei* was amplified using specific primers and sequenced for confirmation. The gene was strategically inserted into GFP vector to build a β-actin promoter-GFP gene construct for further studies. The gene construct was then cloned into a DH5-α strain of *Escherichia coli*. The β-actin–GFP plasmid was isolated and injected intramuscularly to *P. vannamei* juveniles to study the integration of transgene

to muscle tissue. The injection was given at two different doses *viz.* 50 µg/mL and 100 µg/mL and reared in the laboratory to check for fluorescence along with control shrimp (un-injected). There appears to be a change in colour of the chromatophores among the



control and treatments consequent to which the building of gene construct and transfer of gene are in the process of standardisation.

Population diversity of *Etroplus suratensis*

The populations or stocks of a species differ among them due to limited migration among the adjacent populations and continuous inter-breeding of the individuals of the same population. Further, the stocks have very well adapted to their local habitats too and therefore the existence of maximum level of genetic variation among the stocks is considered to be vital. Hence, documentation of the diversity of a species helps us to understand its genetic makeup as well as to construct the conservation strategies. Among the cichlids, Etroplus is the only genus endemic to India. *Etroplus suratensis* (pearlspot), an omnivorous fish widely distributed across brackish and fresh water sources of peninsular India. It is primarily of brackish-water fish which has naturally acclimatized to the freshwaters too. The delicacy of its meat fetches higher price in the market. *E. suratensis* has the potential for both food and ornamental markets. Here, the genetic diversity of *E.suratensis* was estimated using ATPase 6/8, a mtDNA gene. The *E. suratensis* tissue samples were collected across the Indian coast from Chilika (19), Nagayalanka (10), Pulicat (32), Vellayani (17), Ashtamudi (8), Vembanad (40), Goa (19), Mangalore (19) and Ratnagiri (23). The total DNA was isolated from the tissue samples. About 930bp of ATPase 6/8 gene was amplified and sequenced. The consensus sequences were utilized to estimate the F_{ST} (**Table 4**) using arlequin 3.5.1.2 tool. The F_{ST} estimates revealed that the stocks Chilika Vs Nagayalanka; Vellayani Vs Ashtamudi; Mangalore Vs Vellayani & Ashtamudi did not differ. All other stocks differed significantly (P<0.01) among them.

FST estimates between stocks of *Etroplus suratensis*

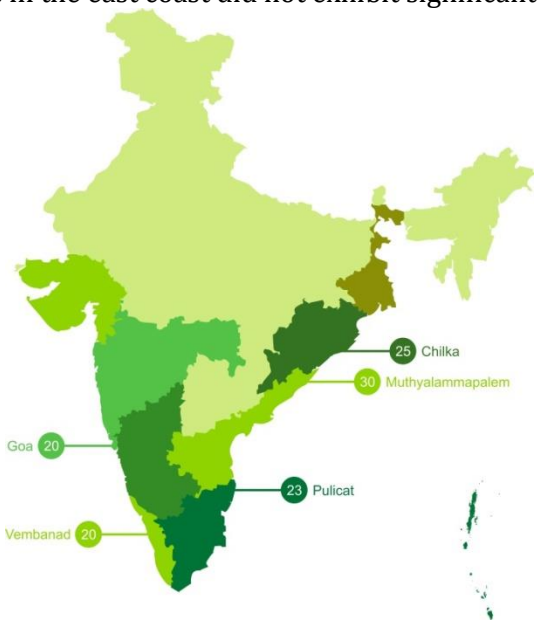
	Chilika (19)	**Nagayalanka (10)**	**Pulicat (32)**	**Vellayani (17)**	**Ashtamudi (8)**	**Vembanad (40)**	**Goa (19)**	**Mangalore (19)**	**Ratnagiri (23)**
Chilika (19)	____								
Nagayalanka (10)	-0.04^{ns}	____							
Pulicat (32)	0.73**	0.74**	____						

Vellayani (17)	0.60**	0.57**	0.50**	___					
Ashtamudi (8)	0.85**	0.89**	0.69**	0.12^{ns}	____				
Vembanad (40)	0.30**	0.29**	0.46**	0.12**	0.20**	_____			
Goa (19)	0.61**	0.59**	0.53**	0.30**	0.49**	0.32**	____		
Mangalore (19)	0.61**	0.59**	0.52**	0.07^{ns}	0.10^{ns}	0.14**	0.33**	_____	
Ratnagiri (23)	0.95**	1.00**	0.81**	0.68**	0.94**	0.59**	0.65**	0.69**	____

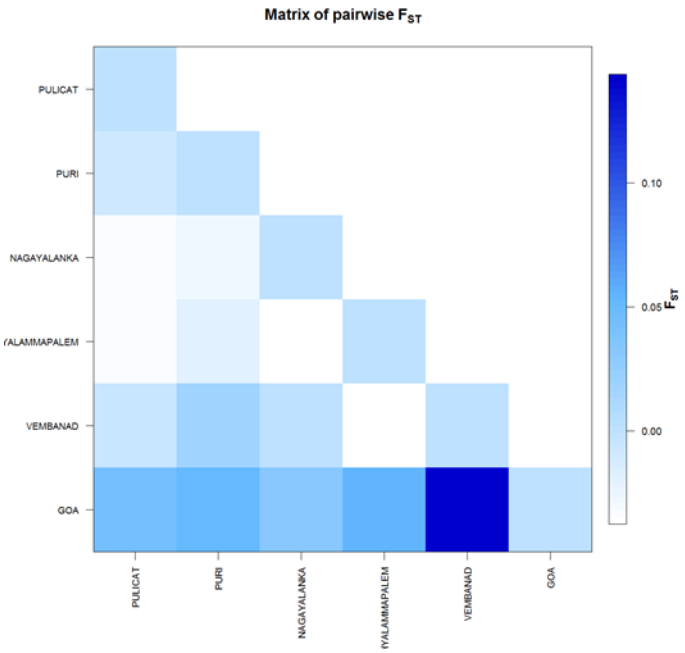
(** significant P<0.01; ns – non-significant)

Population structure of Chanos chanos using mitochondrial DNA

Milkfish samples were collected from the west coast (Goa:Mandovi river; Kerala: Vembanad river) and east coast (Tamil Nadu: Pulicat lake; Andhra Pradesh: Nagayalanka & Muthyalammapalem; and Odisha: Chilika lake) . The mitochondrial genes ATPase and CO I were amplified and sequenced in 98 and 111 individuals respectively. High haplotype diversity and low nucleotide diversity was observed in both sets of sequences. The analysis of ATPase sequences revealed 24 haplotypes out of 98 individuals with a haplotype diversity of 0.782 and nucleotide diversity of 0.002. The sequences of CO I revealed 17 haplotypes out of 111 individuals with a haplotype diversity value of 0.768 and nucleotide diversity value of 0.002. The most common haplotype was found in 44 individuals. Pair-wise F_{ST} analysis revealed significant genetic differentiation between the milkfish populations of Goa and Kerala. Milkfish from other regions in the east coast did not exhibit significant divergence.



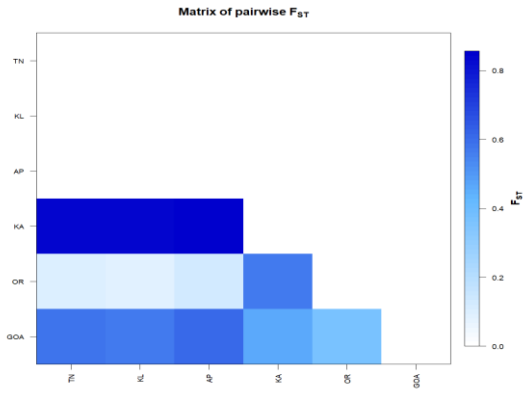
Sampling locations of *Chanos chanos*



Matrix of pair-wise F_{ST} values in milkfish

Population genetics study of *Mugil cephalus* based on mtDNA genes

The genetic variation in natural populations of *Mugil cephalus* was analysed using ATPase 6/8 gene (842bp) of mitochondrial genome. Total DNA extracted from fin clips of grey mullet collected from Odisha, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka and Goa Coast. The ATPase 6/8 gene was amplified by PCR using universal Primers. Analysis of molecular variance (AMOVA) of sequence data revealed that stocks from Karnataka and Goa were divergent from the stocks of Tamil Nadu, Andhra Pradesh, Odisha and Kerala. A total of 10 haplotypes were identified among 110 samples collected. Overall, three distinct genetic stocks exist for grey mullet, Goa, Karnataka and the stocks from Kerala to Odisha.

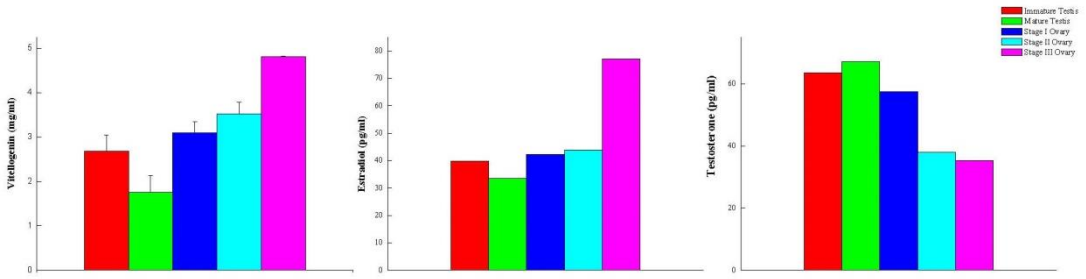


The F_{ST} estimates between stocks of *Mugil cephalus*.

Plasma sex steroid hormone levels in *Mugil cephalus*

Sex steroid hormones play an important role in many physiological processes, particularly in the reproduction of vertebrates. The association of changes in gonadal development with plasma levels of gonadal steroids has proven to be a valuable tool for understanding the endocrine control of reproduction in teleosts. To analyse the changes in plasma sex steroid levels with maturation in grey mullets, adult females at different

stages of gonadal development were collected from wild and were grouped into as immature or Stage I (ova diameter 30 – 110 µm), Maturing or Stage II (ova diameter 120-180 µm) and Mature or Stage III (ova diameter 180-650 µm). Sera separated from the blood samples of five fishes of the same maturity stages, were pooled for analysis. The concentration of 17β-estradiol and testosterone in the plasma was determined by the enzyme-linked immunosorbent assay. Vitellogenin levels in the sera were also measured using anti-seabass vitellogenin with purified vitellogenin as standards. Higher levels of estradiol were observed in females compared to males while the levels of testosterone were higher in males. A positive correlation was observed between the serum estrogen levels, vitellogenin and growth of vitellogenic oocytes (ova diameter).

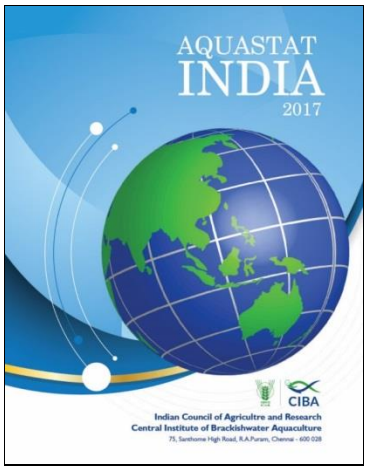


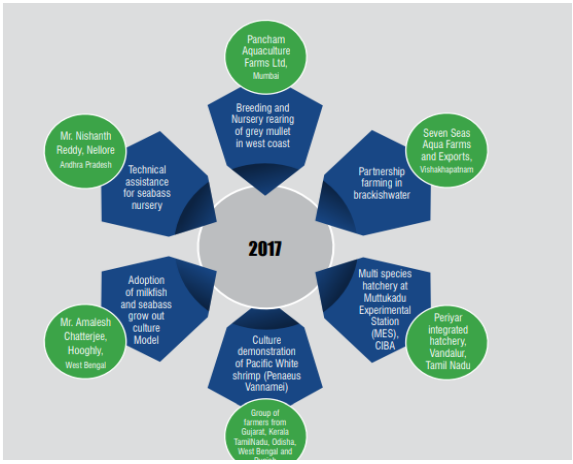
Vitellogenin, Estradiol and testosterone levels in grey mullets

SOCIAL SCIENCES AND DEVELOPMENT

Aquastat India 2017- A statistical compendium on Indian brackish water aquaculture scenario

ICAR-CIBA took the initiative to prepare "Aquastat India 2017", the first comprehensive database on the global and Indian scenario of brackishwater aquaculture. This compendium consists of resources, production and trade statistics of aquaculture from 1991 to 2016. Also, it includes information on technical aspects of the brackishwater aquaculture and their economic impact and infographics on technology transfer to various clients, etc.





Document on Aquastat SSD 2: Infographics on CIBA seed

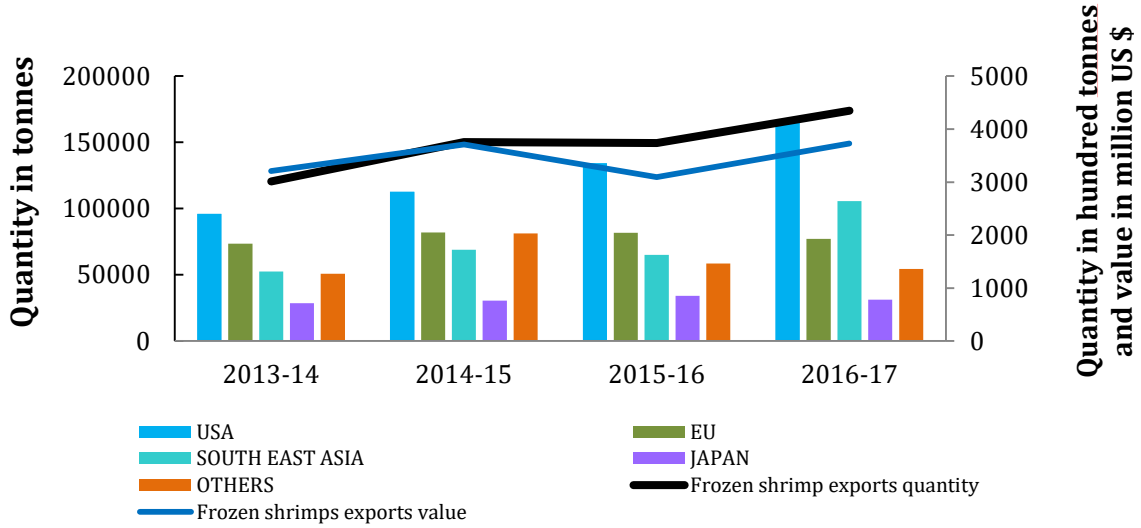
Technologies transferred to clients

CIBA technology timeline from 1997 to 2017

Indian shrimp export scenario

Shrimp is the world's most important commodity, accounting for about 15.3 percent of the international seafood trade. India ranked first in shrimp exports to the global market in 2016 with 14.5% growth over the previous year (FAO, 2016). India's shrimp export volume reached 4.38 lakh tonnes during 2016–17. During the same period, frozen shrimp

maintained its position as the top item of fisheries export, accounting for 38.28% in quantity and 64.50% of the total earnings in USD. Shrimp exports increased by 16.21% in quantum and 20.33% in USD. Farmed shrimp alone contributed about 3.7 billion USD, which is more than half of the fish and fishery export from India. The increase in export quantity and value attributable to the introduction of *P.vannamei* in India and the decrease in international trading from competing nations such as South-East Asian countries due to disease problems. India's major shrimp exporters in 2016 were USA (38%), South-East Asia

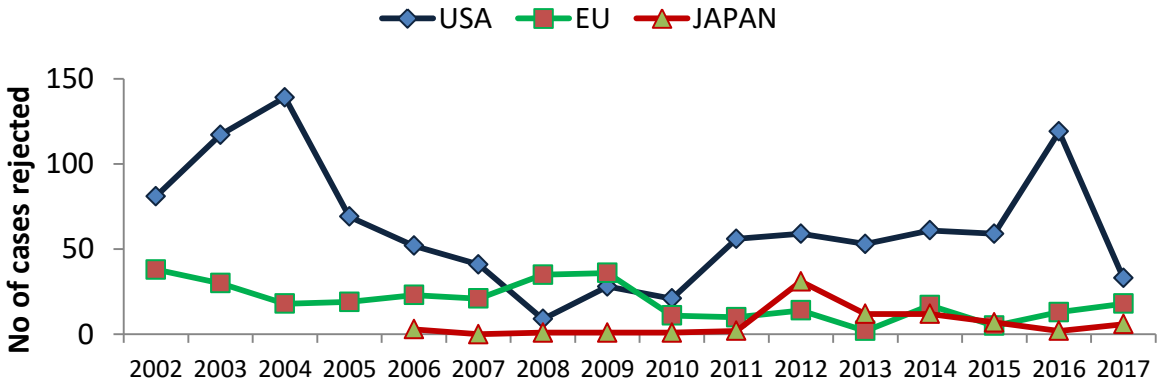


(24%), the EU (18%) and Japan (7%).

Frozen shrimp exporters of India

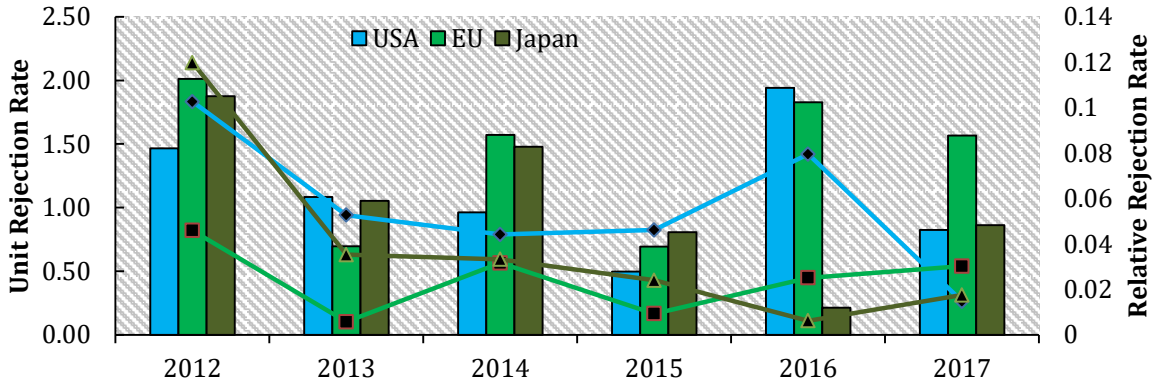
Trend in Indian shrimp exports rejection by USA, EU, and Japan

Among the exported aquaculture products, shrimp being a high valued item and produced mostly from aquaculture farms, the import denial due to the antibiotic residue is a matter of concern for all the stakeholders' including R&D agencies, development agencies, exports promotion arm, and policymakers. Secondary data analysis indicated that from 2002 to 2017, a total of 997, 310 and 78 Indian shrimp consignments denied entry by the US, EU, and Japan, respectively.



Rejection frequency of India's shrimp exports by USA, EU, and Japan

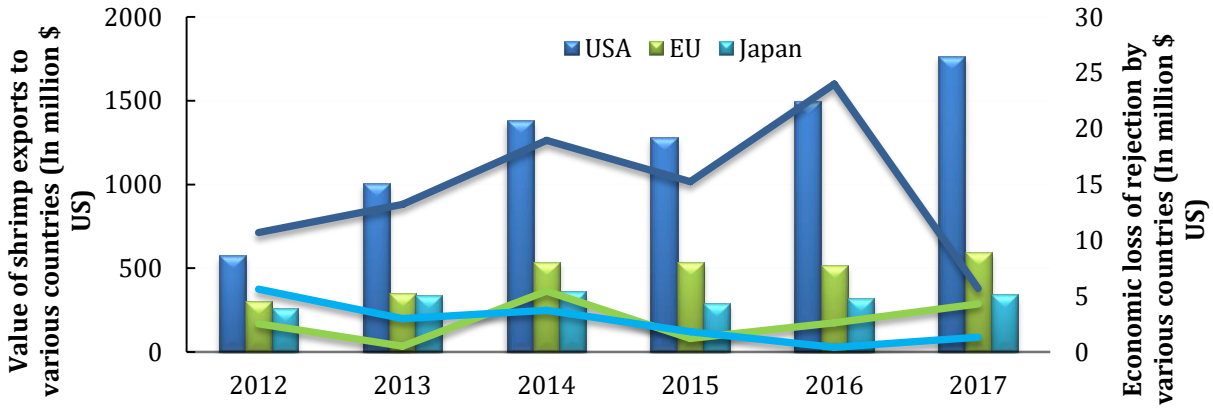
Unit Rejection Rate (The number of rejections per million US$ exports) reflected the reducing trend of shrimp rejection by USA and EU due to the adoption of BMS in farms, HACCP protocols in the processing units and National Residue Control Plan (NRCP) by export authorities.



Column represents URR, Line represents

Unit Rejection Rate and Relative Rejection Rate of India's shrimp exports

But in case of Japan, it indicated a reducing trend except during 2012 due to the presence of chemicals Viz., furazolidone and ethoxyquin. Relative Rejection Rate (Ratio of country's share of total rejections in one market to its share of all import in that market) was meager (0.8) for US and Japan, whereas it was 1.57 for EU during 2017 and significantly declined over the years



Column represents value of shrimp exports, Line represents economic loss

Economic loss of Indian shrimp exports rejection

The share of economic loss to the value of exports was 0.3% for USA and Japan whereas it was 0.7% for EU during 2017. The results indicated that the loss was less than 1% of shrimp exports value. Filth and salmonella (83%) was the major cause of rejection by USA which can be easily prevented by further effective implementation of BMP at farms and HACCP protocols at processing level in future. Awareness and regulations in input use at farms and improved infrastructure facilities at farms would also help reduce rejection in future.

