भाकृअनुप
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भाकृअनुप - केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

ANNUAL REPORT
2016-17

Farm reared Hilsa shad, *Tenualosa ilisha*, at Kakdwip Research Centre of CIBA, West Bengal

A cost effective indigenous shrimp feed 'Vannami*Plus*' was launched by Sri Prathipati Pulla Rao, Honounarble Minister for Agriculture, Animal Husbandry, Dairying and Fisheries, Government of Andhra Pradesh at farmers meet, Bapatla, Andhra Pradesh on 4th February 2017.

Front Cover :

Farm reared Hilsa shad, *Tenualosa ilisha,* at Kakdwip Research Centre of CIBA, West Bengal
Fishes were harvested after two years of rearing in brackishwater pond.

Back Cover :

Top - Pond reared mature Hilsa shad at Kakdwip Research Centre of CIBA, West Bengal
Bottom - Aerial View of shrimp and fish hatchery facility at Muttukadu Experimental Station of CIBA

वार्षिक प्रतिवेदन

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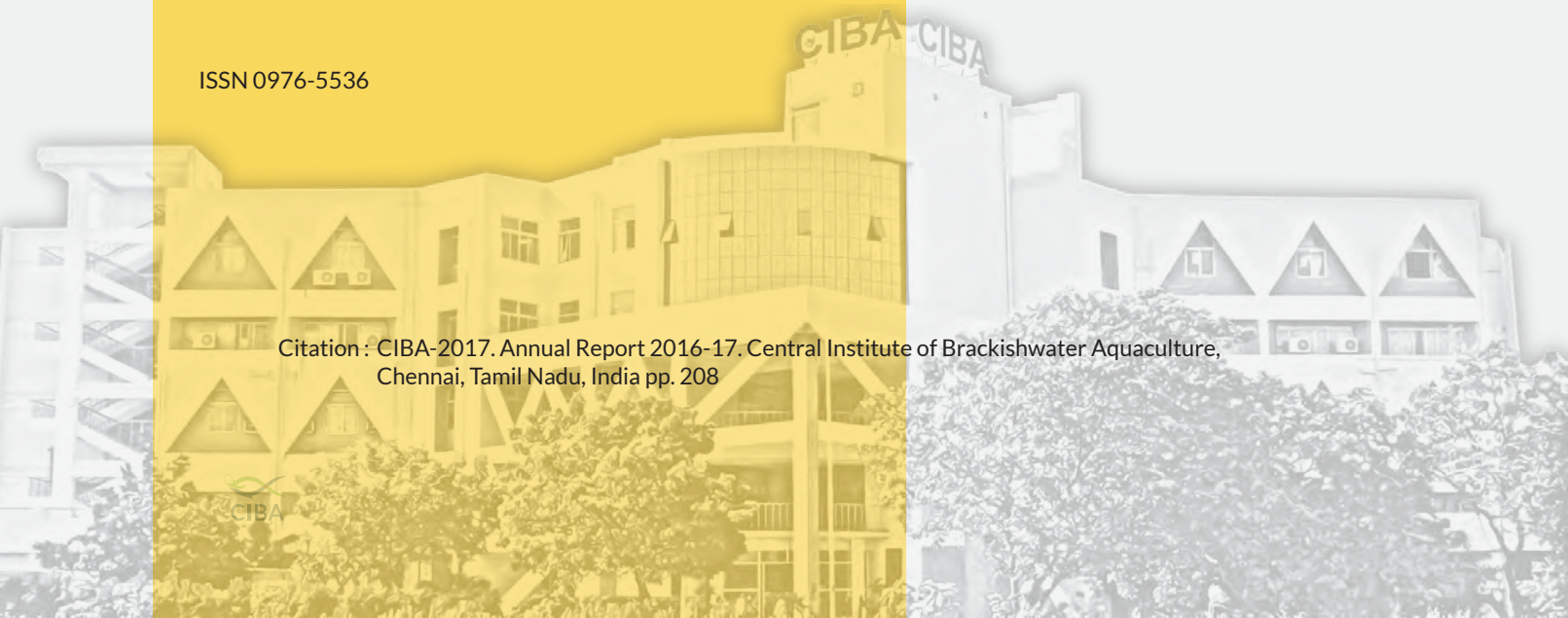