Impact analysis of brackishwater aquaculture technologies

Economic impacts of three select aquaculture technologies viz., WSSV kit (2002-2009), Introduction of *Penaeus vannamei* (2009-2016) and the product CIBASTIM (2012-2016) were estimated using impact assessment methodology of 'Input-Output time series intervention model.' The total economic benefits that accrued to the national exchequer cumulatively from 2002 to 2016 was evaluated to Rs. 34,413 crores, from three select technologies/policy support interventions attributable to the work of ICAR-CIBA. The returns to the investment made on brackishwater aquaculture research estimated were huge though only these three technologies were considered.

Brackishwater aquaculture and doubling of farmers income

Scientific production and management of shrimp and finfishes yield high income to the farmers within a short span of time, which are four-fold increase than the traditional practices. Production of shrimp species like Pacific white shrimp (*Penaeus Vannamei)*, milkfish (*Chanos chanos)*, Asian Sea Bass (*Lates calcarifer*), cobia (*Rachycentron canadum*) and mud crab (*Scylla serrata*) are the dominant species which would fetch higher income within short to medium time span.

Under farmers field conditions in Kozhikode district of Kerala (n=5), cultivation of seabass, milkfish and pearl spot resulted a higher level of profit to the tune of Rs.1.70 lakh/crop, 1.47 lakh/crop, and 0.70 lakh/ha respectively. The Benefit-Cost Ratio range is 1.29, 1.38 and 1.41 respectively in case of seabass, milkfish and pearl spot.

Economics of the culture of brackishwater species under optimum management conditions

S. No.	Particulars	Pacific White shrimp	Milk Fish	Asian Sea Bass	Pearl Spot
01	Culture duration in months	4	6-8	6-8	6-8
02	Stocking density in number/ha	500000	8000-10000	5000	2000
03	Yield in kg/ ha	8000-10000	4000-5000	3500-4000	2000-3000
04	Market price in Rs./kg	220	140-150	300-350	300-350
05	Gross Return in Rs. lakh/ha	22.00	6.00	12.00	9.00
06	Gross Cost in Rs. lakh/ha	15.00	3.6	8.00	7.00
07	Net Return in Rs. lakh/ha	7.00	2.40	4.00	2.00
08	Cost of Production in Rs/kg	150-180	72-80	200-250	230-250
09	Benefit Cost Ratio	1.47	1.67	1.5	1.29

Based on 2015-16 market prices in Southern India

Aquaculture Extension

Extension and developmental interventions for sustainable brackishwater aquaculture production systems

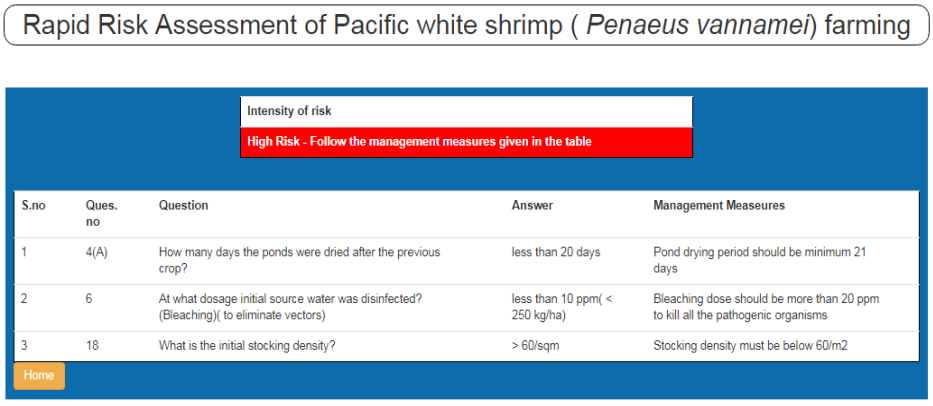
The technology package for a three-tier model of cage farming of Asian seabass (*Lates calcarifer*) in open brackishwater comprises of nursery rearing, pre-grow out and grow out phases was validated in partnership with the NIOT Chennai and fisher youth group at Vennangupattu village cluster in Kancheepuram district, Tamil Nadu. The farming cycle began with the stocking of fish fry (2cm size) initially in the nursery cages, they were grown to fingerlings size in 45-60 days (7-8 cm size), transferred from nurseries to the pre-

grow-out cage and then 90-100g juveniles from pre-grow out were transferred to grow out cages @12 kg per/m^3 for further rearing. The fishes were fed with CIBA's formulated indigenous feed (*Seebass*^{Plus} @ Rs80/kg). The average Feed Conversion Ratio (FCR) was 1.85. The juveniles were grown to a marketable size of 900 g - 1.25 kg in 6 months. The productivity of 460 kg was realized in two partial harvests in one cycle. With proper planning, two cycles of production are possible in a year. The production cost was worked out to be Rs.190 per kg of fish and sale price was Rs.380 per kg with a BCR of 2.0. A person is spending 2 hours per day in the nursery rearing, pre-grow out and grow out phases get a monthly income of Rs.6000, Rs.5000 and Rs.8500, respectively. The fish producers were linked to Tamil Nadu Fisheries Development Corporation a state government body which procures fishes from producers giving farm gate price and sale to the consumers through its outlets. This model is being replicated in Puducherry UT, Kerala and Maharashtra states.

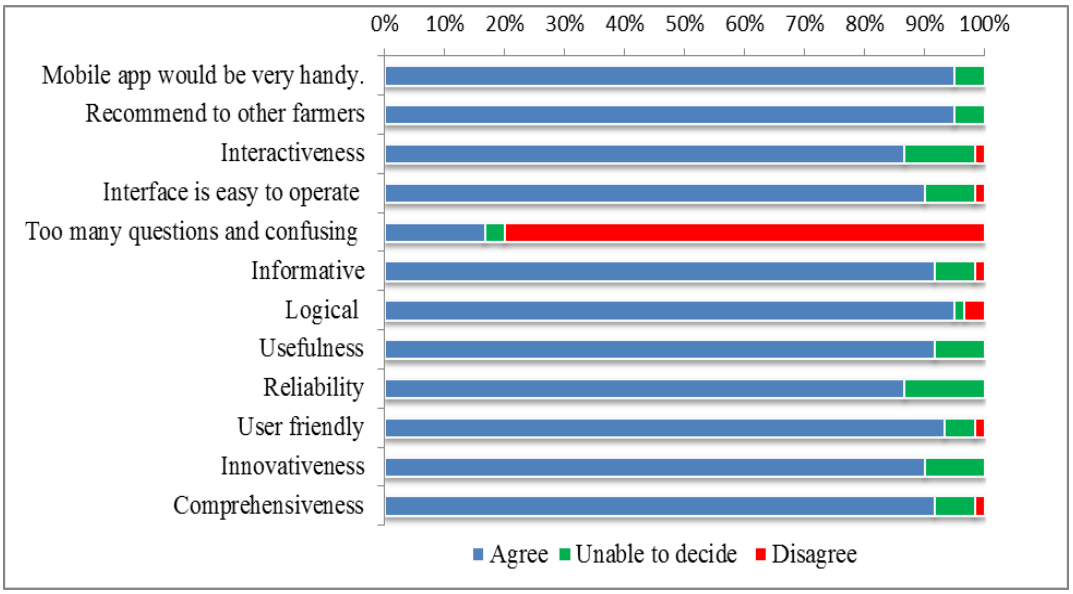
Three-tier model of cage farming in open brackishwater

Development and validation of an online 'probabilistic risk diagnosis module' for Pacific white shrimp farming and evaluate its utility

A questionnaire-based *on-farm risk assessment module* for vannamei farming was developed. The module contains three distinct categories viz., phase1: Up to 40 Days of Culture (DOC); phase2: 40-80 DOC and phase3: above 80 DOC. On completion of this questionnaire, the results will indicate the risk level of the farm, practices need immediate attention to minimize the risk levels. This tool was validated with a sample size of 60 shrimp farmers in TN and AP, and the farmers felt that the tool was comprehensive, educative, reliable and highly useful to the farming community.



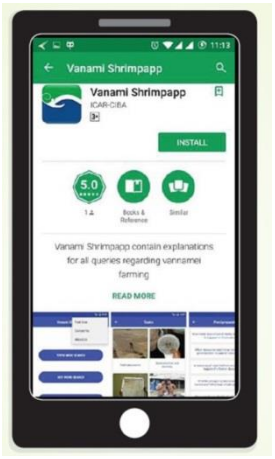
Final page of the module with results



Perception of end users on the disease diagnosis module

Technology dissemination through mobile phone: Updation of *Vanami Shrimpapp* with additional modules

Vanami Shrimpapp is the first mobile app on shrimp farming and has been regularly followed by more than 7500 stakeholders (farmers and extension workers) across the globe (India, Indonesia, Vietnam, Brazil, Peru, Mexico, Ecuador, and the USA). The app is comprehensive and updated with several modules recently.



Farmer receiving response to his query through Vanami Shrimpapp mobile app

Preparation of Farmer Friendly Publication

A farmer friendly publication *Penaeus Vannamei Ginga Palan Ke Bara Mae Akshar Poochae Janaevalae Prashna* ***(in the Hindi language****), (Vannamei Shrimp Farming: Farmers Frequently Asked Questions (FAQs) and Explanations),* was prepared and published.

The value chain of family participation in aquaculture sectors

A value chain study was conducted among 50 coastal farmers to identify and measure the family involvement in aquaculture value chains and significance of both women and men roles in the aquaculture sectors at coastal villages of Kancheepuram, Nagappatinam, Villupuram , Thiruvallur districts of Tamil Nadu, and Kozhikode district of Kerala.SEAGA analysis indicated that women and their families had supported the men in aquaculture sectors (50%), have now adopted new techniques in fish farming practices (20%), entered into new markets and more profitable enterprises (20%) and both men and women play a significant role in the aquaculture and fishery value chain (60%) and decision making practices (60%) in value chain of fish and shrimp farming. The modern and diverse fishery value chains have opened up new avenues for resource-rich groups (40%) while resource poor and weaker groups (60%) remain in low-value nodes of the value chain.

Interactions with aqua farmers on aqua-business, and Asian seabass farming

Assessment and transfer of brackishwater aquaculture technologies among tribals of Tamil Nadu (under TSP)

Under the CIBA-TSP sub-plan, an assessment was made on tribal participation in aquaculture sectors, and awareness was created on dissemination and adoption of CIBA technologies among 50 coastal irular tribal aqua farmers of Nagapattinam and Thiruvallur districts of Tamil Nadu. The socio-economic status of the tribals and resource availability in the coastal tribal villages was studied for dissemination and adoption of fish farming as an alternate livelihood option among the tribal communities. Fishing, wild shrimp collection, and crab collection was their major occupation (90%). The majority of the beneficiary's (70%) monthly income ranged from Rs.4001- 10,000/- followed by Rs.1000- 4000/- (20%) and Rs. 10,001 - 15,000/- (10%).

Awareness meeting with the tribal farmers of Tamil Nadu

Nursery rearing of Seabass (*Lates calcarifer*) by Adidravida families as a livelihood activity at Keelarkollai village, Kanchipuram District, Tamil Nadu

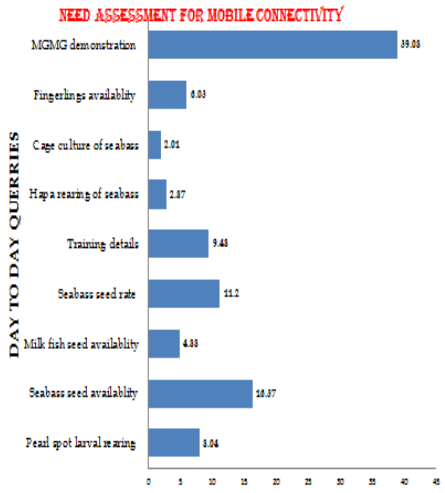
The suitability of Keelarkollai water source in Kancheepuram district of Tamil Nadu was assessed for nursery rearing of seabass in hapas technology mobilizing four Adidravida families in partnership mode. A nursery rearing unit comprised ten hapas (2x1x1m size) with a total volume of 120 m^2 was developed in open waters and seabass fish fry of size 1.2-1.8 cm provided by CIBA were stocked @ 500 no/hapa. The nursery rearing duration was 57 days. The survival realized was 35.80% .A production of 1820 fingerlings of size 3-9.5 cm was realized. On an average one member spent two hours in the for feeding the fry twice and monitoring. The net income per cycle was Rs.28, 000 and each family got an income of Rs.7000/- per head. This could be a model for earning extra income through job-sharing

employment which could be taken up throughout the year as a livelihood activity.

Evaluation and Execution of Extension Programmes for sustainable brackishwater Aquaculture

One hundred and thirteen frequently asked questions (FAQs) about seabass culture and its farm management along with answers under 12 heads have been prepared in the Tamil language. The 12 heads include; 1.Hatchery Management 2.Nursery Rearing of seabass in Hapas.3 Nursery Rearing of seabass in ponds.4 Cage culture.5. Grow-out culture 6.Management of seabass 7.Soil and water Management.8.Feed Management and Feeding 9.Health Management.10.Integrated Management 11.Harvest and 12. Production and Marketing.

Development of Android-based Mobile app for Seabass culture and farm management is in progress.The need assessment for mobile connectivity regarding the day to day queries showed that the fish farmers approached CIBA regarding MGMG demonstration (39.08%), seabass fingerlings availability(6.03%),cage culture activities (2.01%), nursery rearing of seabass in hapas (2.87%),training details (9.48%),seabass seed rate (11.2%), milkfish seed availability(4.88%), seabass fry availability (16.37%) and Pearl spot larval rearing (8.04%). It was also observed that localization and native language of farmers need to be considered for incorporation into the systems.



Demonstration of mud crab culture in pen and floating boxes in the open water system at Adyar Creek water bodies

Trials were conducted to standardize the culture of mud crab adopting different systems in Adyar creek water bodies. Under pen culture system, total 50 crabs (9.6 kg; body weight range 95-250 g) were stocked in 100 m^2 pen structure. Crabs were fed with trash fish @ 10% body weight daily in two times. After 40 DOC, 30 crabs (body weight range 168-627 g) with total biomass of 10.27kg were collected through partial harvesting and an amount of Rs. 16405/- were realized as interim profit. Under cage culture system, twenty crabs (Av. body weight 109.9 g) were stocked individually in 20 floating boxes. Crabs were fed with trash fish @ 10% body weight daily in two times. After 40 DOC, crabs attained average body weight of 212.81g and profit of Rs. 2380/- were realized.

Partial harvest of mud crab at Adyar creek

Demonstration of milkfish culture in pen at Adyar Creek water bodies

Based on the experimental trial conducted at Adyar creek water bodies during 2016-17 for identifying the suitable brackishwater species for cultural practices, demonstration of milkfish culture in pen was initiated at Adyar creek water bodies. A total of 280 milkfish fry (avg. wt - 4.8 g; avg total length 6.7 cm) was stocked in 100 m^2 pen structure. Fishes were supplied with the formulated feed prepared by ICAR-CIBA @ 5% body weight daily in two times. After 55 DOC, milkfish attained average weight of 52.5 g and average length of 20.2 cm. The adopted ten nos. of fisher folks (5 families; 2 nos. from each family) were trained with cage and pen installation and maintenance, feeding to animals, handling of crabs, and sampling, etc.

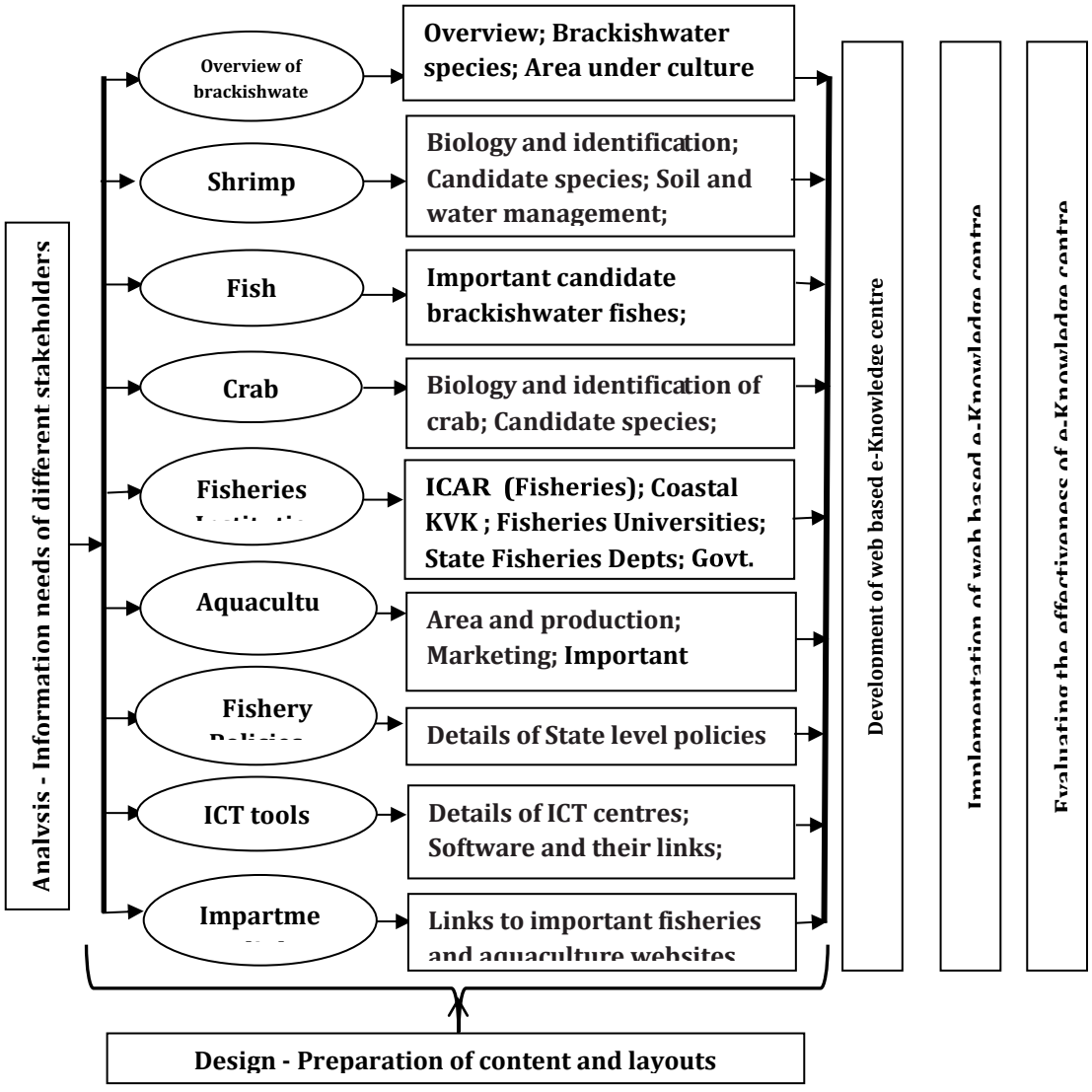
SS

Computer Applications

Web-based knowledge centre in brackishwater aquaculture

Web-based knowledge centre in brackishwater aquaculture was designed based on the ADDIE model of Instructional System Design (ISD), including Analysis, Design, Development, Implementation, and Evaluation. Needs assessment of 110 stakeholders, users of ICT projects of Village Knowledge Centre of MSSRF, Tamil Nadu, and Aquachoupal, Andhra Pradesh (50 nos); aqua/tribal farmers of Gujarat (50 nos.) and students (10 nos.)was completed. The required information was designed into eight categories viz., Overview of brackishwater aquaculture; Details of Shrimp; Details of fish; Details of Crab; Fisheries institutions; Aquaculture statistics; Fisheries policies; ICT tools and Important links. Each category has many sub-categories for highlighting the information about the topic. Before designing the web-based centre, content was processed and evaluated. The evaluation results revealed that the items related to materials produced, visual design, accessibility and presentation style had good responses. Knowledge centre in brackishwater aquaculture was developed using Drupal content management software (CMS). This system is built-up with PHP and MySQL for the design of pages and database respectively.

ADDIE model framework for the development of knowledge centre in brackishwater aquaculture



Adyar Creek and Estuary Information System (ACEIS-Aqua) for aquaculture development

Adyar Creek and Estuary Information System (ACEIS-Aqua) was developed using MySQL database management system and PHP scripting language for the development of aquaculture in the water bodies. This web-based system describes the database/search modules that permit end users fast and easy access to large amounts of analyzed data which are collected in different sample locations and details of culture practices which are suitable for these water bodies for the development of brackishwater aquaculture. The home page of this system was designed into eight modules namely, about Adyar creek and estuary, System needs and objectives, Sample location, Water parameters, Soil parameters, phytoplankton, zooplankton, culture practices, and personal and contacts. In the system, search module is used to search and retrieve information based on users' keywords in the form of season wise, location-wise, month-wise, year-wise, salinity-wise, phytoplankton class/genies-wise and zooplankton group-wise. Although illustrations are based on the six sample locations, the system is general and can act as a model to elaborate for the entire Adyar creek water bodies.

Home page of Adyar Creek and Estuary Information System (ACEIS-Aqua)

Human Resource Development (HRD) Trainings, Capacity building and Skill development

Trainings attended by individuals

International

1. Dr. P.K. Patil, Principal Scientist attended the training programme on "Methods of determination for drug residues in fish, meat and poultry", Joint Institute for Food Safety and Applied Nutrition, during 10-14th April 2017 at Maryland USA.

National

2. Smt. V. Usharani, Asst. Administrative officer, Shri. P. Srikanth, Junior Accounts Officer attended the Training Programme on "FMS" organized by IASRI at New Delhi from 17-19th April 2017.

3. Ms. Misha Soman, Scientist attended the training programme on "Molecular Biology and Biotechnology for Fisheries Professionals" organized by ICAR- CMFRI, at Kochi from 15th February 2017 to 14th May 2017.

4. Dr. Prem Kumar, Scientist attended the training programme on "Techniques pertaining to molecular biology and reproductive endocrinology" organized by Department of Animal Biology, School of Life Sciences, University of Hyderabad, from 8-28th June 2017.

5. Shri R. Aravind, Scientist attended the training programme on "Taxonomic Identification of Coastal and Oceanic Copepods (TICOC-2017)" organized by Marine Planktonology & Aquaculture Laboratory, Department of Marine Science, Bharathidasan University, at Tiruchirappalli, from 12-14th July 2017.

6. Dr. D. Deboral Vimala, Principal Scientist attended the training programme on "Digital Media Innovations in Extension" organized by National Institute of Agricultural Extension Management, at Hyderabad, from 26-28th July 2017.

7. Christina Lalramachhani, Scientist attended the training programme on "Analysis of experimental data" Organized by ICAR National Academy of Agricultural Research Management, at Hyderabad, from 3– 9th August, 2017.

8. Dr. Sujeet Kumar, Scientist attended the training programme on "Good Aquaculture Practices & Food Safety Preventive controls for Aquaculture Farms" organized The Marine Products Export Development Authority (MPEDA) in Association with United States Food and Drug Administration, at Sirkali, from 13-14th November 2017.

9. Dr. M. Makesh, Principal Scientist attended the training programme on "Management Development Programme on Leadership Development" organized by ICAR National Academy of Agricultural Research Management at Hyderabad from 12-23rd December 2017.

10. Shri. R. Elankovan, Chief Technical Officer attended the training programme on "KOHA for Library staff of ICAR organized by ICAR- NAARM, at Hyderabad, from 5 – 9th February 2018.

11. Dr. Raymond Jani Angel, Scientist attended the training programme on "Genomics and Proteomics-2018" organized by Department of Biotechnology, Alagappa University, at Karaikudi, from 14 -16th February 2018.

12. Dr. M. Kumaran, Principal Scientist attended the Training Programme on Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR, organized by ICAR-NAARM at Hyderabad from 15 - 17th February 2018.

13. Dr. N. Lalitha, Scientist attended the training programme on Vetinformatics, organized by Bioinformatics Centre & ARIS Cell, Madras Veterinary College at Chennai, from 12-16th March 2018.

14. Mr. Joseph Sahayarajan, Senior Technical Officer attended the training programme on Antimicrobial Resistance & Alternative to Antibiotic use in Aquaculture, organized by ICAR – CIFA at Bhubaneswar, from 12- 13th March 2018.

Trainings attended by individuals

Headquarters

Sl. No	Name of the Training /FGD	Duration	No. of participants
1.	Training Programme on "Innovative and evolving brackishwater crustacean aquaculture"	15 -21 April 2017	8
2.	Training Programme on "Grow-out cage farming of finfish in open brackishwaters" at Kottaikadu village, Kanchipuram Dist.	12 -13 May 2017	12
3.	Training Programme on "Innovative and evolving brackishwater crustacean aquaculture"	22 -27 May 2017	3
4.	Hands-on training programme on "Recent advances in soil and water management in brackishwater aquaculture"	20-24 June 2017	21
5.	Skill development programme for the fisher youths and aquaculture graduates on "Crafting low volume cages and farming of brackishwater fishes in cages"	11-14 July 2017	19
6.	Training Programme on "Innovative and evolving brackish water crustacean aquaculture"	17 -22 July 2017	9
7.	Training Programme on "Seed production and culture of brackishwater finfishes"	2-11 August 2017	1
8.	Sensitization Training programme on DNA based diagnostic "Polymerase Chain Reaction (PCR) detection of *Enterocytozoon hepatopenaei* (EHP) in shrimp" for the stakeholders of shrimp-farming sector	17-18 August 2017	14
9.	Training Programme on Hatchery Production and farming of milk fish and grey mullet	22-26 August 2017	10
10.	Training Programme on "Seed Production and culture of brackishwater finfishes"	12-16 September 2017	3
11.	On-farm training cum demonstration of Seabass nursery rearing in hapas to the youth and families at Kovalam, Kanchipuram Dist	7, 10, 13 & 19 October 2017	10
12.	Nursery rearing of seabass fry in hapas for tribals at Kezhar Kollai village, Koovathur, Kanchipuram Dist.	1, 6, 15 & 20 October 2017	5
13.	Training Programme on Seed production and culture of brackishwater finfishes"	9 – 13 October 2017	2
14.	National Training Programme on "Advances in shrimp aquaculture and biofloc based farming technology"	6-10 November 2017	10
15.	Nursery rearing of seabass and rearing of milkfish to tribals at Kezhar Kollai village, Koovathur, Kanchipuram Dist.	8 December 2017	30
16.	Brackishwater aquaculture in the changing climatic scenario and distribution of soil and water health cards to aqua farmers (Kota, Gudur Division, Nellore Dist., Andhra Pradesh)-FGD	21 December 2017	222*
17.	Brackishwater aquaculture in the changing climatic scenario and distribution of soil and water health cards to aqua farmers (Allur, Kavali Division, Nellore Dist., AP)-FGD	22 December 2017	225*
18.	Profitable technologies in brackishwater aquaculture for doubling farmers' income	29 January 2018	6
19.	National Training Workshop on "Aquaculture Nutrition and Feed Technology"	3-12 January 2018	20
20.	Customized Training on "Shrimp feed preparation and quality control" during	13-17 February 2018	2

21.	Training on Proximate Analysis of feeds and feed ingredients	13-14 February 2018	2
22.	A three day training programme on “Science and agricultural careers after School Education”	28-31 March 2018	25
	KRC, Kakdwip		
23.	Training Progrmme on “Feed formulation and feed management in brackishwater aquaculture”	19-24 June 2017	5
24.	Training programme on "Advances in Brackishwater Aquaculture Practices"	17-22 July 2017	12
25.	Training Programme on “Scientific management practices for sustainable shrimp and crab culture”	21-26 August 2017	12
26.	Training Programme on “Diagnosis and control of brackishwater finfish and shellfish diseases with special reference to emerging diseases”	13 – 18 November 2017	13

*These farmers were provided with soil and water health cards.

Workshops/Seminars/Meetings

CIBA-Foundation Day celebrated as OPEN DAY for school students

The 30th "Foundation Day" of CIBA was observed on 4th Apr 2017 as an "Open Day" to create awareness among school children about the importance of agriculture and allied subjects, including fisheries and aquaculture and their career prospects. About 300 students and 18 teachers from schools in and around Chennai visited the facilities and gained knowledge of aquaculture. Dr. K. K. Vijayan, Director, ICAR-CIBA stressed the

Workshop on
Revitalizing Fisheries and Aquaculture in Tamil Nadu for Doubling Farmers' income by March 2022

ICAR-CIBA and Federation of India Chamber of Commerce and Industry (FICCI) along with Tamil Nadu Fisheries University, Nagapattinam and Coastal Aquaculture Authority (CAA), Chennai jointly organized a "Workshop on Revitalizing Fisheries and Aquaculture in Tamil Nadu – Doubling income by March 2022-"on 30th May 2017 at ICAR-CIBA, Chennai. In his inaugural address, Dr K.K.Vijayan, Director, ICAR CIBA Chennai stated that Fisheries and Aquaculture Sector is a 'Sleeping Giant' in Indian Economy and its true strength is yet to be fully conceived by the planners and policy makers. The speakers stressed on the potential of aquaculture for the Indian economy and the scope for expansion of aquaculture in Tamil Nadu in a safe and sustainable manner.

World Environment Day and World Oceans Day celebrated jointly by ICAR-CIBA and CMFRI

The ICAR-Central Institute of Brackishwater Aquaculture (CIBA) along with Madras Research Centre of CMFRI and the Society of Coastal Aquaculture and Fisheries (SCAFi) jointly observed the World Environment Day and World Oceans Day at CIBA on 7th June, 2017 with the theme on "Life Systems in the Ocean Environment with reference to Fisheries and Aquaculture". Dr.P. Laxmilatha, Scientist-In-Charge of MRC-CMFRI, appealed for a clean environment and pollution-free sea. Dr.K.K.Vijayan, Director, ICAR-CIBA explained on the positive nterventions that protect the environment and at the same time to make use of the water source for food production, such as the cage farming programme taken up by CIBA in the Adayar creek with the involvement of Srinivasapuram fisher folk and Chennai River Restoration Trust for developing as well as alternative livelihoods of the people of that locale.

Training programme on "Recent advances in soil and water management in brackishwater aquaculture

A five-day hands-on training programme on "Recent advances in soil and water management in brackishwater aquaculture" was conducted during 20th -24th June 2017. 21 participants comprising of farmers, technicians, academicians, students and entrepreneurs participated in the training programme and gained hands-on training on soil and water quality testing and BMPs.

Third International Yoga day celebration

A week long training programme by a renowned yoga guru Mr. K. Nanjapathi was organised in ICAR-CIBA to commemorate the third international day of yoga from 15th to 21st June 2017. Speaking on the occasion, Dr. K.K. VIjayan, Director, ICAR-CIBA highlighted the significance of yoga and emphasized its relevance in today's lifestyle and the need to maintain a healthy body for a sound mind. Guest speaker Dr. Raji Velmurugan, life style expert from MIOT hospital delivered a lecture on “Life style modifications for lifelong good health

Farmers' Interaction Meet at Uttar Chandanpiri, Namkhana, West Bengal

Farmer's Meet was organized at Uttar Chandanpiri, Namkhana, South 24 Parganas., West Bengal on 29 June 2017. To provide technical support to the aqua farmers and vegetable growers of this village, scientists from ICAR-CIBA and subject matter specialists from Ramakrishna Ashram Krishi Vigyan Kendra, Nimpith, West Bengal delivered lectures in scientific session. Total 100 progressive farmers participated in the meet.

National Fish Farmers Day celebration atkkilamedu, Kanchipuram District, Tamil Nadu.

National Fish Farmers Day was celebrated on 10th July, 2017 with shrimp farmers, fishers and womenfolk at Kokkilamedu village, Kanchipuram district, Tamilnadu with the theme on “Doubling fish farmers” income. Initiatives taken by CIBA for alternative income generation of farmers/fishers through nursery rearing of fin fishes in open waters and ornamental fish farming in household tanks in the Kokkilamedu village were explained to the participants. Success story of “Ornamental fish farming unit” of the womenfolk of Thiruvidanthai village using the technology developed by CIBA was shared with the participants.

Skill Development Programme on Crafting low volume cages and farming of brackishwater fishes in cages

A skill development programme was organized for the fisher youths and aquaculture graduates on "Crafting low volume cages and farming of brackishwater fishes in cages" during 11-14th July, 2017. 19 trainees participated in the training. Resource persons from NIOT provided hands-on training on cage fabrication and deployment at Vennangupattu village where ICAR-CIBA is demonstrating cage farming. The brackishwater fish species suitable for cage farming, seed availability, optimum seed size, seed transportation, acclimatization, stocking density for different cages and sampling procedures were demonstrated to the trainees.

ICAR Foundation day

The 89th foundation day of ICAR was celebrated at ICAR-CIBA on 17th Jul, 2017. Ms. Swapna Sundar, IP Strategist & Patent Agent and CEO, IP Dome Strategy Advisors, Pvt. Ltd. Chennai presented on the "Recent developments in IPR and science policy issues.

Harvest cum interaction meet on cage farming of seabass fish as alternate livelihood support of coastal population in Tamil Nadu

A harvest cum interaction meet on cage farming of Asian seabass was organised at Vennangupattu village, on 4th Aug, 2017. About 120 fishers including fisherwomen and school children participated in the event and witnessed the harvest. Dr.K.K.Vijayan, Director, ICAR-CIBA handed over the revenue generated to the group.

National Workshop on Farming technology and propagation of indigenous Indian white shrimp for diversification of shrimp farming industry

A national workshop on "Farming technology and propagation of indigenous Indian white shrimp for diversification of shrimp farming industry" was conducted at ICAR-CIBA, Chennai on 3rd Aug 2017 to demonstrate and disseminate P. indicus culture. 150 farmers from various coastal states participated and benefited from the workshop. Addressing the large gathering, V.P. Thandapani, I.A.S, DOF,Govt. of TamilNadu and Dr.K.K. Vijayan, Director, CIBA emphasised the urgent need to promote native indigenous species along with exotic vannamei as the backup for sustainable aquaculture.

Sensitization Training programme on DNA based diagnostic “Polymerase Chain Reaction (PCR) detection of Enterocytozoon hepatopenaei (EHP) in shrimp”disting

ICAR-CIBA reported the cause of growth retardation problem due to presence of icrosporidian parasite, Enterocytozoon hepatopenaei or EHP for the first time in the country. ICAR-CIBA conducted a hands-on training programme on “Polymerase Chain Reaction (PCR) detection of Enterocytozoon hepatopenaei (EHP) in shrimp” in collaboration with CAA and MPEDA on 17th and 18th Aug, 2017 to train 14 hatchery personnel, colleges and government laboratory representatives for screening larval samples from the hatcheries and artemia. Mr. S.andrasekar, Presedent, SAP, Chennai, inaugurated the training, expressed his concern about the grim scenario emerging in the shrimp culture industry in India, especially with new pathogens and related crop failures.

Farmers Conclave and National Workshop on Sustainable Livelihood Options in Aquaculture for Rural Population for Doubling Aquafarmers Income

ICAR-CIBA in association with the Fisheries Technocrats Forum (FTF), Chennai conducted a farmers' conclave cum workshop on “Sustainable Livelihood Options in Aquaculture for Rural Population” at Nagapattinam on 19th August, 2017 to emphasise the Government of India initiative to double the farmers' income by 2022 and the role aquaculture can play in achieving this objective. About 100 participants including farmers, rural youth, scientists, scholars and officials from RGCA, NIOT, TNFU and Department of Fisheries attended the conclave

ICAR-CIBA celebrated Annual day-2017 and Family get-together

ICAR-CIBA celebrated its annual day 2017 and family get-together on 26th Aug 2017 organised jointly with SCAFi. CIBA staff and retired employees attended the annual day with their families. An exhibition of technologies , recent publications of the institute, and aquarium of brackishwater candidate species were also displayed

Society of Coastal Aquaculture and Fisheries (SCAFi) was inaugurated and logo released

The newly formed society at ICAR-CIBA for promotion of coastal aquaculture and fisheries (SCAFi) was inaugurated by Dr. E.G. Silas. He also unveiled the logo of SCAFi and launched the thematic logo of the society, he addressed the gathering by briefing about the history of CIBA formation and appreciated the activities of CIBA and formation of SCAFi..Director of CIBA, Dr. K K Vijayan underlined the need and proactive role of SCAFi in bringing R&D from the institution to benefit the society.

Invited talk by Dr.K.Narayana Gowda, Formerly V.C, UAS, Bengaluru

A lecture programme was organized by Agri-Business Incubator (ABI) and Society of Aquaculture and Fisheries (SCAFi) of ICAR-Central Institute of Brackishwater Aquaculture on 29th August 2017 at ICAR-CIBA, Chennai. Dr.K.Narayana Gowda, Formerly Vice-chancellor, UAS, Bengaluru delivered the invited talk on "Entrepreneurship development for attracting youth to agriculture". In his talk, he briefed the importance of fish and milk for nutritional security.

Interaction Meet on Role of Media in Dissemination of Brackishwater Aquaculture Information to the Stakeholders and Public

ICAR-CIBA organised a Scientists-Media interaction meet on 15th Sep 2017 to discuss the means for increased engagement with the media for disseminating technology innovations, success stories and development initiatives to farmers, policy makers and stakeholders. Correspondents from press, visual and digital media, agriculture magazines, media students and scientists participated in the programme. The speakers highlighted the necessity of constant interaction between the research institutions and media to understand the needs of the society and bringing technologies to the common man.

ICAR – CIBA participated in Aqua Aquaria India 2017

ICAR-CIBA actively participated in the Aqua Aquaria India 2017 with the theme "Diversification in Sustainable Aquaculture" organised by MPEDA at Mangalore during 14-16th May 2017. Posters, aquarium and specimen related to rearing, feed and disease management technologies for shrimp, Asian sea bass, milk fish, pearl spot, etc. were displayed. About 3,000 stakeholders visited the CIBA stall and interacted with the scientists.

ICAR-CIBA participated in the India International Science Festival

ICAR-CIBA participated and acted as the nodal institute for ICAR in the 3rd India International ICAR-CIBA showcased novel technologies developed at “Aqua Goa Fish Festival” organized by Government of Goa at Panaji during 7th to 10th Dec 2017. Smt. Mridula Sinha, Hon'ble Governor of Goa, Shri. Manohar Parikar, Chief Minister of Goa and Shri. Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare visited the CIBA stall and interacted with CIBA scientists. He appreciated the research efforts

undertaken by CIBA in the direction of 'Make in India' in brackishwater aquaculture and advised the scientists to further take it up to greater heights.

Attracting and Retaining Youth in Agriculture (ARYA) Programme

ICAR-CIBA conceived a 'Student project module on brackishwater aquaculture' to expose school students to farming systems and technologies to kindle interest among them. A group of nine students from Kendriya Vidyalaya School, Chennai participated in the programme held for seven weeks during Sep – Oct 2017. The students learned the basics of aquaculture and completed short-term projects to study brackishwater resources and aquaculture.

Partnership Farming of Penaeus vannamei in inland low saline water for doubling farmers

With the objective of doubling farmers' income, ICAR-CIBA took the inititative to demonstrate pacific white shrimp (Penaeus vannamei) farming in inland low saline water in South western Punjab where farmers used to earn an income of around Rs. 30,000 to Rs. 50,000 per acre from crop based activities. Under the ARYA program, two young engineers were trained in CIBA and were provided with support in terms of technology and specially formulated feed for the region. The farmers realised around Rs. 2 lakhs per acre from aquaculture.income

World Fisheries Day Celebrations at Koovathur Village, Kancheepuram District, Tamil Nadu

World Fisheries Day was celebrated on 21st November 2017 at Keelarkollai village in Koovathur Panchayat of Kancheepuram district of Tamil Nadu in convergence with about 120 villagers including fishers, tribals, rural youth and local leaders. The CIBA team disseminated the aquaculture technologies to the villagers, which can provide alternate livelihood opportunities, to increase their income. Dr. V. Selvam, Executive Director, MSSRF, Chennai, Chief guest of the function, distributed the hatchery produced milk fish (Chanos chanos) seeds from CIBA finfish hatchery, to the farmers of Koovathur village, which were released for pen culture operation.

Agricultural Education Day

Agricultural Education Day was organized on 4th December, 2017 to educate the school students on various facets of brackishwater aquaculture and inspire them to develop interest in agriculture. About 250 higher secondary students and 17 school teachers from leading schools of Chennai participated in the programme held at Muttukadu Experimental Station of CIBA.

Farmers interaction meet and Harvest Mela of Indian white shrimp (Penaeus indicus) in Kerala and Tamil Nadu

Multi-location culture demonstration of Penaeus indicus were carried out along different coastal states by ICAR-CIBA with an objective of propagating indigenous 'Desi' shrimp culture with support of NFDB. A partnership farming model of Indian white shrimp P. indicus were taken up in Tamil Nadu and Kerala for the performance evaluation. At both the demonstration sites the results were encouraging and the performance were on par with Pacific white shrimp, /farms in the adjacent ponds with respect to ABW, production and profitability. This present culture demonstrations were successful in terms of sustainability and profitability as the produced shrimps were sold at a rate of Rs.300-350/- per kg against a production cost of Rs.210-225/- per Kg. Farmers interaction meet and Harvest Mela were organized on 27th Aug 2017 at Kannur Kerala and on 30th November, 2017 at Shirkhali, Nagapattanam Tamil Nadu near the demonstration site.

Distribution of "Soil and Water Heath Cards" – PPP model to scale up

ICAR-CIBA is the first institute initiated the distribution of soil and water health cards (SWHC) in fisheries sector. The Institute has distributed about 705 SWHCs since 2015.In 2017, CIBA developed a working model to issue a SWHC through Public Private Partnership mode by impressing upon the fisheries colleges and private aquaculture laboratories existing in a particular district to analyze the samples at free of cost. In which the technical backstop and validation for the analysis was provided by CIBA. This model was tested in Nellore District, Andhra Pradesh and was appreciated by the farmers. In this regard, Brackishwater Aquaculture Farmers Meetings were organized by ICAR-CIBA in Nellore District, Andhra Pradesh on 21st and 22nd December 2017 at Kota and Allur, respectively under NICRA Project.

National Workshop on 'Strategic Approach In Fisheries Sector on the Potential and Viability of Culturing Endemic and Exotic Species in India' at ICAR-CIBA, Chennai

One day national workshop on "Studying the potential and viability of culturing endemic and exotic species for aquaculture" was organized by CIBA on 29th December 2017.
Dr. B. Meenakumari, Chairperson, NBA inaugurated the workshop and emphasised the importance of cataloguing of exotic fish species in India and stressed the co-ordination among the national bodies to create region wise quarantine facilities in order to address the biosecurity concerns in Indian context. In the Presidential Address, Dr. K.K. Vijayan, Director, ICAR-CIBA emphasized the importance of identifying the endemic fish species with economic importance, and put a mechanism in place to analyse positive and negative aspects of exotic species already introduced in India. He also stressed to create awareness among aquaculture farmers on the management of these species, through cataloguing and familiarisation.