TABLE OF **CONTENTS**

Annual Report 2016-17

Preface

Year 2016-17 has been an exciting and dynamic for ICAR-CIBA with success stories and meaningful research achievements, of which many have been developed into technology format and translated for stakeholders' use. We continue to evolve to come out with technological solutions in response to new issues and challenges emerging from the brackishwater aquaculture sector. The institute drives innovation in science based coastal aquaculture for food security, creating employment, income generation, and social development. Advances, especially in brackishwater aquaculture, continue at each level of the production chain, for example, hatchery, farm, feed industry, aquatic animal health management and other allied sectors. While it is inspiring to witness the impressive growth of the brackishwater aquaculture industry, to become leads in the farming and the export of shrimp, as the nodal institute, we are aware of the role and responsibility that ICAR-CIBA has to be played in sustaining the momentum. This annual report provides our research progress during the period from April 2016 to March 2017.

Diversification of species and systems has been our major research thrust during the past years. To diversify the species for aquaculture, we have been working on several species, for example, milkfish, pearlspot, red snapper, hilsa shad, mud crab, Indian white shrimp, kuruma shrimp and several brackishwater ornamental species. Hilsa shad, *Tenualosa ilisha*, is a commercially and culturally important species linked to West Bengal in India and several South Asian countries. For the first time, CIBA's research group in Kakdwip Research Centre at West Bengal has developed a captive breeding stock in brackishwater ponds, with a significant number of females in an advanced phase of reproductive maturation. In parallel, we have also standardized and developed a spawning protocol for this species using wild caught brooders. This will be a remarkable first step in hilsa farming and aquaculture based fisheries.

Aquaculture feed and nutrition have been another major thrust area of the institute since its establishment. Since the introduction of vannamei shrimp in India, the feed price has been on the rise, and has driven the production cost up and reduced the profitability. Accessibility of feed as per requirement is a constraint for most small and medium farmers, with supply regulated through an authorized chain. To address this problem, CIBA has developed a cost effective desi feed, Vannami^{Plus}, made with locally available ingredients and indigenous feed manufacturing technology. It was successfully demonstrated in Gujarat, Andhra Pradesh and Kerala. This feed technology has been transferred to progressive and leading shrimp farmers, from Andhra Pradesh and Gujarat, on a non-exclusive basis and it has been scaled up for commercial production.

The development of native species for aquaculture offers several advantages such as protection of biodiversity, quarantine and biosecurity issues. The Indian white shrimp, *P. indicus* has been identified as a species of choice for domestication and genetic

improvement owing to the relative ease of captive reproduction in this species. To evaluate the real-world production performance of this species, demonstration trials have been carried out in six coastal states of India. An average production of 3-4 metric ton at a stocking density of 20 to 35 post larvae/m^2 was obtained, and, more importantly, the growth of this species was found to be almost similar to the growth of SPF *P. vannamei*, producing marketable sizes of 15 to 20 g. A database on the hatchery performance of this species has also been developed. These research results provide proof for the potential of native species for the development of genetically improved stock that will be the immediate priority of the Indian shrimp farming sector.

About two centuries after its formation, the genus *Penaeus* become controversial when Perez Farfante and Kensely (1997) elevated the six sub genera under genus *Penaeus* to the rank of genus. This unilateral action of elevation of the genus *Penaeus*, based on morphology, has been one of the most significant and controversial actions in the history of phylogeny, systematics and commercial aquaculture. Our genomics research group has generated the complete mitochondrial genome of *Penaeus indicus* for the first time, and performed phylogenetic analysis among the representative shrimp species in this genus using the full mitochondrial genome. Our whole mitogenome study dismisses the six-genus/subgenera classification and suggests restoring the old genus *Penaeus*. This work is being processed for publication in a peer-reviewed high impact journal.

India has continiously been vulnerable to extreme climatic events such as cyclones, storms, floods and drought. Saltwater intrusion is one of the likely scenarios of climate change, and therefore, using the newly formed system would be an opportunity for the expansion of brackishwater aquaculture. Changes in salinity levels would affect the distribution of the brackishwater biota, and developing farming systems according to the changes would be a challenge for brackishwater aquaculture development. Integrated multi-trophic aquaculture system has been considered to be one of the adaptive strategies in coping with the impact of climate change on brackishwater shrimp farming. ICAR-CIBA is a pioneer in India carrying out research and development in this newly emerging area of system diversification. Our on-farm studies show the success and readiness of the people to adopt the IMTA system, with a sustainable production of 15-20 kg of biomass, and a market value of ` 450/kg in 6-8 months.