National Workshop on Aquaculture Nutrition and Feed Technology

The national workshop on "Aquaculture Nutrition and Feed Technology" was inaugurated by the CEO, Shri Ramakanth V. Akula of The Waterbase Ltd., a leading shrimp feed manufacturer in India on 3rd January, 2018 at ICAR - CIBA, Chennai. He recorded his appreciation on the achievements of ICAR-CIBA in developing indigenous feed technologies and its subsequent commercialization for the benefit of brackishwater farmers in the country. Dr K.K Vijayan, Director, ICAR-CIBA stressed the need for joint ventures of research institutes and industries in PPP mode in scaling up of the technologies for sustainable development of the sector and for increasing profitability of farmers using the desi technologies. Farmers, technicians, academicians, research scholars, scientists and entrepreneurs from Punjab, Haryana, U.P, Gujarat, West Bengal, Andhra Pradesh, Telangana, Tamil Nadu and Kerala were participated in this workshop.

ICAR-CIBA partnered in the national seminar 'Aquaculture Kerala 2018 – A Blue Revolution Initiative

ICAR-CIBA, Chennai partnered in the 'Aquaculture Kerala 2018-A Blue Revolution Initiative' organized by Kerala Aqua Farmers Federation at Kannur in Kerala State during 10th to 12th February 2018. It was inaugurated by Shri Pinarayi Vijayan, Honourable Chief Minister, Government of Kerala. Chief Minister in his address stated that Government of Kerala will give support for promotion of aquaculture in Kerala through relevant policy including the leasing of public water resources and planning. Dr K K Vijayan Director CIBA Chennai in his key note address on “Brackishwater and Marine Aquaculture” stated that CIBA has several technically feasible, environment friendly and economically viable technologies in shellfish and finfish culture and the same need to be scaled-up through strategic planning and implementation of development schemes in convergence with State Government, aqua farmers and other stakeholders. Scientific adoption and scaling up of these technologies would definitely double the farmers income in a span of one to two years itself considering short crop period in aquafarming.

Women empowerment through Brackishwater Aquaculture

ICAR-CIBA, Chennai celebrated World Women's Day at Keezar Kollai in Koovathur village of Kancheepuram district in Tamil Nadu on 8th March 2018 with the theme on “Empowering farm women through brackishwater aquaculture” in consonance with the global theme of “Transformation of Women through empowerment.” CIBA scientists showcased successful Pearl Spot seed rearing and 'Brackishwater Ornamental Aquariculture' technologies. Smt Pushpa, a tribal woman from Thiruvidanthai village in Kancheepuram district, who has already taken up ornamental rearing, shared her experiences, and presented economic benefits gained from ornamental fish culture with the technical support of ICAR-CIBA, in a period of six months.

Krishi Unnati Mela

ICAR-CIBA organized a Farmers-Scientists meet on the occasion of 'Krsihi Unnathi Mela' and Prime ministers address, along with the project workshop on “Poverty alleviation through prevention and future control of the two major socioeconomically important diseases in Asian aquaculture' on 17th of March, 2018 at Elavoor Village in Thiruvallur district of Tamil Nadu”. On that occasion live streaming of Honourable Prime Minister of India Shri Narendra Modi addressing to the farming community was webcasted. Dr Chris Hauton, Scientist from University of Southampton, United Kingdom and Dr.Salam from Bangladesh Agricultural

University, shared their experiences on management of aquaculture diseases and interacted with the farmers. They emphasized that disease surveillance and Best Management Practices would help to reduce the risks in shrimp culture and able to maintain the sustainability.

Society of Coastal Aquaculture and Fisheries , CIBA (SCAFi-CIBA) lecture series

Invited talk by Shri. N. Vasudevan, Additional Principal Chief Conservator of Forests, Mangrove Cell, Mumbai, Maharashtra

Under the collaborative initiatives between Mangrove cell of Maharashtra Government and ICAR-CIBA, Shri. N. Vasudevan, Additional Principal Chief Conservator of Forests delivered an invited talk on "Mangrove ecosystems and its relevance to coastal development and blue economy" organized by SCAFi, CIBA-Chennai on 16th June,2017. He briefed the ecological role of mangroves and their role in the livelihood of the poorest of the poor who depend on these unique natural resources. He stressed the need for conservation of mangroves and options for a sustainable livelihood from mangrove ecosystems, such as eco-friendly brackishwater aquafarming, eco-tourism, etc.

Invited talk by Dr. Mruthyunjaya, former National Director, NAIP, ICAR

SCAFi, CIBA organised a lecture on "Challenges in the Indian Agricultural Research and Planning – a way forward" delivered by Dr. Mruthyunjaya, former National Director, NAIP, ICAR on 20th March 2018. He insisted Agricultural Science and Technology Innovations need to be quipped to meet the emerging food safety challenges of India, hence need to be 3-times rich in the R&D content in the days to come. Dr.K.K.Vijayan, President, SCAFi in his presidential remarks emphasised that brackishwater aquaculture is one of the vibrant farming sectors and our research findings have direct applications in the field, and the institute was able to transfer the technologies from the lab to the field, where social benefit is measurable. He added that institute is taking special care in mentoring the young scientists to blend their capabilities with the research requirements of the sector and the end users.

Awards and Recognitions

CIBA received Hindi Magazine award

ICAR-CIBA received best prize for its Hindi magazine "Jal Tarang" at 89th Foundation day celebrations of ICAR on 16th July 2017.

CIBA was recognised and appreciated by Govt. of Andhra Pradesh for its efforts in promotion of native Indian White Shrimp

CIBA and its team were appreciated for its effort for native shrimp species promotion at the Andhra Pradesh Agri Tech Summit 2017 organized by Andhra Pradesh Government in association with Bill and Melinda foundation during 15-17 November, 2017 at Visakhapatnam. As a token of appreciation Dr A. Panigraghi,

Principal Scienitist of CIBA receiving a Memento from Mr Chandra Mohan Reddy, Honourable Agriculture Minister, Govt of Andhra Pradesh.

- Dr. T. Sathish Kumar awarded with best poster presentation in the International Symposium on "Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture" held during April 20-21, 2017 at NBFGR Lucknow for the poster with the title "Development and validation of Loop mediated isothermal amplification (LAMP) for the detection of *Enterocytozoon hepatopenaei (EHP)"*

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- Dr. M. Kumaran received Letter of Appreciation from the Founder Chancellor and President Vel Tech Rangarajan Dr.Sagunthala R & D Institute of Science and Technology, Deemed University, Avadi, Chennai for being an expert Jury for the "VISAI 2018-8th International Project Competition and Exhibition" held during 23-24th February, 2018, Avadi, Chennai.

- Dr. R.Ananda Raja, Scientist was conferred with the "certificate of outstanding contribution in reviewing" from the Editors of "Fish and Shellfish Immunology" and "Microbial Pathogenesis ", Elsevier, Amsterdam, The Netherlands.

- Sri Sandeep K.P. and Dr. T.Sivaramkrishnan have been recognised as reviewer for Turkish Journal of Fisheries and Aquatic Sciences.

Ph. D. Obtained

Sl no		Title of thesis	Date
1.	**Dr. Sujeet Kumar**	Quorum Sensing and Virulence Mechanism in Vibrio and Clostridium Species	February, 2018
2.	**Shri. R. Vijayakumar**	Identification and immunoproteomic analysis of outer membrane proteins (OMPS) of *Vibrio anguillarum* as potential vaccine candidates	21st April 2017
3.	**Shri. S. Elangeshwaren**	Reproductive biology of Cobia *Rachycentron canadum* in and around Chennai coast	30th May 2017
4.	**Mrs. A. Gomathi**	Studies on Sequential pathogenesis and immune gene expression analysis of WSSV infection in *Penaeus mondon*	7th September 2017
5.	**Mr. R. Jannathulla**	Nutrient utilization of fermented plant protein sources in the diet of shrimp	7th February 2018

Linkages and Collaborations

The Institute maintained linkages with the following national and international organizations

ICAR Institutes

- Central Institute of Fisheries Education, Mumbai
- Central Institute of Freshwater Aquaculture, Bhubaneswar
- Central Marine Fisheries Research Institute, Cochin
- Central Agricultural Research Institute, Port Blair
- Central Inland Fisheries Research Institute, Barrackpore
- Central Institute of Fisheries Technology, Cochin
- Central Research Institute for Dryland Agriculture, Hyderabad
- Directorate of Seed Research, Mau
- Directorate of Research on Women in Agriculture, Bhubaneswar
- National Academy for Agricultural Research Management, Hyderabad
- National Bureau of Agriculturally Important Microorganisms, Mau
- National Bureau of Fish Genetic Resources, Lucknow

Other Institutes / SAUs / State Agriculture Departments

- Agricultural & Processed Food Products Export Development Authority, New Delhi
- Center for Advanced Studies in Marine Biology, Annamalai University, Parangipettai
- Coastal Aquaculture Authority, Chennai
- College of Fisheries, University of Agricultural Sciences, Mangalore
- College of Fisheries, Sri Venkateswara Veterinary University, Muthukur
- Dept. of Horticulture, Govt. of Tamil Nadu, Chennai.
- Dept. of Animal Husbandry, Govt. of Tamil Nadu, Chennai.
- Department of Animal Husbandry, Dairying and Fisheries, New Delhi
- Department of Biotechnology, New Delhi
- Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Thoothukudi
- Indian Institute of Technology, Chennai
- Mangrove Cell, Government of Maharashtra, Mumbai
- Ministry of Science and Technology, New Delhi
- Ministry of Water Resources, New Delhi
- Marine Products Export Development Authority, Cochin
- Navsari Agricultural University, Navsari, Gujarat
- National Fisheries Development Board, Hyderabad
- National Institute of Ocean technology, Chennai
- Sundarban Development Board, Govt. of West Bengal
- Tamil Nadu Veterinary and Animal Sciences University, Chennai
- Tamil Nadu Agricultural University, Coimbatore
- University of Madras, Chennai
- West Bengal University of Animal and Fisheries Sciences, Kolkata

State Fisheries Departments/BFDAs

- The Institute has well established linkages with State Fisheries Depts. /BFDAs mainly for transfer of technology programmes.

PUBLICATIONS, PARTICIPATION IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA

Institute Publication list

Annual Report 2016-17
Training Calendar 2017-18
CIBA News Jan-Jun 2017
CIBA News 2015-16
CIBA News Special Issue
Jal Tarang Vol.3 September 2017 (Hindi magazine)

CIBA Extension Series

- Managing hepatopancreatic Microsporidiosis, An emerging threat to shrimp farming. CIBA extension series No. 49. (Telugu).
- Acute hepatopancreatic necrosis disease/early mortality syndrome (AHPND/EMS). CIBA Extension Series No. 50. (Telugu).
- Prevention and management of white spot disease of shrimp. CIBA Extension Series No. 51. (Telugu).
- Seed production and grow-out culture technology of brackishwater catfish, Mystus gulio. CIBA extension series No. 60.
- Lumiphage (Malayalam) - Aquaculture Kerala, 10-12th February 2018.
- CIBAMOX (Malayalam) - Aquaculture Kerala, 10-12th February 2018.
- Mobile-based initiatives for e-Extension services for Fisheries and Aquaculture Agriculture Situation in India, VOL XXIV No.1

CIBA Technology Series

- Poly plus – a cost effective feed for brackishwater polyculture. CIBA Technology Series 15.

CIBA Special Publication

- Revised Handbook on Biofloc Technology: Concepts, Benefits and Application in Aquaculture. Edited by, A Panigrahi., S. K. Otta., K. P. Kumaraguru Vasagam and P. S. Shyne Anand. CIBA Special Publication No.82, 130 pp.

CIBA Training Manuals

- Training Manual on "Recent Advances in Soil and Water Management in Brackishwater Aquaculture". CIBA TM Series 2017 No. 8.
- Training Manual on "Polymerase Chain Reaction (PCR) detection of Enterocytozoon hepatopenaei (EHP) in shrimp". CIBA TM series 2017 No. 9.
- Innovative and evolving Brackishwater Crustacean Aquaculture. Edited by: A Panigrahi., M Jayanthi, Balasubramanian, C.P., Biju, I. F. and Jose Antony. CIBA-TM-Series-2107-No.5, 127 pp.
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Books by CIBA

- Penaeus Vannamei Ginga Palan Ke Bara Mae Akshar Poochae Janaevalae Prashna (in Hindi), (Vannamei Shrimp Farming: Farmers Frequently Asked Questions (FAQs) and Explanations), ICAR-CIBA, Chennai, ISBN No: 978-81-932937-6-8, 48p
- Compendium on prophylaxis in Aquaculture. ISBN No. 978-81-932937-7-5.

Reports by CIBA

- Environmental impact assessment of (EIA) of mangrove crab (Scylla serrata) farming in the coastal villages of Sindhudurg District, Maharashtra and carrying capacity assessment of creeks for crab farming. Published by ICAR-Central Institute of Brackishwater Aquaculture,

  Chennai, p. 84.

Peer Reviewed Journals

1. Abhilash, E. C., Alavandi, S.V., 2017. Isolation and characterisation of *Vibrio alginolyticus* lytic bacteriophage φ*Va*-1 from brackishwater clam *Meretrix meretrix* in India. *Indian J. Fish.,* 64(3): 116-121.

2. Ali, S.S.R., Ambasankar, K., Musthafa, M.S., Harikrishnan, R., 2017. Jerusalem artichoke enriched diet on growth performance, immunohematological changes and disease resistance against *Aeromonas hydrophila* in Asian seabass (*Lates calcarifer*). *Fish and Shellfish Immunology*, 70: 335-342

3. Ali, S.S.R., Ambasankar, K., Praveena, P.E., Nandakumar, S., Dayal, J.S., 2017. Effect of dietary fructooligosaccharide supplementation on growth, body composition, haematological and immunological parameters of Asian seabass (*Lates calcarifer*). *Aquaculture International* 25:837-848.

4. Altunoglu, Y.C., Bilen, S., Ulu, F., Biswas, G., 2017. Immune responses to methanolic extract of black cumin (*Nigella sativa*) in rainbow trout (*Oncorhynchus mykiss*). Fish Shellfish Immunol. 67, 103–109.

5. Avunje, S., Jung, S.J., 2017. Poly (I:C) and imiquimod induced immune responses and their effects on the survival of olive flounder (*Paralichthys olivaceus*) from viral haemorrhagic septicaemia. Fish shellfish immunol. 71: 338-345.

6. Balasubramanian, C. P., Shailesh, S.M., Sukumaran, K., Panigrahi, A., Vasagam, K.P.K., Kumararaja, P., Thigale, D., Sawant, R., Vijayan, K. K., Vasusdevan, N., 2018. Development of integrated multi-trophic aquaculture system for brackishwater brackishwater species in Sindhudurg district, Maharashtra, India. Indian Journal of Fisheries. 65(1): 59-64

7. Bera, A., Sawant, P.B., Dasgupta, S., Chadha, N.K., Sawant, B.T., Pal, A.K., 2017. Diel cyclic hypoxia alters plasma lipid dynamics and impairs reproduction in goldfish (*Carassius auratus*). *Fish physiology and biochemistry*, *43*(6), pp.1677-1688.

8. Bindu, J., Kamalakanth, C.K., Das, S., Asha, K.K., Gopal, T.K.S., 2017. Quality evaluation of high pressure-processed edible oyster (*Crassostrea madrasessis*) during chilled storage. Fishery Technology, 54: 36-41.

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67. Sarkar, S., P. Nila Rekha, Ambasankar, K., S. Hemanth kumar, V. Naresh & Vijayan, K. K., 2017. Bioremediation efficacy of the indigenous seaweed *Gracilaria sp.* in brackishwater salinity regime, 11th Indian Fisheries and Aquaculture Forum at Cochin during 21 – 24 November 2017.

68. Sarkar, S.,, P. Nila Rekha, Ambasankar, K., S. Sivagnanam, S. Rajamanickam and Balasususbramanian C.P. (2018). Nutrient Removal from Shrimp (*Penaeus vannamei*) Culture Discharge Water Using the Macroalgae *Gracilaria tenuistipitata* (Rhodophyta), Madras University Post-Centenary Diamond Jubilee International Conference on Biodiversity and Sustainable Resource Management (ICBSRM 2018) at Chennai during 12 – 13 March, 2018.

69. Satheesh Kumar S, Ananda Bharathi R, Chitra V, Rajan JJS, Alavandi SV (2017). Viability of WSSV in shrimp pond sediments with reference to physicochemical properties. In: 26th Annual

Conference of Indian Virological Society VIROCON 2017 "Viruses to Viromes in Health and Disease" December 7-9, 2017, Mangaluru, India.

70. Subhendu Kumar Otta, Saravanan P, Bala Amarnath C, Makesh M and Alavandi SV (2017) Exploring dsRNA for therapy of shrimp white spot syndrome virus (WSSV). In: 26th Annual Conference of Indian Virological Society VIROCON 2017 "Viruses to Viromes in Health and Disease" December 7-9, 2017, Mangaluru, India.

71. Sukumaran, K., Rekha M.U., Dani Thomas, Bera, A., Mandal, B., Makesh, M., Ambasankar, K., Kailasam, M., K.K. Vijayan, 2017. Reproductive characteristics of captive grey mullet *Mugil cephalus:* report from south-east coast of India. In: Book of abstracts- 11th Indian Fisheries and Aquaculture Forum; Kochi, Kerala. 21-24th 2017. Pp: 196.

72. Suvana, S., Kumararaja, P., Saraswathy, R., A. Nagavel., Muralidhar, M., 2017. Significance of carbon saturation and labile carbon in shrimp culture pond sediments varying in soil texture. In: Thomas, S. N., Roa, B.M., Madhu, V.R., Asha., K.K., Binsi, P. K., Viji, P., Sajesh, V. K., and Jha, P. N. (Eds.,) Fostering Innovations in Fisheries and Aquaculture: Focus on Sustainability and Safety – Book of Abstracts, 11th Indian Fisheries and Aquaculture Forum, ICAR- Central Institute of Fisheries Technology, Kochi and Asian Fisheries Society, Indian Branch, 21 – 24 November, 2017, India, pp.254.

73. Swathi, V., Preethy, Kumar, K.V., Kumar, J.A., Gopikrishna, G., Chris Hauton, Shekhar, M.S., Vijayan, K. K., 2017. Deciphering the transcriptome of Pacific white shrimp (Penaeus vannamei) infected with White Spot Syndrome Virus (WSSV). 11th Indian Fisheries and Aquaculture forum. 21-24 November 2017. pp331.

74. Thirumurthy, S., Jayanthi, M., Muralidhar, M., 2018. Assessment of impact of past and future shoreline changes using remote sensing & GIS: A case study of Kanchipuram district in Tamil Nadu. The Second International Symposium, SAFARI2, organized by ICAR-CMFRI, Kochi, India. January 15-17, 2018. ISBN: 978-93-82263-19-7.

75. Thomas, D., Vimala, D.D., Sukumaran, K., Sandeeep K P.,Thiagarajan,Kailadam and Vijayan, K. K., 2018. Alternate livelihood option through skill development in seed production of Brackishwater candidate fish species, *Etroplus suratensis* for tribal women. Paper presented at National Conference on Empowerment of Rural Communities through aquaculture held during 9-10 February 2018, Ratnagiri, Maharashtra Book of abstracts, pp 10.

76. Vijayan, K.K., Kumar, S., Alavandi, S.V., 2017. Emerging Pathogens in Brackishwater Aquaculture and Challenges in Aquatic Health Management. In: International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture, NBFGR. Lucknow, India, 20-21 April, 2017.

77. Vijayan, K. K., C V Sairam, Ravisankar, T., and R Geetha, 2018. Brackishwater Aquaculture for Food Employment and Prosperity Lead Paper presented in APFishTech-2018 organized by Society of Fisheries Technologies, Kochi, ICAR-Central Institute of Fisheries Technology, Kochi and Visakhapatnam Research Centre of ICAR-CIFT on 23rd March 2018 held at Visakhapatnam

78. Vijayan, K.K., Alavandi, S.V., 2017. Viral Disease Emergence in Brackishwater Aquaculture in India. In: 26th Annual Conference of Indian Virological Society VIROCON 2017 "Viruses to Viromes in Health and Disease" December 7-9, 2017, Mangaluru, India.

79. Vijayan, K.K., and C V Sairam, 2017. Way Forward on the Sustainable Brackishwater Aquaculture and R&D Initiatives by CIBA Chennai, Lead Paper presented during the Aqua Aquaria 2017 held at Mangalore during 14-16th May 2017

80. Vijayan, K.K., Muralidhar, M., Saraswathy, R., 2017. Climate Change and Brackishwater Aquaculture – Opportunities, Challenges and Adaptation Measures (Lead lecture). International Confernce on Climate Change and Sustainable Development with a special reference to Indian context (ICCCSD 2017), at Annai Fathima College of Arts and Science, Madurai, 14-15 December, 2017.

81. Vijayan, K.K., Otta, S.K.,Alavandi, S.V., 2017. Health management in coastal aquaculture in India: the way forward. Aqua Aquaria India 2017, 14th -16th May 2017, Mangalore, India.

Participation in conferences, meetings, workshops, symposia

National

Dr. K. K. Vijayan, Director

1. Brainstorming session on "Current Issues and Challenges in Indian Shrimp Aquaculture Industry", organized by Society of Aquaculture Professionals (SAP) at Chennai on 5th April 2017
2. Meeting to discuss on finalization of EFC and Cadre Strength of Scientific Staff, held at SMD (Fisheries), ICAR, New Delhi on 6th April 2017
3. Seventh meeting of the Project Screening Committee (PSC) constituted under the Guidelines for establishment of operation of SPF Shrimp Broodstock Multiplication Centre (BMC), under the Chairmanship of Joint Secretary (Fisheries) at Krishi Bhavan, New Delhi on 20th April 2017
4. International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture, organized by National Bureau of Fish Genetic Resources (NBFGR) at Lucknow on 21st April 2017
5. National Consultation Meet on Fisheries Policy, organized by NABARD, Kochi on 25th April 2017
6. Diamond Jubilee Foundation Day Celebration of Central Institute of Fisheries Technology (CIFT) at CIFT, Kochi on 29th April 2017
7. Brainstorming Meeting on Deep Sea Mission – Marine Biodiversity and Genomics and Marine Biotechnology, held at National Institute of Ocean Technology, Chennai on 12th June 2017
8. Meeting of SFC/EFC chaired by Secretary, DARE and Director General, ICAR, at ICAR, Krishi Bhavan, New Delhi on 19th June 2017
9. Eighth meeting of the Project Screening Committee, constituted under the guidelines for establishment of operation of SPF Shrimp Broodstock Multiplication Centre (BMC), organized under the Chairmanship of Joint Secretary (Fy.), DAHDF, at Krishi Bhavan, New Delhi on 19th June 2017
10. 26th Research Council meeting of Science Research Scheme (RC-SRS) at Sasthra Bhavan, Pittom, Trivandrum on 29th & 30th June, 2017
11. Fish Farmers Day celebration organized by Kerala University of Fisheries and Ocean Studies (KUFOS) at Kochi on 10th July 2017
12. ICAR Foundation Day and Directors' Conference, held at A.P.Shinde Auditorium, NASC Complex, New Delhi on 16th July 2017
13. 31st Executive Committee Meeting of National Fisheries Development Board (NFDB), at Hyderabad on 29th July 2017
14. 5th National Conference of the Ocean Society of India – OSICON 17, jointly organized by National Centre for Earth Science Studies, Trivandrum, Integrated Coastal and Marine Area Management (ICMAM), Chennai and Ocean Society of India (OSI), at Trivandrum, Kerala on 29th August 2017
15. Assessment Committee Meeting for assessment of CAS for the promotion of Senior Scientist (RGP – Rs.9000/-) to Principal Scientist under Revised CAS, held at Agricultural Scientist Recruitment Board, New Delhi on 20th September 2017
16. S&T Minister's Conclave as a part of India International Science Festival 2017 at IC&SR Auditorium, IIT, Chennai on 13 October 2017
17. 27th Swadeshi Science Congress 2017, organized at Amrita Viswa Vidyapeetham University, Vallikkavu, Kollam on 8th November 2017
18. 11th Indian Fisheries and Aquaculture Forum organized by Central Institute of Fisheries Technology (CIFT) in association with Asian Fisheries Society – Indian Branch (AFSIB) at Kochi during 21-24th November 2017
19. 59th Meeting of the Coastal Aquaculture Authority, held at CAA, Chennai on 10th January 2018
20. 44th Meeting of the Board of Management of Central Institute of Fisheries Education (CIFE) as a Member, at CIFE, Mumbai on 30th January 2018
21. 2nd Fishery Skill Advisory Meeting for skill development in fisheries, organized by Agriculture Skill Council of India, at CIFNET, Kochi, as an invited expert on 7th February 2018
22. Aquaculture Kerala 2018 organized by Kerala Aquafarmers Federation in association with DoF, Kerala, KUFOS, Kochi, CMFRI, Kochi, CIFT, Kochi, CIBA, Chennai and ADCOS, Kerala, at Kannur during 10-11th February 2018
23. National Science Day Celebration organized by Kerala University of Fisheries and Ocean studies (KUFOS), as an invited expert, 2018 at Kochi on 28th February
24. Meeting of the Farmers Forum of ADCOS to formulate strategies for the development of aquaculture in the State of Kerala on 3rd March 2018
25. Director's Conference at A.P.Shinde Hall, NASC Complex, Pusa, New Delhi during 8-9th March 2018

Participation in Workshops/Seminar/Meeting by Scientists

1. National Seminar Cum Workshop on Genomics and Proteomic - 2018" organized by The Department of Biotechnology of Alagappa University at Karaikudi during 14-16th February 2018 - Dr. J. Raymond Jani Angel
2. New India Manthan-*Sankalp se Siddh* programme on 29 August 2017 at Sasya Shyamala KVK, Ramakrishna Mission Vivekananda University, Narendrapur -

   Dr. T.K. Ghoshal
3. "Roundtable on bridging the divide in climate change and uncertainty" jointly organized by IIHMR University, and Norwegian University of Life Sciences, Kolkata on 29th January 2018 - Dr. T.K. Ghoshal, Dr. G. Biswas
4. "VISAI 2018-8th International project Competition and Exhibition" at Vel Tech Rangarajan Dr.Sagunthala R & D Institute of Science and Technology, Deemed University, Avadi, Chennai held during 23-24th February, 2018 – Dr. M. Kumaran
5. 12th WatMAN 2018 International Conference and Exhibition on Water Management" organized by Chennai Trade Centre, Nandambakkam, during 9-10th February 2018 at Chennai -Dr. M. Muralidhar

6. 20th Scientific Advisory Committee Meeting of KVK Kancheepuram on 06-11-2017 as Nominated Member of Director CIBA Chennai for the SAC Meeting - Dr. C.V. Sairam

7. 29th All India Congress of Zoology during 9-11 June 2017 at ICAR- CIFRI, Barrackpore, Kolkata - Dr. Gouranga Biswas, Ms. Leesa Priyadarsani

8. 3rd India International Science Festival (IISF-2017), organized by Ministry of Science and Technology and the Ministry of Earth Sciences, in association with Vijnana Bharati during 13-16th October 2017 - Dr. K.P. Kumaraguru Vasagam, Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. Krishna Sukumaran, Shri. Tanveer Hussain, Shri. Sathish Kumar

9. 5th National Conference of the Ocean Society of India (OSICON-17) , organized by ESSO – National Centre for the Earth Science Studies, during 28-30th August 2017 at Thiruvanthapuram - Dr. M. Jayanthi.

10. 6th International Conference on contemporary Engineering and Technology, 2018, organised by OSIET in association with Prince Shri Venkateshwara Padmavathy Engineering, Chennai during 10th and 11th March, 2018 - Dr. K. P. Kumaraguru Vasagam

11. 9th Scientific Advisory Committee Meeting of KVK Thiruvallur on 09-11-2017 as Nominated Member of Director CIBA Chennai for the SAC Meeting - Dr. C.V. Sairam

12. A Festival of Innovation and Entrepreneurship (FINE) organized by NIF, Ahmedabad 19-23rd March 2018 – Dr.T. Ravisankar

13. APFishTech-2018 held at Vishakapatnam organized by CIFT Kochi on 23rd March 2018 – Dr. C. V. Sairam

14. Aquaculture Kerala 2018- A blue Revolution Intiative, organised by Kerala Aqua Farmers Federation, Kannur during 10th -12th February, 2018 - Dr.C.V.Sairam, Dr. J. Raymond Jani Angel

15. As an expert participated in the project evaluation committee meeting convened by GITA to evaluate the international projects submitted to GITA on 22nd January 2018 at New Delhi - Dr. K. Ambasanakar

16. As an invited expert participated the Brain storming session on Nutrition and live feed for aquaculture species during 21-22nd February 2018 at FMU, Balasore organised by DBT -Dr. K. Ambasanakar

17. Asian Veterinary Pathologists Congress 2017, organized by Department of Veterinary pathology Veterinary College, KVAFSU, Hebbal, during 9-11th November 2017 at Bengaluru - Dr. P. Ezhil Praveena

18. Attended a meeting at ADAK on 27th December 2018 at Trivandrum and discussed about the forthcoming collaborative feed mill project between ADAK and CIBA - Dr. K. Ambasanakar

19. Attended a meeting convened by additional Chief Secretary (Fisheries) along with ADAK officials at Trivandrum in connection with the proposed feed mill establishment at Kerala. - Dr. K. Ambasanakar

20. Attended Management Development Programme on Leadership Development (a pre-RMP programme) organized at ICAR-NAARM, Hyderabad during 12-23 December, 2017 – Dr. M. Makesh

21. Attended National Workshop on "Revisiting Foundation Course for Agricultural Research Service (FOCARS): Reflections and feedback of Trained Scientists" during 15 – 16th March, 2018 at ICAR-NAARM, Hyderabad - Mrs. Babita. M.

22. Attended review meeting for Fisheries Domain institutions participating in the Network project on Agricultural Bioinformatics and Computational Biology on December 26-27, 2017 at IASRI, New Delhi - Shri Ashok Kumar Jangam

23. Attended steering committee meeting of Network project on Agricultural Bioinformatics and Computational Biology during 19-20th April 2017 at IASRI, New Delhi - Shri Ashok Kumar Jangam

24. Attended the conference "Sensitizing youth to flagship programs of government" (SYPOG) biodiversity and environment session in India international science festival (IISF, 2017) organized by the Ministry of earth sciences, Biodiversity and environment on 15th October, 2017 at Vijnana bharathi at Anna university campus, Chennai - Shri.I.F. Biju

25. Attended to overseas inquiries for CIBA technologies and products from Vietnam, Russia, and Spain in consultation with AgIN-Agrinnovate India Limited - Dr. T. Ravisankar

26. Biodiversity and Sustainable Resources Management (BSRM-2018). Jointly organized by Centre for Environmental Sciences (CES) and Centre for Water Resources Management (CWRM) University of Madras, Chennai, INDIA March, 12-13, 2018 - Dr. K. P. Kumaraguru Vasagam

27. Brain Storming on "Nutrition and Live Feed for Aquaculture Species" organized by Department of Biotechnology, during 21-22nd February 2018 at New Delhi - Dr. K. Ambasankar

28. Brain storming session on "Cage aquaculture in inland open waters of India" on 16 March 2018 at ICAR-CIFRI, Barrackpore, Kolkata - Dr. Prem Kumar

29. Chairperson for the walk-in- interview conducted on 9th February 2018 by Rajiv Gandhi Centre for Aquaculture, Neelankarai, Chennai – 41.- Dr.B. Shanthi

30. Chennai science congress 2018, Council for science and technology, Government of Tamilnadu, Chennai 21-24 February 2018 - Dr. N. S. Sudheer.

31. Collaboration with Seven seas Aqua farms and Exports Ltd., #9-6-21/2, C.B.M compound, Visakhapatnam - 531 003 for partnership farming in brackishwater aquaculture – Dr. R. Saraswathy

32. Community education programme for Adyar river eco-restoration, Tamil Nadu Slum Clearance Board, Chennai, 19th December 2017 - Dr. P. Mahalakshmi

33. Delivered lectures on "e-Extension strategies for Knowledge led rural growth" and "Mobile-based initiatives for e-Extension services in fisheries and Aquaculture" on 20.06.2018 for students at Fisheries College & Research Institute, Ponneri – Dr.D.D. Vimala

34. Discussion Meeting, organized by Department of Marine Biology, Microbiology and Biochemistry, CUSAT, Cochin on 16th March 2018 - Dr. Sujeet Kumar

35. Expert Jury for the "VISAI 2018-8th International project Competition and Exhibition" held during 23-24th February 2018 at Vel Tech Rangarajan Dr.Sagunthala R & D Institute of Science and Technology, Deemed University, Avadi, Chennai - Dr. M.Kumaran

36. Farmers Meet for doubling farmer's income on 9 February 2018 at Ramkrishna Mission Krishi Vigyan Kendra, Nimpith, West Bengal - Dr. Prem Kumar

37. First Meeting of the committee for "Monitoring of aquaculture farms and hatcheries in order to check the undesirable use of antibiotics and other pharmacologically active substances in the country" organized by NFDB, on 5th February 2018 at Hyderabad - Dr. P.K. Patil

38. Fisher Friend Multi Stakeholder Workshop at M.S.Swaminathan Research Foundation, Chennai on 13th December 2017 – Dr. Deboral Vimala

39. Harvest mela cum scientist farmers interaction meet in connection with *Penaeus indicus* harvest on 1st September 2017 at Contai, West Bengal- Dr. Sanjoy Das

40. Harvest mela cum scientists farmers interaction meet in connection with *Penaeus indicus* harvest on 1 September 2017 at Contai, West Bengal - Dr. Sanjoy Das, Ms. Leesa Priyadarsani

41. Harvest mela cum scientists farmers interaction meet in connection with *Penaeus indicus* harvest on 4 September 2017 at Balasore, Odisha - - Dr. Sanjoy Das, Ms. Leesa Priyadarsani

42. ICAR Short course on 'Advances in risk analysis and GIS based prediction modelling of livestock parasitic diseases' organized by ICAR – National Institute of Veterinary Epidemiology and Disease Informatics (ICAR –NIVEDI), Ramagondanahalli, during 23rd October 2017 to 1st November 2017 at Bengaluru. - Shri. T. Sathish Kumar

43. India International Science Festival-2017 at Anna University, Chennai organized by ICAR New Delhi during 16th October 2017 –Dr.C.V. Sairam

44. Indian Conference on Life Cycle Management (ILCM 2017), organized by India LCA Alliance (ILCAA) during 9-10th October 2017 – Dr. M. Muralidhar

45. Inspection committee of the aquatic quarantine facility of RGCA on 2nd June 2017at Neelankarai, Tamil Nadu - Dr.M.Jayanthi

46. Institute for empanelment of experts as Evaluation Committee members under National Programme for organic production, organized by NPOP APEDA on 27th December 2017 - Dr. Akshhya Panigrahi, Dr. Debasis De, Dr. Shyne Anand, Shri. T. Sathish Kumar, Shri. Pankaj Amrut Patil

47. Interaction meeting with Hon'ble Union Agriculture Minister on 13 June, 2017 at ICAR-NIRJAFT, Kolkata- Dr. T.K. Ghoshal

48. International Conference on "Biodiversity and Sustainable Resources Management (ICBSRM-2018)" organized by Centre of Environmental Sciences & Centre for Water Resources Management, University of Madras during 12-13th March 2018 at Chepauk – Dr. K.P. Kumaraguru Vasagam.

49. International Conference on "Climate Change and Sustainable development with a special reference to Indian context" organized by Annai Fathima college Alampatti, Tirumangalam, Madurai, 14 -15th December 2017- Dr. R. Saraswathy

50. International Conference on "Invigorating Transformation of Farm Extension towards Sustainable Development: Futuristic Challenges and Prospects" organized by Tamil Nadu Agricultural University, during 09-10th March 2018 at Coimbatore - Dr. C.V. Sairam.

51. International Conference on Biological applications of nanoparticles (ICON –BIO 2017), organized by The MagGenome Technologies Pvt. Ltd is association of IIT Chennai, Slovak Academy of Sciences and Charotar University during 4 – 5th December 2017 - Dr. R. Saraswathy, Dr. P.K. Patil, Dr. Vinaya Kumar Katneni, Dr. Sujeet Kumar, Dr. Vinay Tharabenahalli Nagaraju.

52. International Seminar on Coastal and Marine Biodiversity and Conservation (ISCMBC-2018), 15th and 16th of March 2018 at CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai - Dr. K. P. Kumaraguru Vasagam

53. International Symposium on "Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture" organized by The Aquatic Biodiversity Conservation Society (ABCS), India, ICAR- National Bureau of Fish Genetic Resources, on 20–21st April 2017 at Lucknow - Dr. S.K. Otta, Dr. T. Sathishkumar

54. International Symposium on 11th Indian Fisheries and Aquaculture Forum, organized by "Asian Fisheries Society Indian Branch (AFSIB)" and ICAR –CIFT during 21-24th November 2017- Dr. C.P. Balasubramanian, Dr.M. Jayanthi, Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. Makesh, Dr. Debasis De, Dr. Krishna Sukumaran, Dr. N. Laitha, Dr. Satheesha Avunje, Dr. K.P. Kumaraguru Vasagam, Shri. K.P. Sandeep, Dr. Aritra Bera, Shri. T. Sathish Kumar, Ms. Suvana Sukumaran, Shri. Dani Thomas, Shri. R. Aravind, Shri. Jose Antony, Shri. T. Sivaramakrishnan, Dr. R. Geetha, Dr. G. Biswas, Ms. L. Christina, Shri. Subburaj, Dr. J. Raymond Jani Angel

55. International Symposium on SAFARI, organized by Central Marine Fisheries Research Institute during 15-17th January 2018 - Dr. M. Jayanthi

56. Invited lecture on agricultural education the current perspectives in Madras Veterinary College, Chennai on 4th Dec 2017 - Dr. T. Ravisankar

57. Meeting on "BMPs and guidelines for vannamei shrimp farming and rules and regulations for the registration of shrimp farms with CAA" organized by Fish Farmers Development Agency, Ernakulum during 25-27th July 2017 - Dr. C.P. Balasubramanian.

58. Meeting on "Establishment of Disease Diagnostic Laboratories for Aquatic Animals under Blue Revolution Scheme received form States" organized by Department of Animal Husbandry, Dairying & Fisheries, at Krishi Bhawan, New Delhi on 27th June 2017- Dr. S.K. Otta

59. Meeting on "Establishment of fish feed mill" with the Additional Chief Secretary, organized by Development of Aquaculture on 19th October 2017at Kerala - Dr. K. Ambasankar

60. Meeting on "To evolve standard design on GMPs and to address concerns about Antibiotic residue in Aquaculture" organized by Department of Fisheries, Govt. of Andhra Pradesh at Sub Collector Office, on 14th September 2017 at Vijayawada, Krishna District - Dr. P.K. Patil.

61. Meeting on Indian food exports: understanding regulatory and safety requirements, Export Promotion Council, Taj Club House, Chennai, 7th March 2018 – Dr. R. Geetha

62. Member of Doctoral Committee of Ph.D student Ms. K. Marie Anne Preetha, Centre for Nano science and Nano Technology, Anna University,

Chennai- Dr. R. Saraswathy

63. Member, Doctoral Committee for a research scholar in School of Information Technology, VIT University, Vellore - Dr. P. Mahalakshmi

64. Mid-term Review Meeting of ICAR Regional Committee-II on 13 November 2017 at ICAR-CIFRI, Barrackpore - Dr. T.K. Ghoshal

65. Mr. Saifulla Mondal entered into an MOU with CIBA for production of fish and shrimp feed on 3rd July 2017 - Dr. K. Ambasanakar

66. National conclave on Scientific Co-operation on Food Safety and applied Nutrition" organized by FSSAI, FDA Bhawan, on 5th February 2018 at New Delhi - Dr. Satheesha Avunje

67. National Conference on "Empowerment of Rural Communities through Aquaculture" College of Fisheries, during 9-10th February 2018 at Ratnagiri - Dr. M. Kailasam

68. National Consultation on Mari culture and open sea cage culture development in India, organized by The Mandapam Regional Centre of CMFRI, Ramanathapuram, during 8-9th June 2017 – Dr. M. Kailasam.

69. National Convergence Conclave on the Climate Change, organized by Sree Narayanan College on 19th March 2018 at Chennai - Dr. M. Jayanthi

70. National Fish Farmer's Day celebration on 10 July, 2017 at ICAR-CIFE, Kolkata Centre - Dr. T.K. Ghoshal

71. National Level Seminar on "Marine Biotechnology and Shrimp Genetics Research" organized by Tamil Nadu Fisheries University Directorate of Centre for Sustainable Aquaculture on 14th October 2017 at Tanjavur. - Dr. C.P. Balasubramanian

72. National Workshop on "Antimicrobial Resistance & Alternatives to antibiotic use in Aquaculture" organized by ICAR- CIFA during 12-13th March 2018 - Dr. S.V. Alavandi, Mr. Joseph Sahayarajan.

73. National Workshop on "Revisiting Foundation Course for Agricultural Research Service (FOCARS): Reflections and feedback of Trained Scientists" organized by ICAR – National Academy of Agricultural Research management during 15-16th March 2018 - Dr. Raymond Jani Angel, Ms. Babita, Shri. Dani Thomas

74. Network Project on "Ornamental fish breeding and Culture" organized by ICAR-Central Marine Fisheries Research Institute on 12th March 2018 - Shri. Dani Thomas.

75. NICRA project meeting held during 26-27th May 2017 at ICAR, New Delhi - Dr.M.Jayanthi

76. Officiated as a Nodal Officer in conducting the ICAR's 22nd All India Entrance Examination for Admission (AIEEA)U.G and P.G.Degree Programmes and SRF (PGs) -2017 in Agriculture and Allied Sciences for Academic session 2017-18 at Tamil Nadu Veterinary and Animal Sciences University on June 10 the &11th 2017 – Dr.D.D. Vimala

77. One day seminar-cum-workshop on 'Pros and cons of use of antibiotics in Aquaculture' on 22 February 2018 at the Office of Deputy Director of Fisheries (Microbiology and Parasitology), Govt of West Bengal, Pailan, Kolkata - - Dr. Sanjoy Das

78. Participated and deliver lecture in farmers meet for doubling farmer's income at Ramkrishna Mission Krishi Vgyan Kendra, Nimpith, West Bengal on 9th Feb. 2018 - Dr. Prem Kumar

79. Participated and delivered a guest lecture in the national workshop on Augmenting Animal Productivity Through Emerging Technologies to Ensure Food Security in the Era of Climate Change held during 6-7th July 2017, at Veterinary college and Research Institute Namakkal Jointly organised by TANUVAS and ANSI, Karnal - Dr. K. Ambasanakar

80. Participated and made presentation at AQUABIZ 2017 organised by CII - Department of Fisheries, Govt of AP held at Vijayawada on 15th and 16th September 2017 - Dr.S.V. Alavandi

81. Participated and made presentation at the National Workshop on Antimicrobial Resistance & Alternatives to Antibiotic Use in Aquaculture organised at ICAR-CIFA Bhubaneswar from 12-13 March 2018 – Dr.S.V. Alavandi.