Generating new knowledge and turning it into new products and services are crucial to achieving the mandate of the institute. The institute has grown to generate an income of over ` 2.5 million during the current year through consultancies and transfer of technologies developed by the institute.This is evidenced by the commercial agreements/memorandum of understanding (MoU) made during the last year.

The achievements provided here are highlights, and I invite readers to go through the detailed report.

We thankfully acknowledge all our stakeholders who have supported us, and their faith in our mission enables our effort. We are immensely grateful to Dr Trilochan Mohapatra, the Director General ICAR, without whose 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. When I look back at what CIBA has done during the last year, it makes me happy to see the institute's tangible and visible influence in the brackishwater aquaculture sector and aquaculture research in the country.

Dr K K Vijayan
Director

कार्यकारी सारांश

कार्यकारी सारांश

जलजीव पालन एक आशाजनक क्षेत्र बन गया है जो विश्वि के खाद्य उत्पा दन क्षेत्र में महत्वनपूर्ण भूमिका निभाता है। खारा जलजीव पालन जिसि 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 स्यर्ता एवं आनुवंशकिी तक अनुसंधान एवं वकिास कार्य करता है। हमारा ध्योन नरितर प्रजातयिों में सुधार एवं परषि्कृत करने में योगदान देने की ओर है, जो प्रजातयिों उत्पा दन अवस्थाि में है और नई प्रजातयिों के वकिास में अनुसंधान अंतराल कम करना है।

हलि्सा तेनयूलोसा इलीशा का बंद स्थतियिों में संवर्धन एवं प्रजनन

तेनयूलोसा इलीशा जिसे सामान्य त: हलि्साि कहा जाता है, दक्षणि एशयिा वशिषकर पश्चमि बंगाल में एक अत्यं महत्वैपूर्ण मत्स्या प्रजाति है। बाजार की उच्च, मांग के कारण वकिहीन शोषण तथा अन्यि मानवजनति दबावों के कारण जलीय परतिंत्रों में इस प्रजाति की उपज घटने लगी है। यद्यपि बंद प्रजनन का प्रयास वर्ष 1990 से कयिा 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 हलि्सा् मछली का बंध नषिचन का मानकीकरण कयिा। प्रजनकों के वकिास के लिए मुरीगंगा, पश्चमि बंगाल से प्राप्त हलि्सां पोनों का संवर्धन काकद्वीप अनुसंधान केन्द्रर में मट्टिी के खाराजलीय तालाब में कयिा गया। हलि्साक मछली की पोने (1.37 ग्रा., 52.97 मि.मी.) 32 माह के संवर्धन काल में बढ़कर 383.80 ग्रा/339.33 (शारीरकि भार एवं कुल लम्बाई) की हो गई है। भारी संख्याप में परपिक्वा नर मछलियों (139.35 ग्रा./260 मि.मी.) के साथ अंडाणु परपिक्वपता की 5वीं अवस्था की अंडाणुओं (570 मैक्रोमीटर) वाली परपिक्वम मादा मछलयिां (358.18 ग्रा.-425.2 ग्रा./352 मि.मी.-370 मि.मी.) प्राप्ता हुई है। नवम्ब3र से फरवरी के दौरान परपिक्वब नर एवं मादा मछलियों का अध्यथयन कयिा गया जिससे बंद स्थतियिों में परपिक्व.ता और बीज उत्पामदन के लिए प्रजनन की संभावना स्पथष्ट हुई है। खाराजलीय तालाब की बंद स्थतियिों में प्रजनकों की यह पहली सूचना है।

आईसीएआर-सीबा बंद स्थतियिों में मलि्कभफशि प्रजनन की सफलता से आगे बढ़कर मलि्कआफशि हैचरी हेतु प्रौद्योगकिी परशिोधन की ओर

बंद स्थतियिों में मलि्कौफशि प्रजनन प्रौद्योगकिी के परशिोधन से वर्ष 2016-17 के दौरान 2,12,500 लार्वा अंडों का उत्पादिन हुआ। कुल उत्पाकदति जीरे 54% नषिचन की दर से 1,15,000 है। लार्वा अतजीवति दर 45.5% प्राप्तत कयिा गया है। बीजों को देश के वभिन्नि खारा जलीय पालन प्रणालयिों में जलजीव पालन हेतु पश्चमि बंगाल, केरल और तमलिनाडु के कसिानों में वतिरति कयिा गया। संभावति उद्यमयिों के लिए घेरलूकृत मत्स्यि संपदा के सृजन के लिए 200 मछलियों का एक ब्रूडबैंक का रखरखाव कयिा जा रहा है। पश्चमि बंगाल में बंद स्थतियिों में मलि्कोफशि के प्रजनन के प्रथम बैच को 'डेकन हलि्सा ' के नाम से प्राप्तब कयिा गया। श्री अमलेश चटर्जी, एसी फशि एण्डा प्रोन फार्मस से भागीदारी के अंतर्गत कए गए पालन परीक्षणों में उत्पाचदन लागत 90-100 रुपए प्रतकिलिोग्राम और स्थानीय बाजार दर 150-170 रुपए प्रतकिलिोग्राम पाया गया।

देश के खाराजलीय कसिानों के लिए आईसीएआर-सीबा के पखमीन हेचरी का एशयिन सीबास बीज उत्पालदन में दो दशक

पछिले दो दशकों की कटबिद्धता को जारी रखते हुए चालू वर्ष में भी आईसीएआर-सीबा देशभर के कसिानों के लिए वीएनएन फ्री सप्लाई के माध्यसम से लगभग 0.9 मलियिन एशयिन सीबास बीजों की आपूर्ता की गई। संस्थान ने आंध्र प्रदेश के मछलीपट्टनम जलि में अत्पनकालकि सीबास नर्सरी उत्पा दन प्रणाली के उभरने में महत्व पूर्ण भूमकिा नभिाई। संवर्धन गतविधिि वाली यह एक मॉडल सेटेलाइट नर्सरी बन गई है जो देश के वभिन्निम भागों में मछली पालन के लिए अंगुलकिाओं की आपूर्ता करती है। यह नर्सरी सीमांत ग्रामीण युवाओं के लिए आजीवकिा सृजन तथा खुले जल संसाधनों के उपयोग में भी एक मॉडल जैसा कार्य कर रही है।

फार्म आधारति प्रजनन प्रणाली में प्रेरति प्रजनन द्वारा ग्रे मुल्लेट का लार्वा उत्पाकदन

एक नजिी उद्यमी के प्रक्षेत्रि पर

स्थगल पर ग्रे मुल्लोट 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 अंडोत्सपर्जन देखा गया एवं क्रमश: 750-850 µm प्राप्तथ किया गया। प्रेरित प्रजनन के माध्यनम से प्रति मादा से लगभग 0.5 मिलियन 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 स्थितियों में परिपक्वता एवं निषेचन

चालू वर्ष में ग्रे मुल्लोट 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 मिलियन 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।

माइक्रटस गुलियो के लिए छोटे पैमाने पर हैचरी प्रणाली के विकास के लिए

प्रोटोकोल का अनुकूलन

माइक्रटस 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 व्यासस 850 µm होने पर hCG का एक डोज आवश्यक होता है।

बंद स्थितियों 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 स्नैपर लुटजानस अर्जेंटमिक्यू 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 स्पॉट नर्सरी संवर्धन के लिए संग्रहण घनत्वh 1.5 नग प्रति लीटर तथा 15 पीपीटी लवणीयता अनुकूल है।

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

कर्नाटक से प्राप्त् किनारा पर्ल स्पॉ ट (100 नग औसत लंबाई 88.9± 8.9 मि.मी.; औसत भार 18.26±6.79 ग्रा.) मछलियों को हैचरी स्थितियों (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 एक्वाकल्चमर (आईएमटीए) का परीक्षण

चार भ्रनिन्नि 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 कटकेनससि) – (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 श्रम्पिा पीनयिस इंडकिस के पालन का नरि्पण

वभिन्निव कृषा जिलवायु 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 अवर्धा के पश्चा त नम्निउ एवं उच्च। 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 व्हागइट श्रम्पि पी. इंडकिस के उत्पा.दन गुण

टाइगर श्रम्पिक पी. मोनोडोन, पेसफिकि व्हाइइट श्रम्पि पी. वन्नामिई तथा इंडयिन व्हारइट श्रम्पि- पी. इंडकिस के उत्पाइदन गुणों की तुलना के लिए काकद्वीप अनुसंधान केन्द्र के प्रक्षेत्र स्टेशन में 120 दनिों का प्रयोगात्मक परीक्षण किया गया। 14 सप्ताह की पालन अवर्धा के दौरान पी. इंडकिस की वृद्धा का स्वयरूप पी. वेन्नाामई के समान ही रहा और इससे यह सूचति होता है कि इस प्रजाता 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 वृद्धा, नम्निस एफसीआर, पालन की छोटी अवर्धा 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 अतजीवितिा से समझौता कि बनिा संवर्धन किया जा सकता है।