82. Participated in Brain storming session on "cage aquaculture in inland openwaters of India" at CIFRI, Barrackpore, Kolkata on 16th March 2018 - Dr. Prem Kumar

83. Participated in the Annual Review Meeting of National Surveillance Programme of Aquatic Animal Diseases (NSPAAD) and International Symposium on Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture (ISAAHE) from 18th to 21st April 2017 at ICAR-NBFGR, Lucknow. - Dr.S.V. Alavandi

84. Participated in the conference on Roadmap for Indian Feed Industry organised by BENISION Media, held at Pune during 8-10th February 2018 - Dr. K. Ambasanakar

85. Participated in the Fisher Friend Multi-Stakeholder Meeting on December 13, 2017, at MSSRF, Chennai – Dr.D.D. Vimala

86. Participated in the Indian white shrimp, *P.indicus* harvest mela cum farmers interaction meet at Nellore on 11th January 2018 - Dr. K. Ambasanakar

87. Participated in the International conference on biological applications of nanoparticles, ICON-BIO-2017, organized at IIT, Chennai on December 4th and 5th, 2017- Dr K. Vinay Kumar

88. Participated in the stakeholder meeting on Tamil Nadu Nutrition Alliance at MSSRF on 9th January 2018 Dr. K. Ambasanakar

89. Participated in the training Programme on Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR, at ICAR-NAARM, Hyderabad, from 15.2.2018 to 17.2.2018 - Dr. M.Kumaran

90. Participated in the workshop on 'Indian Food Exports: Understanding regulatory and safety requirements' organized by Export Inspection Council, Ministry of Commerce and Industry, Govt. of India, Canadian food inspection agency, European Union and United States Food and Drug Administration on 7th March, 2018 at Taj Club House, Chennai - Dr. M. Makesh

91. Participated in the workshop on Regional consultation on farming system for Nutrition at MSSRF during 7-9th August 2017 - Dr. K. Ambasanakar

92. Participated equipment specification committee meeting for the purchase of Aqua feed twin screw extruder to Fisheries Institute of Technology and Training, Tamil Nadu Fisheries University on 20.04.2017 at TNFU Campus, Vaniyanchavadi, Chennai - Dr. K. Ambasanakar

93. Participated in the tender opening committee meeting for the purchase of Aqua feed twin screw extruder to Fisheries Institute of Technology and Training, Tamil Nadu Fisheries University on 23.05.17 at TNFU Campus,

Madhavaram, Chennai - Dr. K. Ambasanakar

94. Prepared document on technical consultancy on aquaculture (Shrimp) insurance to Oriental Insurance Company Ltd - Dr. T. Ravisankar

95. Review meeting for Fisheries Domain institutions participating in the Network project on Agricultural Bioinformatics and Computational Biology on 26-27th December 2017 at IASRI, New Delhi – Dr. Ashok Kumar Jangam

96. Roundtable on bridging the divide on climate change and uncertainty- engaging with diverse perspectives from the above, middle and below jointly organized by IIHRM University and Norwegian University of Life Sciences on 29 January 2018 in Kolkata - Dr. T.K. Ghoshal, Dr. Gouranga Biswas

97. Scientific Advisory Committee Meeting of Ramkrishna Ashram KVK, Nimpith on 18 November 2017 - Dr. T.K. Ghoshal

98. Scientific committee member, 4th International Conference on Fisheries and Aquaculture 2017 (ICFA 2017), 24-25 August 2017, Colombia, Sri Lanka. - Dr. P. Mahalakshmi

99. Served as a selection committee member in the panel for recruiting Assistant Professor /Associate Professor at Tamil Nadu Fisheries University, Nagapattinam on June 14th, 2017 – Dr.D.D. Vimala

100. Served as an external expert for the promotion of assistant professor to a higher grade in Sri Venkateswara Veterinary University, Tirupati – 16.03.2018.

101. SFC meeting held during 19-20th June 2017 at ICAR, New Delhi - - Dr.M.Jayanthi

102. SFC preparation and cadre review meeting held during 6-7 th April 2017 at fisheries DDG office, KAB-II, New Delhi - Dr.M.Jayanthi

103. Special Lecture on "Bioacoustics for preventing Crop Loss" organized by MSSRF, Chennai on 16th February 2018 - Dr. Suvana Sukumaran

104. Sri Sathvika Aqua Agro Industries Private Limited, Ongole, Andhra Pradesh signed MOU, for the shrimp feed mill and Vannami Plus technology on 4th May 2017 – Dr. K. Ambasanakar

105. Stakeholder workshop/consultation meet at Bhimavaram organized by Marine Products Export Development Authority (MPEDA), 9th January 2018 – Dr. P.K.Patil.

106. Sustainable Livelihood Options in Aquaculture for Rural Population, conducted by Fisheries Technocrats Forum and Central Institute of Brackishwater Aquaculture at Nagapattinam on 19-08-2017 - Dr. K. P. Kumaraguru Vasagam

107. Tamil Nadu Slum Clearance Board, Chennai for organizing Community education programmes for Adyar river eco-restoration - Dr. P. Mahalakshmi

108. The "AP Ag Tech Summit 2017: Progressive Farmer, Smart Farming" organized by Government of Andhra Pradesh in partnership with Bill & Melinda Gates Foundation, Dalberg Advisors and Confederation of Indian Industry APIIC Ground, Harbor Park, Visakhapatnam, during 15-17th November 2017 at Andhra Pradesh- Dr. A. Panigrahi

109. The "Stake holders meet on Shrimp Aquaculture" organized by NFDB, 4th Block Meeting hall AP Secretariat, Velegapudi, Amaravathi, on 22nd August 2017- Dr. C.P. Balasubramanian, Dr. Akshaya Panigrahi, Dr. Subhendu Kumar Otta.

110. The 17th Edition of BENGALURU TECH SUMMIT with focal theme "Ideate Innovate, Invent" organized by Department of Information Technology, Biotechnology Government of Karnataka, during 16-18th November 2017 at Bangalore- Dr. M.S. Shekhar

111. The Brainstorm Meeting on "Deep Sea Mission – Deep Sea Fishery and Krill" organized by The Centre for Marine Living Resources and ecology Kochi, on 22nd May 2017 - Dr. G. Gopikrishna

112. The Certificate Course on Effective Patent Drafting "PATDRAFT" in Chennai, organized by Tamil Nadu Development and Promotion Centre of Confederation of Indian Industry in Association with Centre for Intellectual Property Rights (CIPR) of Anna University during 8-12th November 2017 at Chennai - Shri. K.P. Sandeep, Dr. J. Raymond Jani Angel

113. The India – EU Dialogue Seminar on " The Use of Veterinary Medicines and Anti- microbial resistance" organized by Department of Commerce, Export Inspection Council, during 15-16th November 2017 at New Delhi - Dr. P.K. Patil

114. The India International Science Festival (IISF), organized by Ministry of Science and Technology and the Ministry of Earth Sciences "Biodiversity and Environment" and Vijnana Bharati, Anna university Campus on 15th October 2017 at Chennai- Dr. C.P. Balasubramanian, Dr. R. Geetha, Dr. Krishna Sukumaran, Shri. Biji Francis

115. The Meeting on " Status on Hilsa Fisheries related Research in ICAR institutes and seed production technology of hilsa fish the country" organized by ICAR on 11th December 2017 at New Delhi - Dr. Debasis De

116. The Meeting on "Community Education Programme for Adyar River Eco Restoration" organized by Tamil Nadu Slum Clearance Board (Chennai) on 19th December 2017 - Dr. P. Mahalakshmi.

117. The One day Training cum Awareness Workshop on J-Gate@ CeRA for Southern region (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Telangana) organized by CMFRI, Cochin on 15th December 2017 - Shri. R. Elankovan

118. The Winter School Programme on "Antimicrobial resistance in fish and aquatic environment and its impact on human health CIFT, Cochin during 1-21st December 2017 - Smt. Vidya Rajendran

119. The Workshop on "Development of Marine Fisheries and Post-Harvest Technologies" organized by National Fisheries Development Board during 7-8th September 2017 at veraval, Gujarat - Dr. C. Gopal , Shri. Pankaj Amrut Patil

120. Third global Rajasthan Agri-tech Meet (GRAM) 2017, organized by Rajasthan Government in collaboration of FICCI, during 7-9th November 2017 at New Delhi - Dr. P.K. Patil

121. Third International Conference on Bio resource and Stress Management (ICBSM), organized by Visva-Bharti (Santiniketan) in association with ICAR (New Delhi), Society for Bio resource and Stress Management (Kolkata) during 8-11th November 2017 at Jaipur. - Dr. R. Saraswathy

122. Train-the-trainer Program of Veterinary Drug Residues by UPLC-MS/MS at College Park, Maryland, United States, 10-14th April 2017 – Dr.

P.K.Patil.

123. VIROCON 2017, 26th National Conference of Indian Virological Society (IVS) "Viruses to viromes in health and Disease" organized by Nitte University Deralakatte, Mangaluru, during 7-9th December 2017 at Karnataka - Dr. M. Poornima, Dr. S. K. Otta, Dr. Ezhil Praveena, Dr. Satheesha Avunje

124. Visited the feed mill established by TN state Fisheries Department with technical assistance from CIBA on 06.03.2018 at Sengipatti, Achampatti in Thanjauvur district of Tamil Nadu and successfully undertaken trial run for production. - Dr. K. Ambasanakar

125. VIT University, Vellore, 12th January 2018 - Comprehensive viva voce examination for Research Scholar - Dr. P. Mahalakshmi

126. Workshop on 'Developing multi-disciplinary approach in project formulation and innovation in agriculture and allied sector' on 17 February 2018 at ICAR-CIFRI, Barrackpore - Dr. Sanjoy Das

127. Workshop on " Environment sustainability through science based tools and approaches: Getting started with life cycle assessment" organized by CSIR – NEERI with FCCI during 6-7th March 2018 - Dr. Suvana Sukumaran

128. Workshop on "Application on Single Molecule Real Time (SMRT) Sequencing and Bioinformatics Analysis" organized by The ICAR-National Bureau of Fish Genetic Resources, Imperial Life Sciences and Pacific Biosciences, ICAR-NBFGR, Lucknow during 25-26th July 2017- Dr.M. Shashi Shekhar, Dr. K. Vinaya Kumar.

129. Workshop on "Developing multi –disciplinary approach in project formulations and innovations in agriculture and allied sectors" organized by ICAR- CIFRI, Barrackpore on 17th February 2018- Dr. Sanjoy Das

130. Workshop on ICAR NASF Project "Stock characterization, captive breeding, seed production and culture of hilsa" organized by ICAR – CIFRI Barrakpore, during 24-26th October 2017 at Kolkata. - Dr. Debasis De

131. Zonal Workshop on "Promotion of Skill Development in Agricultural Sectors for Eastern States of India" organized by Department of Agriculture, Govt. of West Bengal on 25 May 2017 at Ramakrishna Mission Institute of Culture, Kolkata - Dr. G. Biswas

132. Compilation of site inspection committee in On the inspection conducted on 21 March 2018 for NFDB BMC at Mulapolam, Srikakulam district, Andhra Pradesh in collaboration with erstwhile MONA INDIA Company – Dr. A. Panigrahi

Consultancies, Technology Development and Transfer

Institute Technology Management and Agri Business Unit

Institute Technology Management Unit and Agri Business Incubator are functioning with ICAR-National Agricultural Innovation fund at CIBA. The performance has been consistently good and CIBA is generating revenue of Rs.25 lakhs and above every year from commercialization.

MoUs signed in 2017-18

Initiation of responsible aquaculture development in and around Kachchh region of Gujarat

To initiate responsible aquaculture development in and around Kutch region of Gujarat, Gujarat Institute of Desert Ecology (*GUIDE)* proposed collaborative research with ICAR-CIBA for aquaculture research development and extension in this region. On 4th April 2017 Dr. K.K. Vijayan, Director, ICAR-CIBA, Chennai and Dr. V. Vijay Kumar, Director, GUIDE signed MoU to initiate joint work programmes on aquaculture activities.

A progressive farmer signed MoU for commercial scale seabass nursery technology

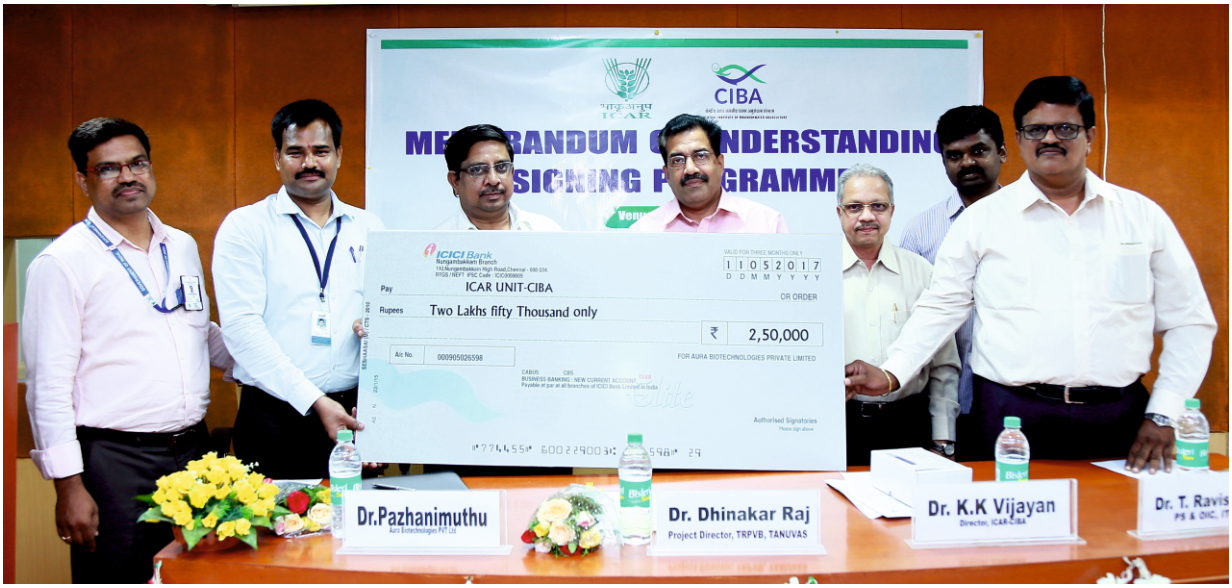
Shri.Nishanth Reddy, a young farmer from Nellore signed an MoU for commercial operation of Seabass nursery on 17 April 2017. Later he shared the revenue generated from his project.

CIBA's desi shrimp feed technology was transferred to young entrepreneur from Andhra Pradesh

MoU was signed with Mr. E. Sudhakar, Sri Sathvika Aqua Agro Industries Private Limited Prakasam District, Ongole, Andhra Pradesh for the shrimp feed mill and Vanami^{Plus} technology.

Technology transfer for cost-effective White Spot Syndrome (WSSV) diagnostic kit.

A technology of DNA based nested-Polymerase Chain Reaction (PCR) diagnostic kit for the detection of lethal shrimp pathogen White Spot Syndrome Virus (WSSV) was transferred to M/s Aura Biotechnologies Private Limited, Chennai on 11th May 2017.



Punjab youth adopted shrimp farming in inland saline areas of Bhatinda, Punjab with guidance of CIBA

A MoU was signed between ICAR-CIBA and M/s Blancas Aqua, Gurthari road, SangatKalan, Bathinda, Punjab-151401 on 3rd June 2017. This MoU, related to inland saline shrimp farming is first of its kind on shrimp farming in inland saline areas of state of Punjab.

Mangrove foundation of Maharashtra government joined hands for development of brackishwater aquaculture livelihood options in mangrove areas of Maharashtra

An MoU for collaborative research and development work was signed with CIBA and mangrove foundation on 17th June 2017 in a function organised at CIBA, Chennai.

Promotion of milkfish and seabass farming in West Bengal towards augmenting the Blue economy

Technical assistance for milkfish and seabass farming and low cost feed production technology to Shri Amalesh Chatterjee and Shri Saifulla Mandal farmers from South 24 parganas district of West Bengal on 3rd July 2017.

Culture demonstration of Indian white shrimp (*Penaeus indicus*)

Ten MoUs were signed between CIBA and the farmer groups and their representative from different states to promote *P. indicus* culture. Under this agreement ICAR-CIBA is being partnered with the farmer to provide technical guidance with respect to providing quality seed and feed for undertaking *P. indicus* culture.

TNFU join hands with CIBA for sustainable development of aquacultur

Tamil Nadu Fisheries University, (TNFU) Nagappatinam joining hands for undertaking collaborative programmes in research, teaching, and extension in the areas of brackishwater aquaculture by signing a MoU on 25th September 2017 at CIBA Chennai.

Knowledge partnership Periyar Integrated hatchery for establishing Mud crab hatchery at Muttukadu Experimental Station

Est
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Mud crab hatchery at Muttukadu Experimental Station (MES) on 25th September 2017 with Sri. V.G Eraniappan, Periyar Integrated hatchery. Under the agreement, partner will provide commercial expertise to operate the mud crab hatchery as required by the institute, and CIBA will provide broodstock and technical assistance to run the hatchery.

Technology collaboration with Seven Sea Aqua farms and exports Ltd., Vishakhapatnam

Collaboration for partnership farming in brackishwater aquaculture was done with Seven seas sea aqua farms and exports Ltd., Vishakhapatnam on 5th October 2018.

Partnership in pond based grey mullet brood stock development and breeding

Memorandum of understanding was signed with Pancham aquaculture farms ltd. (PAFL), Mumbai for partnership in pond based brood stock development, breeding and nursery rearing of grey mullet in west coast at PAFL Ltd., farm at Jalsar on 10th of October 2017.

Technology transfer on Fish/Shrimp Feed processing and production

Technology of Fish/Shrimp Feed processing and production was transferred to ADAK, Agency for Development of Aquaculture, Kerala (ADAK), Trivandrum on 22nd of November 2017.

Transfer of seabass seed production technology to an enterprising farmer in PPP mode

CIBA signed a Memorandum of Understanding under public-private partnership (PPP) mode for hatchery technology for Asian Seabass Seed Production with Golden Eye on 30th December 2017 at ICAR-CIBA, Chennai.

Knowledge partnership for development of eco-friendly and innovative penaeid shrimp production

Venkateswara farms, East Godavari, Andhra Pradesh partnered with CIBA for knowledge partnership for development of eco-friendly and innovative penaeid shrimp production technology on 6th January 2018.

TANUVAS join hands with CIBA for collaborative research programme

CIBA and Tamil Nadu Veterinary and Animal Sciences University, Chennai signed MoU for undertaking collaborative programmes in research, teaching, and extension in the areas of fisheries and animal sciences on 13th February 2018 at TANUVAS, Chennai.

TRANSFER OF "CIBAMOX"- WATER PROBIOTIC TECHNOLOGY for scaling up

CIBAMOX"- water probiotic technology was transferred to National Biosciences, Mysore on 23rd February 2018 on non-exclusive basis.

NRG Feeds of West Bengal signs MOU for the technology transfer of, Polyculture feed- Poly^{Plus}

ICAR-CIBA signed the MoU for transfer of 'Poly ^{Plus}'- Indigenous feed ingredients technology the Poly^{Plus} with Mr.Kajal Kumar Roy, NRG Feeds at Hooghly,West Bengal on 6th March 2018.

Transfer of technology on CIBAMOX- a water probiotic

CIBAMOX"- water probiotic technology was transferred to Sri. Mohan Anjaneya Reddy on 6th March 2018.

Technical support and partnership farming for adoption of modular system of Pearlspot seed production and nursery rearing models

Providing Technical Support and Partnership farming for Adoption of modular System of Pearlspot seed production and Nursery Rearing Models to Sri.Keerthiram, a farmer from Kerala on 26th March 2018.