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

कुरुमा श्रम्पिप पी. जापोनकिस अधकितम मूल्या का पालति झींगा है और इसे जापान में समुद्री खाद्य 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 जिससे अधकि मूल्यी प्राप्तल होता है। इस पृष्ठीभूमि के वपिरीत इस प्रजाति को वविधिकृित 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 अतजीवितिा 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, वृद्धा एवं अतजीवितिा दर से समझौता कि बनिा पालन किया जा सकता है।

तरुण झींगों की बेहतर अतजीवितिा 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 नरभक्षपिता, क्षेत्रीय व्यसवहार तथा प्रतबिंधति आहार का कारण बनता है और इसके परणिामस्वोरूप उपज के दौरान आमाप की ववििधिता तथा नम्निंस्तरीय अतजीवितिा प्राप्तर होती है। मड क्रैब की आक्रामकता के आमाप ग्रेडगि का वृद्धा एवं तरूण झींगों की अतजीवितिा 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 अतजीवितिा दर होती है, तथापि औसत में कोई उल्ले खनीय अंतर नहीं पाया गया।

स्काउइला सर्राटा की अतजीवितिा एवं वृद्धा पर लवणीयता का प्रभाव

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

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

वाणिज्यिक परीक्षणों में पीनियस इंडीकस की प्रजनन क्षमता

घरेलूकरण एवं अनुवांशिक सुधार के लिए स्थासनीय देशज सम्पादाओं को प्रमोट करने में वन्य इंडयिन व्हाइट श्रिम्प्यि के प्रजनन तथा बीज उत्पोदन की अंतर्निहिति क्षमता/अवरोधों का प्रलेखन महत्वपूर्ण कार्य है। इस तथ्यि को ध्यापन में रखते हुए, वभिन्निह स्थावनों से प्राप्त% वन्य् प्रजनकों का प्रजनन क्षमता एवं हैचरी उत्पोदन का परीक्षण कयिा गया। इसके अतरिक्ति डब्यूक एसएसवी प्रकोप का भी मूल्यांरकन कयिा गया। बंद स्थतियिों में संसर्ग की असफलता तथा मैचुरेशन टैंकों में नर मछलियों का नमि्न् संख्याल से नषिचन पर प्रतकिूल पड़ता है। औसत सफल चक्र में नौप्लीयस 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 पूरण है। अध्यायन से सूचति होता है कि पीएल 9 अवस्थास वाली पी. इंडकिस लम्बी 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 कयिा गया। वन्यप रूप से प्राप्त पी. जपोनीकस के प्रजनकों के उपयोग से नषिचन और लार्वा संवर्धन परीक्षण कए गए। लार्वा अवस्थास पूरण होने के पश्चोत उपरोक्ता लार्वा संवर्धन पद्धर्ता से औसत अतजीविता 50% और उच्चजतम अतजीविता 90 प्राप्ता की गई। दो साइकल से कुल 2 लाख लार्वा का उत्पाटदन कयिा गया और पीएल 20 की अवस्थाा में कसिानों के तालाबों तक पालन संबंधी अध्यलयनों को लिए भेजा गया।

मड क्रैब सूका इला सर्राटा की तरूण मछलियों को बड़े पैमाने पर उत्पांदन हेतु द्ववचिरणीय प्रणाली

इस प्रजार्ता के हैचरी उत्पारदन को बढ़ाने के लिए सूका इला सर्राटा के संवर्धन तथा बड़े पैमाने पर उत्पौदन संबंधी प्रयोग कए गए। द्ववचिरणीय प्रणाली में इनडोर एफआरपी टैंक में जेड1 लार्वा को मेघालोपा अवस्थ् तक तथा मेघालोपा अवस्था से आगे मट्टि के तालाबों में स्थानपति आउटडोर नेट केज में पालन कयिा गया। इसके बाद बड़े टैंकों में उच्च् घनत्व (> 150 नग/ली.) तथा छोटे टैंक में नमि्नो संग्रहण घनत्वं (10 नग/ली.) का मूल्यांईकन कयिा गया। यह पाया गया कि इन्डोर हैचरी में मेघालोपा अवस्थ् तक हैचरी उत्पाद्न के बाद बंद कर देना उत्पागदन को अनुकूलतम बनाने के दशि में कुशल पद्धर्ता है। यद्यपि छोटे टैंको का उत्पानदन अधकि है, बड़े टैंकों में उच्च घनत्व 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 पद्धर्ता में बदलाव तथा क्रमकि अवस्थापन के कारण इन्डोर टैंकों में उच्चआ मार्त्यहता दर होती है। मेघालोपा को वैकल्पकि रूप से खाराजलीय तालाबों में स्थौपति नेट केज में संवर्धन कयिा 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 कयिा 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 कयिा 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 मत्या कपालकों को केकड़ा पालन हेतु आपूर्ता की जा सकती है।

झींगा प्रक्षेत्रों में रोग नगिरानी

वर्ष 2016-17 के दौरा 155 झींगा प्रक्षेत्रों का अध्युयन कयिा गया। वर्ष 2016-17 के दौरान भी माइक्रोस्पो।रोडयिन परजीवी एन्टे रोसाइटोजून हेपाटोपेनेय (ईएचपी) खारा जलजीव पालन के लिए बार बार संक्रमण उत्पडन्न। कयिा। सफेद धब्बो रोग 8.9%, हेपाटोपैनक्रयिाटकि माइक्रोस्पो रडिोससि 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 (डब्यूू व एमएस), क्रोनकि मोर्टालटिी सड्रिोम तथा ब्लैएक गलि सड्रिोम क्रमश: 15.17%, 16.5%, 3.4%, 2.7%, 7.5% प्रक्षेत्रों में देखा गया है। अध्ययिन से यह पुष्टि 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. वन्नामेय 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 व्हाटसि एब्डोमनिल मसल के साथ सुस्ती, मांसपेशियों 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 स्थानूकिता 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 कयि 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 स्वरस्थर एसपीएफ वन्नामेय 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 स्व स्थए झींगों को तालाब की मृदा पर 15 दनिों तक एक्पोएज करने पर हुई। अन्यच प्राणजिातों जैसे पॉलीकीट वार्म, ग्रीन मसल और क्लाऽम्सि 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 नेक्शट 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 प्रजातियां प्राकृतकि रूप से रोगजनक हैं।

उन्नत डब्यूँ नडएसएसवी नैदानकि कटि

वन स्टेहप डब्यूडाम एसएसवी पीसीआर एस्सेस से 5 गुना अधकि संवेदनशील फस्टए स्टेरप 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 वजिुअल 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 हैचरियों में फेज थेरेपी के उपयोग से वाइब्रयिोस का जैवनयिंत्रण कार्य जारी रखा गया। फेज प्रॉडक्शजन प्रोटोकोल का अनुकूलन कयिा गया। झींगा हैचरियों में ल्यूनमनिीसेंट बैक्टीरयिल डसिीस (एलबीडी) आउटब्रेक के दौरान फेज थेरेपी परीक्षण कएि 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।

डब्ल्यूतएसएसवी की प्रभावकारी नष्क्रियिता

जलजीव पालन जैव सुरक्षा में कीटाणु शोधन एक महत्वउपूर्ण उपाय है। कृत्रमि झींगा पालन पर्यावरण में डब्यूटाण एसएसवी की प्रभावकारी नष्क्रियिता के लिए क्लो रीन उपयोग की अनुकूल मात्रा एवं अवधि प्रभावति झींगा के ऊतकों में दो दनिों में वायरस की नष्क्रियिता के लिए 10 पीपीएम, जबकि मृदा में डब्यू. एसएसवी की नष्क्रियिता 20 पीपीएम क्लोपरीन की आवश्यलकता है। 42 झींगा प्रक्षेत्रों में पालति झींगों का वश्लिेकषण एंटबिायोटक्सि के लिए कयिा गया जैसे, क्लो,रमफेनकिोल, नाइट्रोफ्यूरान्सि 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