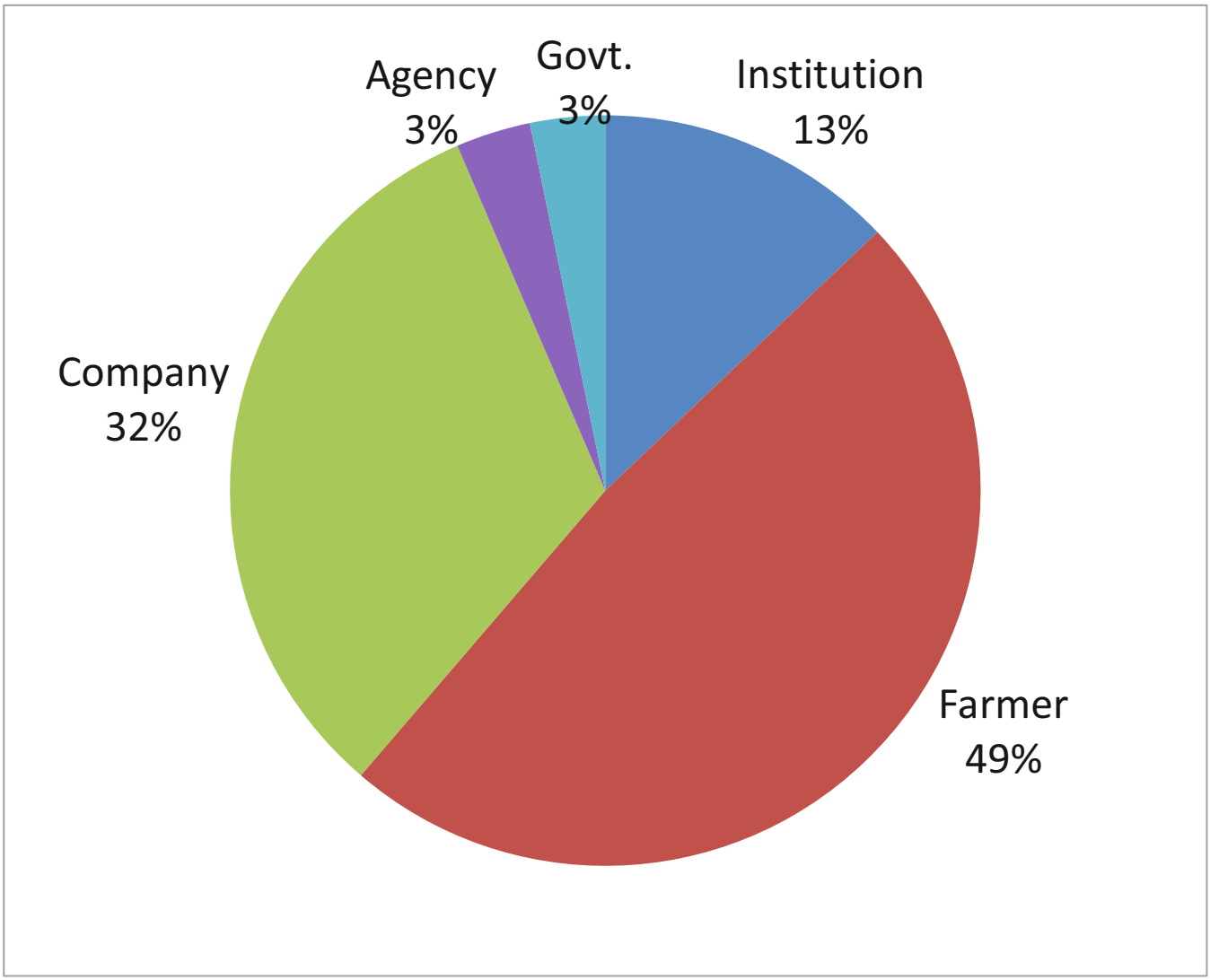
Revenue generated during 2017-18

The performance of institute in undertaking public private partnership activities during the year 2017-18 where analysed on five parameters to understand the pattern of different parameters like type of organisation, work focus towards individual state, type of work demanded from ICAR-CIBA by other PPP entities. The revenue earned from different types of activities and revenue from one time payment and royalty/revenue share obtained in the total revenue generated.

Revenue generated
(2017-18)

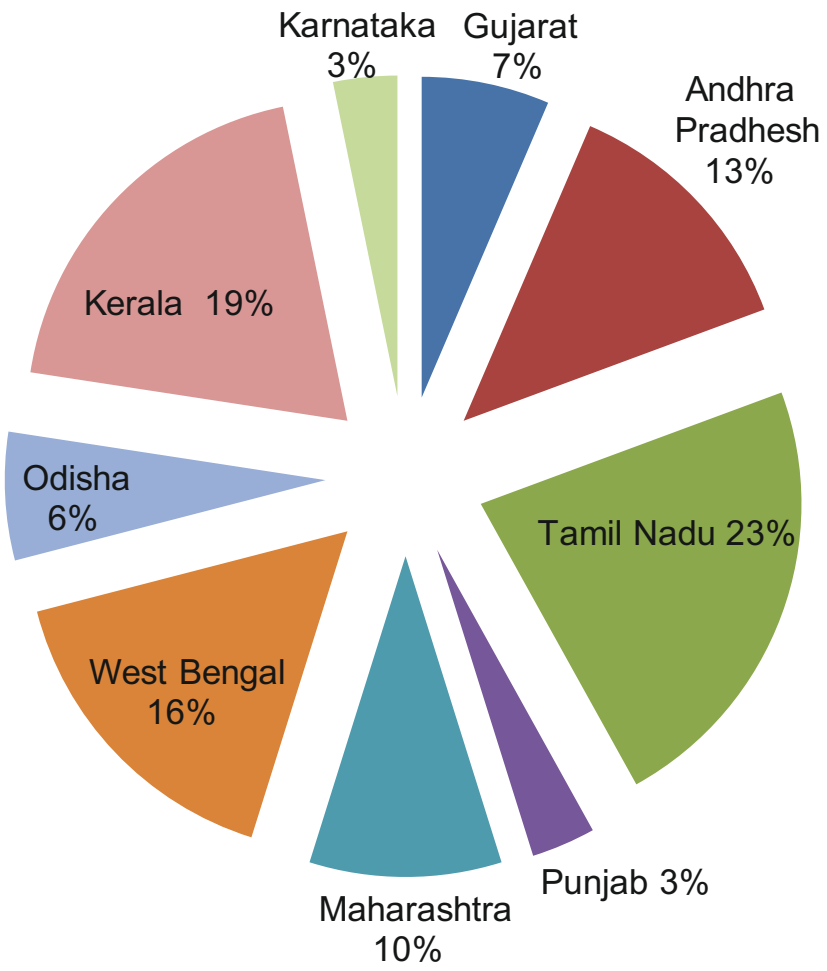
Client name	Revenue generated
Sathvika Aqua, AP	690000
Royalty from Sai aqua, Bapatla	60000
Aura Biotech	143750
Revenue share from Sri.Sudhakaran, AnjanDandapat&Ms.Girija	210000
Revenue share from, AnjanDandapat	199200
Golden Eye, Chennai	200000
Venkateswara farms	59000
ADAK, Kerala	118000
New Bioscience, Mysore	118000
Revenue share from Nishanth Reddy, Nellore	2,52,800
NRG seeds, West Bengal	1,18,000
Sharat industries, Chennai	2,36,000
Revenue share from Sri.AsheshGiri, West Bengal	80,000
Total	**24,84,750** ***(inclusive of tax)***

Type of organization



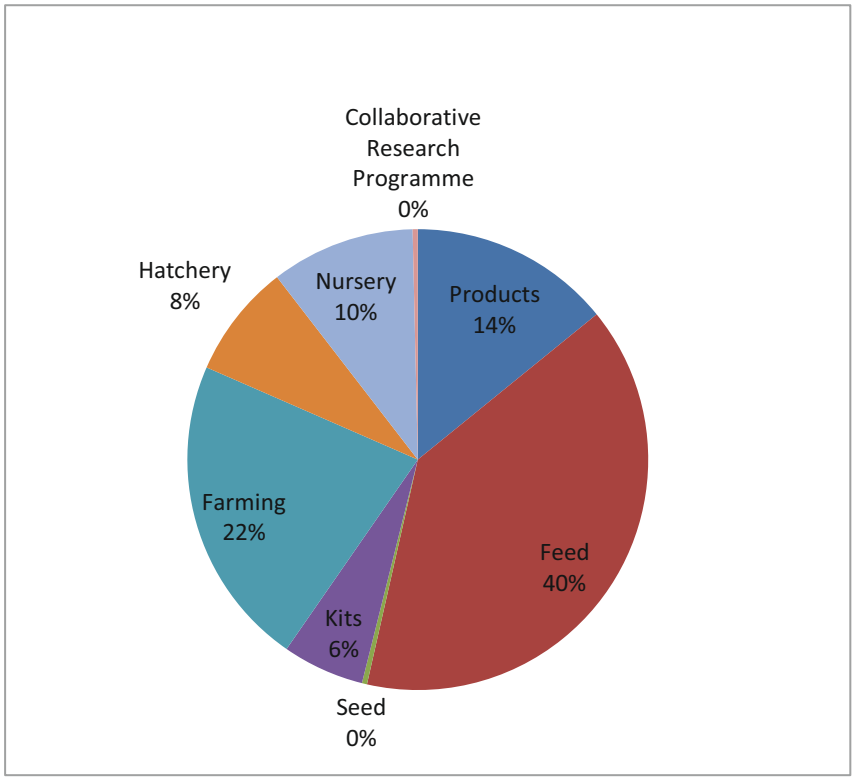
ICAR-CIBA Has forged relationships with other Govt. institutions develop and departments, Govt. agency, companies and farmers due to signing of MoUs with farmers under PPP mode for demonstration of new finfish species and *P. indicus* culture. The farmers MoUs occupied 49% of total MoUs signed. Private companies were also eager to sign MoUs with ICAR-CIBA which was evidenced by 32% of MoUs being signed with ICAR-CIBA in the year 2017-18.

State - wise



The constraints experienced in working with private firms are exclusive ownership demanded by private companies and focuses interest on ealuation for field testing of their products. The institute has been firm on joint ownership of IP with a nominal royalty payment from the companies. ICAR-CIBA has also signed MoUs with state Govt. agencies, other Govt. instititutions.

State-wide interaction and presence of the instate is important to have an image of national institute. This year except Goa and Gujarat all the coastal states of India had MoUs with ICAR-CIBA for public private partnership activities. Notably Punjab representing inland saline soils has also signed an MoU with ICAR-CIBA this year.



The number of MoUs signed for different purpose is another indicator on the technical strength of ICAR-CIBA. Farming related MoUs were Sixteen in number during 2017-18. It is a proof of the strength of institute supporting farming community for undertaking novel farming methods. Hatchery and nursery MoUs were Three in number along with Four MoUs for feed mills. One MoU was signed for commercialisation of diagnostic kit along with Four MoUs for collaborative research programme. Two products were also commercialised through MoUs.

RESEARCH & ADMINISTRATIVE MEETINGS

RESEARCH ADVISORY COMMITTEE (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F.No.18-6/2007-ASR-I dated 22.7.2013) for a period of three years with effect from 25th July 2013:

Chairman	Dr. K. Gopakumar
Members	Dr. V.V.Sugunan Dr. K.M.Shankar Dr. G.Gopakumar Dr. S.N. Mohanty Dr. Aparna Dixit Dr Pravin Puthra Dr.K.K.Vijayan
Member Secretary	Dr M. Jayanthi

The 23rd meeting of the Research Advisory Committee (RAC) of CIBA was held on 27th February 2018 at CIBA Headquarters, CIBA, Chennai.

INSTITUTE RESEARCH COUNCIL

The Institute Research Council (IRC) of CIBA has been constituted as follows:

Chairman	**Dr. K.K.Vijayan, Director**
Members	Assistant Director General (M.Fy.), ICAR, New Delhi Dr. C. Gopal Dr. S.V. Alavandi Dr. G. Gopikrishna Dr. M. Kailasam Dr. V.S. Chandrasekaran Dr. M. Muralidhar Dr. K. Ambasankar Principal Investigators of all the projects
Member Secretary	Dr. Subhendu Kumar Otta

The 34th IRC Meeting was held on 17-19th May 2017 and the progress of research work was reviewed.

INSTITUTE MANAGEMENT COMMITTEE (IMC)

The Institute Management Committee has been constituted as follows :

Chairman **Dr. K.K.Vijayan**

Members

Dr. Pravin Puthra, ADG (M.Fy.), ICAR
Dr. K. Ashok Kumar, PS, ICAR- CIFT, Cochin (upto 12.05.2018)
Dr. Bindu R. Pillai, PS & Head, ICAR- CIFA, Bhubaneswar (upto 12.05.2018)
Dr. Vijaya Gopal, PS, ICAR- CMFRI, Kochi (upto 12.05.2018)
Dr. Joe Kizhakudan, PS, ICAR- CMFRI, Chennai (upto 12.05.2018)
Commissioner of Fisheries, Govt. of Tamil Nadu, Chennai
Commissioner of Fisheries, Govt. of Gujarat, Gandhi Nagar
The Dean, FCRI, TANUVAS, Thoothukudi

Co-opted Members

Member Secretary
Sh. K.V.S. Satyanarayana, Administrative Officer

Members
Dr. T. Ravisankar, Principal Scientist & Head of Office
Dr. M. Kumaran, Finance & Accounts Officer (I/c)
Dr. M. Jayanthi, PS & OIC (Engg. Cell)
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 49th IMC meeting held on 28th October 2017.

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 29.03.2016 to 28.03.2019 vide Office Order F.No.13-1/2012-Admn.
Dated 02.04.2016) is as follows:

Official Side

Chairman	**Dr. K.K. Vijayan**
Members	Dr. T. Ravisankar, P.S. Dr. K.Ambasankar, P.S. Dr. C.P.Balasubramanian, P.S. Dr. R.Saraswathy, P.S. Dr. M.Kumaran, P.S. Shri K.V.S.Satyanarayana, A.O.

Staff Side

Secretary	Shri A.Manoharan, Assistant
Members	Shri N.Jagan Mohan Raj, Sr. Technical Asst. Shri K.Paranthaman, Technical Asst. Smt. E.Mary Desouza, UDC Shri M.Sakthivel, Skilled Support Staff Shri C.Raghu, 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 06.06.2016) is as follows:

Chairman	**Dr. K.K.Vijayan**

Elected Members

Scientific Member	Dr. J. Shyam Dayal, P.S & Dr. Nila Rekha, P.S
Technical Member	Dr. A. Nagavel, Senior Technical Officer
Administrative Member	Mrs. Usha Rani, A.A.O & Shri P. Srikanth, J.A.O Shri. A. Manoharan, Assistant
Staff Member	Shri. M. Pichandi, Skilled Support Staff

WOMEN COMPLAINT COMMITTEE

Women Complaint Committee has been constituted as follows:

Chairman	**Dr. R. Saraswathy**
Members	Dr. Prasanna Kumar Patil
	Dr. Sherly Tomy
	Dr. Vinaya Kumar Katneni
	Shri. S. Nagarajan
	Smt. E. Mary Desouza

External Member Dr. Lita Sunder, Madras Christian College

WOMES'S CELL

Women Cell has been constituted as follows:

Chairman	**Dr. D.Deboral Vimala**
Member	Dr. R.Saraswathy
	Smt. B.Amudavalli
	Smt. K.Subhashini
	Smt. M.Mathuramuthubala
Member Secretary	Shri R. Kandamani

Services and 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, Project Monitoring Committee for monitoring the project works related to setting up of the Specific Pathogen Free Shrimp Seed Multiplication Centre at Mulapolam Village, Sompeta Mandal of Srikakulam District in Andhra Pradesh under the chairmanship of Chief Executive, National Fisheries Development Board, constituted by the Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Govt. of India, New Delhi.

Member, Technical Committee to examine as to whether the concepts and designs provided by MHKL for setting up Multiplication Centre for SPF *P.monodon* could be used for any alternative species of shrimp, constituted by the Department of Animal Husbandry Dairying and Fisheries, Ministry of Agriculture, Govt. of India.

Member of Faculty in the Board of Studies of Cochin University of Science and Technology (CUSAT

Member, Selection Committee - Tamilnadu Scientist Award (TANSA) constituted by Tamil Nadu State Council for Science and Technology), Kochi

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, National Steering Committee of 11th Indian Fisheries and Aquaculture Forum

Member, Scientific Committee of the International Conference on Climate Change and Sustainable development, Annai Fathima College of Arts and Science, Madurai

Member, National Organizing Committee for "Second international symposium on societal applications in fisheries and aquaculture using remote sensing imagery", CMFRI, Kochi

Member, Steering Committee for the Asian Pacific Aquaculture 2019 (APA 2019), Chennai

Other Staffs of CIBA

Member, ICAR Regional Committee No. II - Dr. T.K. Ghoshal, Principal Scientist

Member, Scientific Advisory Committee of Ramkrisahna Ashram Krishi Vigyan Kendra, Nimpith - Dr. T.K. Ghoshal, Principal Scientist

Member, Scientific Advisory Committee of Sasya Shyamala Krishi Vigyan Kendra, Narendrapur - Dr. T.K. Ghoshal, Principal Scientist

Member, Editorial Board for Menba Journal of Fisheries

Faculty, Kastamonu University, Turkey – Dr.Gouranga Biswas

Member, Inspection Committee, Coastal Aquaculture Authority, Ministry of Agriculture and Farmers Welfare, Government of India – Dr.S. Kannappan, Dr. M.Makesh and Dr. M. Poornima

Associate Editor, Journal of Fisheries and Life Sciences, Mangaluru, India - Dr. Gouranga Biswas

Member, Committee for Regulation and Monitoring of Aquaculture Inputs in India, constituted by the Secretary, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Govt. India, New Delhi – Dr. P.K.Patil.

Member, Fish, Fisheries and Aquaculture sectional committee FAD12 and Aquaculture subcommittee FAD12.1- Dr.K.Ambasankar

Member, Expert Committee to 'Study possible side effects of unauthorised use of oxytocin on animal and human health' at the Office of the Drugs Controller General (India), Directorate of General of Health Services, Ministry of Health and Family Welfare, Govt. India, New Delhi – Dr. P.K.Patil.

Member, committee for "Scrutiny of Application received for the post of faculty positions" organized by IIFPT Institute on 10th January 2018 - Dr. K.P. Jithendran

Expert, to the interview of Technical Consultants for Coastal Aquaculture Authority, on 12th January 2018.- Dr. S.K. Otta

Expert, for the Scientific Panels in the Food Safety and standards Authority of India on 16th March 2018 at New Delhi - Dr. P.K. Patil

Expert Faculty Member, working on Application of Artificial intelligence in Agriculture, organized by ICAR-Indian Institute of Water Management at Bhubaneswar on 30th March 2018 - Shri. Ashok Kumar Jangam

Swachh Bharat Mission Programmes

In response to the noble call, Swachh Bharat Mission, the following Swachhta Pakhwada and Swachhta Hi Seva programmes were conducted by ICAR-CIBA, Chennai and Kakdwip Research Centre (KRC) of CIBA, Kakdwip, West Bengal, with due gravity and purposefulness during 16-31 May 2017 and 15 September to 2 October 2018 respectively.

1. Awareness and cleanliness programme at Kakdwip Research Centre of ICAR-CIBA on 22nd May, 2017.
2. Awareness cum Cleanliness programme at Thiruvidanthai village, Tamil Nadu, with participation of local people on 25th May 2017.
3. Awareness cum Cleanliness programme at Kottaikadu village, Tamil Nadu, on 26th May 2017 in Anganvadi School, Kottaikadu village (adopted by ICAR-CIBA for MGMG programme), Kanchipuram District, Tamil Nadu.
4. Hands-on Training on "Waste to Wealth" at Adyar creek and estuary on 27th May, 2017 at Srinivasapuram, Mullikuppam, Mullimanagar villages cluster.
5. Hands-on demonstration on fish silage making Awareness cum cleaning programme at Gangadharpur, West Bengal, on 29th May 2017.
6. Swachhta Hi Seva was observed at Kakdwip Research Centre of ICAR-CIBA, Kakdwip, West Bengal on 17th September, 2017.
7. Swachhta Hi Seva was conducted at Srinivasapuram, Chennai, Tamil Nadu on 24th September 2017 by CIBA team with participation of local village Panchayat representatives.
8. Organized the cleaning, Sarwatra Swachhta, programme of public pathways at Adyar Creek areas, Chennai, Tamil Nadu, on 25th September 2017.

   Muttukadu beach areas nearby Muttukadu Experimental Station of CIBA, Tamil Nadu were cleaned with active participation of CIBA team as part of Swachhta Hi Seva on 1st October 2017.

Distinguished Visitors

Headquarters, CIBA, Chennai		
Sl. No	**Details of visitors**	**Date of visit**
1.	Shri.Baburaj V.Nair, the Chief Human Resources Officer of 'The Hindu' newspaper group	4th April 2017
2.	Mr. E. Sudhakar, Sri Sathvika Aqua Agro Industries Private Limited	4th May 2017
3.	Shri Sunil Kumar Singh, Financial Advisor and Additional Secretary, DARE/ICAR	5th May 2017
4.	Dr. Dhinakar Raj G, Project Director, Translational Research Platform for Veterinary Biologicals (TRPVB), CAHS, TANUVAS, Madhavaram Milk Colony, Chennai & Dr. Pazhanimuthu Annamali, 'Aura Biotechnologies Limited	11th May 2017
5.	Mr. P. Murari, IAS (Retd) Adviser to FICCI and Former Adviser to President of India	30th May 2017
6.	Mr. Manish Goyal and Mr. Vineet Verma from Bathinda, Punjab	3rd June 2017
7.	Shri. N. Vasudevan, Additional Principal Chief Conservator of Forests, Mangrove Foundation, Mumbai, Maharashtra	16th June, 2017
8.	Dr. N.K. Ambujam, Professor and Director, Centre for Water Resources, Anna University	20th June 2017
9.	Yoga Guru Mr. K. Nanjapathi	21st June 2017
10.	Shri Amalesh Chatterjee and Shri Saifulla Mandal farmers from South 24 parganas district of West Bengal	3rd July 2017
11.	Ms. Swapna Sundar, IP Strategist & Patent Agent and CEO, IP DOME Strategy Advisors Pvt Ltd., Chennai	17th July 2017
12.	Shri.P.Parthiban IAS, Secretary Fisheries Government of Puducherry and Director of Fisheries, Government of Puducherry and his technical team comprising of Shri.V.Jayanand, Joint Director of Fisheries, Shri.J.Nadarajan, Deputy Director of Fisheries	21st July 2017
13.	Shri V.P. Thandapani, I.A.S, Director DOF, Govt. of TamilNadu Dr.Suresh	3rd August 2017
14.	Dr.Trilochan Mohapatra, Director General, ICAR and Secretary, DARE and Dr.Joykrushna Jena, Deputy Director General (Fisheries)	6-7th August 2017

15.	Mr. S. Chandrasekar, President, Society of Aquaculture Professionals (SAP), Chennai and Dr. Anup Mandal, representative from MPEDA	17th August 2017
16.	Dr. A.K.Panda, Project Manager of Aquatic Quarantine Facility (AQF) of MPEDA	18th August 2017
17.	Dr. E.G. Silas, Founder Director CIBA & Former Vice Chancellor, Kerala Agricultural University	26th August 2017
18.	Dr.K.Narayana Gowda, Former Vice -chancellor, UAS, Bengaluru	29th August 2017
19.	Shri M.Annadurai, IAS, Director, Directorate of Field Publicity (DFP), Ministry of Information and Broadcasting, Govt. of India	15th September 2017
20.	Dr G. Jeyasekaran, Director of Research, TNFU in the presence of Dr S. Felix, Hon. Vice Chancellor of TNFU	25th September 2017
21.	Dr. C. Suvarna, Commissioner of Fisheries, Telangana State	18th December 2017
22.	Dr. B. Meenakumari, Chairperson, National Biodiversity Authority, Dr. J.K. Sundaray, Director, ICAR -CIFA, Dr. Shubhadeep Ghosh, Senior scientist CMFRI, Dr. T.T. Ajith Kumar, Senior Scientist, NBFGR and Ms. M.C. Ramany, Project manager RGCA-MPEDA	29th December 2017
23.	Mr. E. M. Senthil Kumar of Golden Eye	30th December 2017
24.	Shri Ramakanth V. Akula CEO, The Waterbase Ltd.	3rd January, 2018
25.	Dr. T.J.Harikrishnan, Registrar, TANUVAS, Chennai	13th February 2018
26.	Dr.K.Gopakumar, former DDG, Fisheries. Distinguished members of RAC	27th February 2018
27.	Mr. Kajal Kumar Roy, NRG Feeds, Joyrampur, Arambagh, Hooghly, West Bengal	6th March 2018
28.	Dr. Mruthyunjaya, Former National Director, NAIP, ICAR	20th March 2018
KRC, Kakdwip		
29.	Ms. Seema Chopra, Director, Raj Bhasa, ICAR	25th May 2017

Financial Advisor & Additional Secretary, ICAR-DARE, Shri Sunil Kumar Singh visited ICAR-CIBA, Chennai

Shri Sunil Kumar Singh, Financial Advisor and Additional Secretary, DARE/ICAR made his maiden visit to ICAR-CIBA, Chennai on 5th May 2017, to familiarise with the R&D activities and discuss the financial related matters. Sri Singh expressed his happiness about the CIBA's research achievements and the overall contribution of the institute for the brackishwater sector in the

Secretary Fisheries, Union Territory of Puducherry visited ICAR-CIBA, Chennai

Shri.P. Parthiban IAS, Secretary Fisheries and Director of Fisheries, Government of Puducherry and his technical team comprising of Joint Director of Fisheries, Deputy Director of Fisheries and other officials visited cage farming programme taken up by ICAR-CIBA at Adyar creek on 21st July 2017.

Dr. Trilochan Mohapatra, Director General ICAR and Secretary, DARE Visited ICAR-CIBA, Chennaicountry.

Dr.Trilochan Mohapatra, the Director General, Indian Council of Agricultural Research and Secretary, Department of Agricultural Research and Education visited the ICAR-CIBA, Chennai on 6th and 7th August 2017 and had interactions with the scientists and staff. He visited the research facilities at Muttukadu Experimental Station of CIBA and interacted with the scientists on the ongoing research programmes on breeding and seed production of finfishes, shrimps and mudcrab, nutrition and feed development. He had in depth discussion regarding the genetic stocks, breeding protocols, prioritized programmes and the requirement of the developmental needs of the brackishwater sector. He distributed hatchery produced seabass fish seeds to farmers from Andhra Pradesh, Kerala and Women SHGs from Tamil Nadu. He witnessed the formulated pelletized feed making process in the CIBA's experimental feed mill

DG also released a DNA based diagnostic kit for the screening of EHP disease in shrimp, for the benefit of shrimp farmers in the country, books on CIBA Technologies and FAQs on Shrimp farming in Hindi language.

Fisheries Commissioner Telangana State visited ICAR-CIBA, Chennai

In order to explore the feasibility of *P. vannamei* farming in low saline waters of land locked state of Telangana, Dr. C. Suvarna, Commissioner of Fisheries, Telangana State along with Fisheries Department officials visited ICAR-CIBA on 18th December,2017. Commissioner and team visited all the research facilities at Head Quarters and Muttukadu Experimental Station of CIBA.

Personnel

Director: Dr. K. K. Vijayan

Headquarters

Head of Divisions
Dr. C. Gopal, Crustacean Culture Division (VRS on 23.10.2017)
Dr. G. Gopikrishna, Nutrition, Genetics & Biotechnology Division
Dr. S. V. Alavandi, Aquatic Animal Health & Environment Division

Principal Scientists
Dr. K. P. Jithendran
Dr. V. S. Chandrasekaran (Superannuation on 30.11.2017)
Dr.C.V.Sairam
Dr. T. Ravisankar
Dr. M. Muralidhar
Dr. (Mrs.) M. Jayanthi
Dr. (Mrs.) B. Shanthi
Dr. C. P. Balasubramanian
Dr. M. Kailasam
Dr. (Mrs.) D. Deboral Vimala
Dr. M. Shashi Shekhar
Dr. S. Kannappan
Dr. (Mrs.) P. Nila Rekha
Dr. K. Ambasankar
Dr. J. Syama Dayal
Dr. Akshya Panigrahi
Dr. M. Kumaran
Dr. Debasis De
Dr. (Mrs.) M. Poornima
Dr. (Mrs.) R. Saraswathy
Dr.M.Makesh
Dr. Prasanna Kumar Patil
Dr. (Mrs.) Sherly Tomy
Dr. Subhendu Kumar Otta
Dr. (Mrs.) P. Mahalakshmi

Senior Scientists
Dr. K. P. Kumaraguru Vasagam
Dr. Satyanarayan Sethi

Scientist (Senior Scale)
Shri Ashok Kumar Jangam

Scientists
Dr. K. Vinay Kumar
Dr. R. Ananda Raja
Dr. (Mrs.) Krishna Sukumaran
Dr. (Mrs.) P. Ezhil Praveena
Dr.Sujeet Kumar
Dr. (Mrs.) P. S. Shyne Anand
Dr. (Mrs.) T. Bhuvaneswari
Dr. (Mrs.) N. Lalitha
Dr. P. Kumararaja
Dr. B. Sivamani
Dr.(Smt).R.Geetha
Dr. (Mrs.) Vidya Rajendran
Dr. Satheesha Avunje
Shri K. P. Sandeep
Mrs. M. U. Rekha
Ms. Babita
Shri Aritra Bera
Shri T. Sathish Kumar
Shri.R.Aravind
Shri.Tanveer Hussain
Ms.Suvana Sukumaran
Dr.N.S.Sudheer
Mrs.Neethu.K.C.
Ms.Misha Soman
Shri.Jose Antony
Ms.Leesa Priyadarsani
Shri.Dani Thomas
Shri.Biju.J.E.
Smt.Mary Lini
Dr.J.Raymond Jani Angel
Shri.T.Sivaramakrishnan
Dr.Vinay Tharabenahalli Nagaraju
Shri.Pankaj Amrut Patil

Chief Technical Officer
Shri R. Elankovan

Assistant Chief Technical Officers
Dr. S. Sivagnanam
Shri D. Raja Babu
Shri M. Shenbagakumar
Shri R. Puthiavan
Mrs. K. Jacquline

Senior Technical Officers
Dr. Joseph Sahayarajan
Shri S. Stanline (Expired on 29.07.2017)
Dr. A. Nagavel
Shri R. Subburaj
Shri S. Nagarajan
Shri S. Rajamanickam

Technical Officers
Shri N. Ramesh
Shri S. Saminathan
Shri N. Jagan Mohan Raj
Shri R. Balakumaran (Driver)
(Superannuation 31st May, 2017)

Senior Technical Assistant
Shri D. M. Ramesh Babu
Shri G. Thiagarajan
Shri K. Paranthaman (Driver)

Technical Assistant
Shri K. Karaian

Senior Technician
Shri K. V. Delli Rao

Administrative Officer
Shri K. V. S. Satyanarayana

Finance & Accounts Officer
Vacant from 17.05.2015

Assistant Administrative Officers
Shri R. Kandamani
Mrs. V. Usharani
Shri.S.Pari (Promoted w.e.f. 01.04.2017)

Junior Accounts Officer
Shri P. Srikanth,

Personal Assistants
Mrs. S. Nalini
Shri K. G. Gopala Krishna Murthy

Assistants
Shri A. Manoharan
Mrs. E. Amudhavalli
Shri A. Sekar
Shri.K.Raghavendra (Joined on 28.07.2017)
Smt.E.Mary Desouza (Promoted w.e.f. 13.10.2017)

Stenographer Gr. III
Mrs. K. Hemalatha
Mrs. K. Subhashini

Upper Division Clerks
Mrs. R. Vetrichelvi
Mrs.M.Mathuramuthu Bala

Lower Division Clerks
Shri B. Palanivelmurugan
Mrs. B. Prasanna Devi
Shri R. Kumaresan
Shri A. Paul Peter

Skilled Support Staff
Shri V. Jeevanandam
Shri K. Nithyanandam
Shri V. M. Dhanapal
Shri V. Kumar

Shri E. Manoharan
Shri C. Saravanan
Shri S. Kuppan
Shri M. Pichandi
Shri S. Selvababu
Shri D. Senthil Kumaran
Shri C. Ragu
Shri P. G. Samuvel
Shri M. Sakthivel
Shri R. Mathivanan
Shri R. Indra Kumar
Shri G. Dayalan
Shri Kanaka Prasad
Smt S. Premavathy
Shri J. Murugan
Shri.V.Kisor kumar (Joined on 31.05.2017)

Kakdwip Research Centre

Principal Scientists
Dr. T. K. Ghoshal
Dr. Sanjoy Das

Scientists
Dr. Gouranga Biswas
Dr. Prem kumar
Ms. Christina Lalramchhani
Ms.Leesa Priyadarsani

Technical Officer
Shri P. S. Samanta

Senior Technical Assistant
Mrs. Chhanda Mazumder

Administrative Staff
Private Secretary
Shri S. K. Halder (Superannuation on 31.01.2018)

Assistant
Shri S. K. Bindu

Skilled Support Staff
Shri N. N. Jana
Shri K. P. Naskar
Shri Purna Chandra Das
Mrs. L. R. Bhuiya
Shri.U.K.Santra
Shri.Sanjoy Some (Joined on 30.05.2017)

Redeployed Staff from PRC of CIBA, Puri to CIFA, Bhubaneswar

Technical Assistant
Shri P. C. Mohanty

Skilled Support Staff
Shri Premananda Bisoi
Shri Maharaga Majhi
(Superannuation on 31.08.2017)

INFRASTRUCTURE DEVELOPMENT FOR THE YEAR 2017–18

1. Construction of compound wall at CIBA Head Quarters, Chennai.
2. Construction of Aquaculture laboratory for climate change works over the existing health laboratory at CIBA Head Quarters, Chennai.
3. Replacement of the mosaic flooring with vitrified tiles in Ground floor corridor at CIBA Head Quarters, Chennai.
4. Construction of semi-permanent shed over the parking area at CIBA, Head Quarters, Chennai.
5. Construction of laboratory buildings at CIBA, Head Quarters, Chennai.
6. Supply, Installation, Testing & Commission of 1 No. 320 KVA Diesel Generator at CIBA Head Quarters, Chennai.
7. Conversion of existing 11 KV Overhead 4 pole Structure and HT Metering cubicle in to 11 KV outdoor type compact RMG with metering at CIBA Head Quarters, Chennai
8. Replacement of Faulty neon sign board to LED signs board at CIBA Head Quarters, Chennai
9. Providing 1 No 315 KVA Outdoor Transformer at CIBA Head Quarters, Chennai
10. Conversion to LED lighting system in the Video Conference hall, Auditorium, Library and common area at CIBA Head Quarters, Chennai.
11. Replacement of the poly carbonite roofing sheet in the court yard area at CIBA Head Quarters, Chennai.
12. Construction of platform with lean roof sheet at Muttukadu Experimental Station of CIBA, Muttukadu.
13. Renovation of shrimp hatchery, Fish hatchery and Crab hatchery at Muttukadu Experimental Station of CIBA, Muttukadu.
14. Farmer facilitation centre at Muttukadu Experimental Station of CIBA, Muttukadu.
15. Replacement of electrical earthing system at Muttukadu Experimental Station of CIBA, Muttukadu.
16. Construction of first floor over the existing wet laboratory building at Regional centre of CIBA, Kakdwip.
17. Enhancement of power load from 50 KVA to 200 KVA at Regional centre of CIBA, Kakdwip.
18. Renovation of existing electrical supply to pumps, aerators, water supply systems of KRC of CIBA, Kakdwip
19. Renovation of challenge shed at Regional centre of CIBA, Kakdwip.
20. Desilting of ponds and laying brick pitched road around C- sector farm Regional centre of CIBA, Kakdwip.
21. Construction of Trainee's hostel at Regional centre of CIBA, Kakdwip.

Library and Documentation

a. Library holdings

CIBA Library procured 60 *new books* including official language books during this period 2017-18 and currently holds 2,731books, international and national journals at headquarters, Chennai and Kakdwip Research Centre of CIBA in West Bengal. The details of Library holdings as on 31.03. 2018 are provided in the diagram below.

b. ***Library and e-Resource Centre***

CIBA library has been upgraded as Library and e-Resource Centre with six workstations having the facility to access e-books, online journals, Institute publications and scientists publications for ease of use by scientists and scholars. This facility is now open to students, scholars and academicians from Universities, Colleges and Institutes. The timing of the facility has been extended till 6 p.m. to enable students to use it effectively

c. Digital Repository

Under this initiative, all institute publications and the individual scientists publications have been digitized and uploaded in the Krishi ICAR website. It will be further uploaded in the Eprints (open sources software) and linked to the international databases to facilitate visibility of CIBA research achievements across the globe.

d. Online access to the CIBA Subscribed & CeRA journals and Document delivery services:

CIBA has access to e-books and journals published by Springer, John Wiley and Elsevier through ICAR- CeRA resource sharing platform. The library has listed all the full content accessible online journals with their access links in CIBA web portal for the benefit of users of the library. The library section supplied photocopies of journal articles requested from various ICAR institutes, scientists and research scholars under CeRA-Document Delivery Request (DDR).

e. Exchange services

CIBA library maintained exchange relationship with national and international organizations working on fisheries and aquaculture on mutual interest. The library maintained the free mailing of institute's annual report and other Institute publications to various research organizations, universities and other agencies to give greater to the institute research and development programmes.

f. 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, academicians, university/ college students, research scholars, stakeholders and other related visitors. The library provided Photocopying service to the users on nominal payment basis.

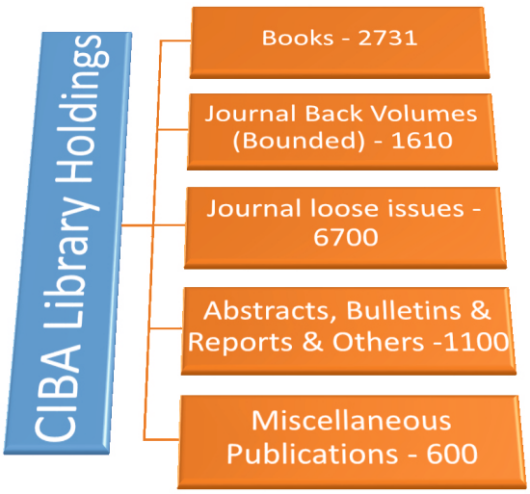
g. Utilization of funds

During this year, there is Rs. 15.00 lakhs funds were utilized towards the procurement of new books for Headquarters and KRC library of CIBA, procurement of Servers, Scanner and Grammarly Software for the library users, Scientists & Staff.

h. ISBN Numbers

CIBA has obtained 50 ISBN numbers for five years from the Ministry of Human Resources Development for its publications. Eight books have been allotted ISBN numbers as of March 2018.

CIBA - Library Holdings



About ICAR-CIBA

Central Institute of Brackishwater Aquaculture (CIBA) is one among the 101 institutes under the nation's apex body, Indian Council of Agricultural Research (ICAR), New Delhi. The institute was established on 1st April 1987, and serves as the nodal agency for research and development of brackishwater aquaculture in the country. ICAR- CIBA with a vision of environmentally sustainable, economically viable and socially acceptable brackishwater aquaculture. It is involved in research and development related to fish seeds, cost effective feeds, environmental monitoring, farm and hatchery management, disease diagnosis, disease monitoring and social research etc. The institute is headquartered at Chennai with an experimental field station at Muttukadu, a backwater zone of the Bay of Bengal located about 30 km south of Chennai. The Institute has one research centre at Kakdwip, Sunderban in West Bengal.

Contact Address:

Headquarters

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E-mail: director.ciba@icar.gov.in, director@ciba.res.in
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Muttukadu Experimental Station of CIBA

Kovalam PostMuttukadu 603 112,
Tamil NaduTelephone : +91 44 27472344, 27472061

Kakdwip Research Centre of CIBA

24 Parganas District (South)
Kakdwip 743 347 West Bengal
Telephone: +91 3210255072Fax : +91 3210255072
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भाकृअनुप
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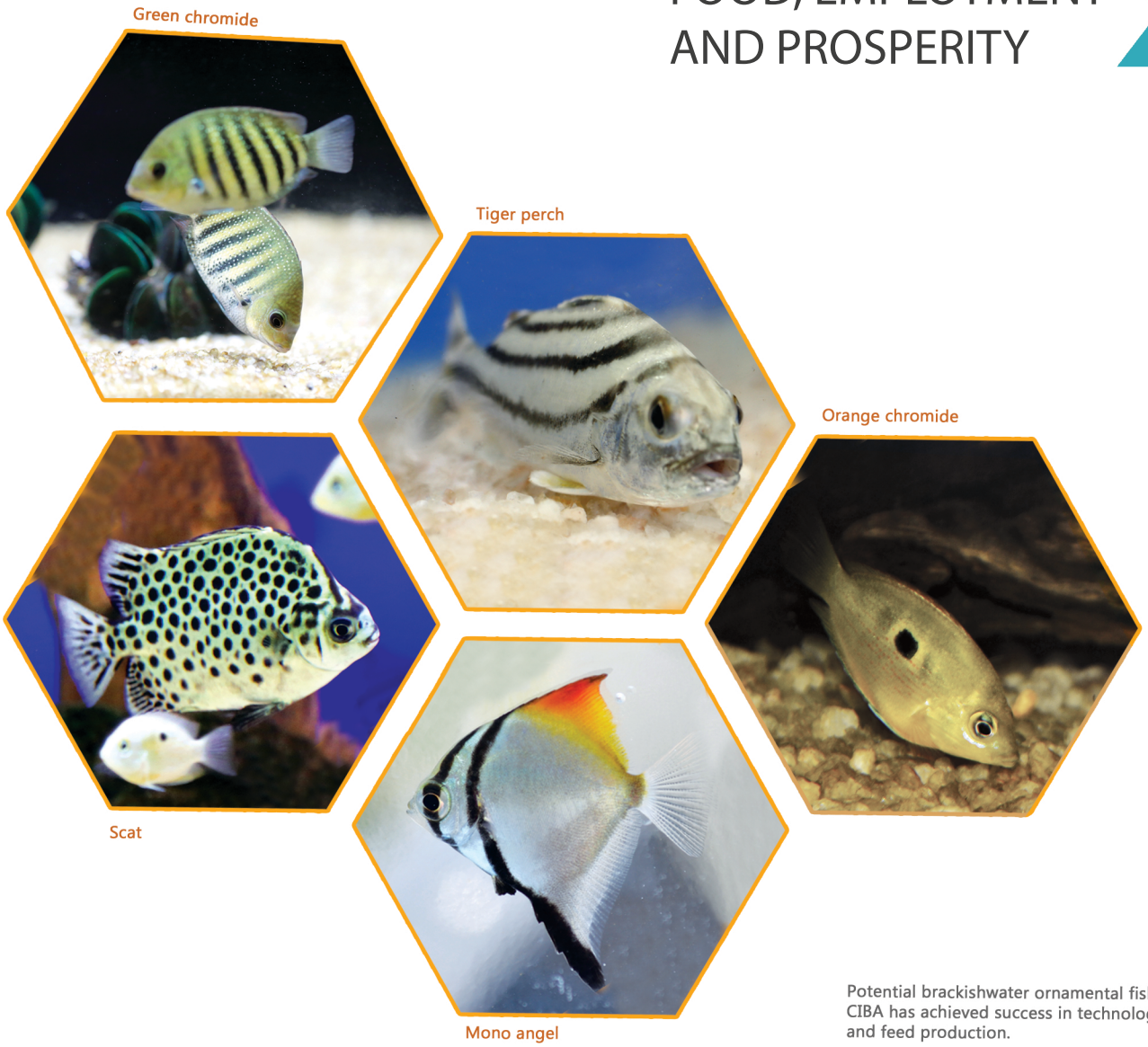
BRACKISHWATER AQUACULTURE FOR FOOD, EMPLOYMENT AND PROSPERITY



Potential brackishwater ornamental fishes in which CIBA has achieved success in technologies for seed and feed production.

ICAR-Central Institute of Brackishwater Aquaculture
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