नैदानकिी का क्षमता नरि्माण एवं सामंजस्यल दर

इस कार्य का मुख्यर उद्देश्यी देश के पूर्वी तट एवं पश्चमिी तट के जलीय कसिानों के हति के लिए कुशल एवं वशि्वशसनीय पीसीआर परीक्षण सेवाएं उपलब्धक कराने हेतु है, जहां वे अपने नमूनों को वशि्सलनीयता के साथ परीक्षण करा सकें ताकि प्रमाणीकरण प्रक्रयिा के माध्यनम से उपयुक्त नरि्णय ले सकें। प्रथम चरण में प्रयोगशालाओं में उपलब्धय पीसीआर सुवधिाओं का सीबा एवं आरजीसीए के एक दल द्वारा नरीक्षण के माध्यम से नरि्धारण कयिा गया। इसके बाद सीबा में प्रयोगशाला तकनीशीयनों के लिए 03 से 05 अक्तूंबर, 2016 के दौरान तीन दविसीय व्यदवहारकि प्रशक्षिण का आयोजन कयिा गया जसिमें न्यू क्लकि एसडि, डब्यू मे एसएसवी, ईएचपी तथा आरएनए वायरस, संक्रामक मायोनेक्रोसिस वायरस के लिए पीसीआर के सद्धिांत एवं व्यबवहार का सैद्धांतकि एवं अभ्यायसात्मरक कक्षाएं सम्मलिति की गई। झींगा रोग न्यूतक्लकि एसडि एवं पीसीआर के मौलकि तथ्यभ, झींगा नमूनाकरण के प्रोटोकोल, न्यूलक्लकि एसडि के नष्कितर्षण, पीसीआर पर कार्य, इलेक्ट्रो फोरेसिस तथा पीसीआर परणिामों की सूचना के अलावा ट्रबल शूटगि पर एक अध्योय वाले प्रशक्षिण मैनुअल प्रशक्षिणार्थयिों को उपलब्धा कराया गया। वर्ष 2016-17 के दौरान आंध्र प्रदेश (11), तमलिनाडु (8), कर्नाटक (3) तथा गुजरात (3) की कुल 25 प्रयोगशालाओं ने इस पीसीआर रगि परीक्षण कार्यक्रम में भाग लयिा। रगि परीक्षण में भाग लेने वाली 25 प्रयोगशालाओं मंप से 24 प्रयोगशालाओं ने परणिामों को प्रस्तुात कयिा जनिमें से 17 प्रयोगशालाएं रगि परीक्षण में सफल हुईं।

जलजीव पालन सुवारसूयशा शविरि

तमलिनाडु के नागपट्टनम जलि के चन्निा थुम्बूर में 19 अगस्तग, 2016 तथा तमलिनाडु के रामनाथपुरम जलि में 28 सतिंबर, 2016 को जलजीव पालन सुवास्य्20 शविरि का आयोजन कयिा गया। इस प्रदेश के झींगा पालकों के हति में पीसीआर-डीएनए परीक्षण के उपयोग से डब्यू इ एसडी तथा ईएचपी के लिए नःशुल्क ऑन-फार्म परीक्षण सेवा उपलब्ध कराई गई। तालाब की मृदा की अवस्थास तथा जल गुणवत्ता प्राचल जैसे रडिॉक्स् पोटेंशयिल, पीएच, लवणीयता, क्षारीयता, कठोरता आदि जनिमें बैक्ट्रीयिल लोड भी सम्मलिति है, जो जलजीव पालन तालाब परतिंत्र के सुवास्यृषा को सूचति करता है। सूचति करने संबंधी परीक्षण कए गए तथा कसिानों को उनकी रपिोर्ट दी गई उपचारात्मकक सुझाव दए गए। डब्यूएसडी, ईएचपी, एक्यूकट हेपाटोपेंक्रयिाटकि नक्रिोसिस डसिीस (एएचपीएनडी) तथा जलजीव पालन के नतिेशों के उचति उपयोग जैसे रोग प्रबंधन वषियों पर मातृभाषा में तैयार कए गए वस्तिावर पत्रकों को झींगा पालकों में वतिरति कयिा गया। तालाब की मृदा एवं जल गुणवत्ता के बेहतर प्रबंधन के लिए मृदा एवं जल गुणवत्ता प्रबंधन, रडिॉक्स। पोटेंशयिल तथा झींगा पालन में खनजिों के उपयोग वषियों पर पत्रक वतिरति कए गए।

पीनीयस वन्नालमेय के लिए लागत प्रभावी आहार

केरल के त्रसिूर जलि के वोडंगलार गांव के एक कसिान के तालाब में सीबा का देशज लागत प्रभावी आहार वन्नामीप्लेस का परीक्षण कयिा गया। हम ने यह नरि्पति कयिा है कि वन्नापमीप्लस के उपयोग से एक कि.ग्रि. झींगा उत्पादिन के खर्च को 91 से 98 रुपए तक सीमति कयिा जा सकता है, जो वाणज्यिकि आहार के उपयोग में 140 रुपए तक जा सकता है। यह नरि्पति कयिा गया है कि 1 कि.ग्रि. झींगा उत्पा दन में आहार खर्च को 91 से 98 रु. तक सीमति कयिा जा सकता है, जो वाणज्यिकि आहार के उपयोग में 140 रुपए तक जा सकता है।

आहार में एक घटक के रूप में राइस ड्राइड डस्टिलरी ग्रेन

पी. वन्नाममेयी, पी. मोनोडॉन तथा मुगलि सेफालस के आहार में घटक के रूप में राइस ड्राइड डस्टिलरी ग्रेन सोल्यूइबल (डीडीजीएस) की संभावना का परीक्षण कयिा गया। परणिामों से स्पष्ट हुआ है कि पी. मोनोडॉन तथा मुगलि सफिालसि के आहार में नष्पिादन से समझौता कए बनिा डीडीजीएस को 10% तक सम्मलिति कयिा जा सकता है। पी. वन्नाझमेयी के आहार में सोयाबीन मील के स्था न पर डीडीजीएस को 10% तक उपयोग कयिा जा सकता है।

कुरूमा झींगा, पी. जापोनीकस के लिए वशिष आहार

नम्निा प्रोटीन (42%) वाले आहार की तुलना में पी. जापोनीकस को दए गए उच्च प्रोटीन (48%) का नष्पिा2दन बेहतर देखा गया है, अधकितम लागत:लाभ अनुपात को प्राप्तस करने में नम्नि8 प्रोटीन आहार लागत प्रभावी है।

कवकीय (एस्पनरगलि्ललस नायगर) कण्विशन का प्रभाव

झींगों के दो तैलीय आहार (सूरजमुखी और मूँगफली) में पोषक तत्वों के उपयोग से सूचति हुआ है कि पी. इंडकिस के कच्चे) आहार में 2.5% सम्मलिन सीमा के वरिुद्ध 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 कयिा गया, जसिके परणिामों से यह स्परष्टह हुआ है कि परंपरागत ट्रैश फशि आधारति 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 मांसपेशयों तथा यकृत में आयु एवं लगि के संदर्भ में फैटी एसडि की भन्नि ताओं पर कए गए अध्यतयनों से स्प ष्ट हुआ है क मादा मछलयों की तुलना में नर मछलयों में प्रारंभकि अवस्थाअ में प्रजनन के लए महत्वपूर्ण फैटी एसडि अधकि होते हैं जसिसे यह सूचति होता है क नर मछलयों में परपिक्वनता शीघ्र होती है। यह भी स्प ष्ट है क आयु के संदर्भ में ऊतक आधारति भन्नि मताएं होती है। यह सूचना मुल्लेयट्स की वभिन्नि जीवन अवस्थांओं में आवश्यतक आहार की रूपरेखा के लए उपयोगी है।

पी. वन्नाममेय में आवश्यपक आहारीय फैटी एसडि का सृतर

हाइपर और हाइपो लवणता तनावपूर्ण पर्यावरण में पी. वन्नीमेयी की अतजीवति एवं वृद्धा नष्पिादन में आवश्यणक फैटी एसडि के सृत रों में बदलाव से आहारीय संशोधनों के कारण वृद्धा दिखी गई है।

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

मल्किजफशि के पोनों के लए वशिष नर्सरी आहार का वकिास कयिा गया जो मल्किजफशि के अधकितम वृद्धा 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 टैंकों में सूक्ष्मध आधारति नर्सरी के आहार के उपयोग से पर्ल स्पॉआट की तरुण मछलयों 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 मछलयों 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 वृद्धा नष्पिादिन पर कए गए अध्ययन से स्पकष्ट हुआ है क बेहतर आहार उपयोग के लए अनुकूलतम घनत्वा 50 झींगा प्रत वर्ग मीटर है।

बायोफ्लॉक मील में न्यू ट्रएिंट प्रोफाइलगि

सी:एन अनुपात के संदर्भ में उत्पोदति बायोफ्लॉक मील में पोषक तत्वों के प्रोफाइलगि से स्पंष्ट 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 स्पीरलुिना 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 अध्ययनों का प्रयास कयिा गया।

पर्ल स्पॉट का आनुवांशकि गुणचत्रिण

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

पीनीयस इंडकिस की आनुवांशकि संपदा

इंडयिन व्हाकइट श्रिंप पीनीयस इंडकिस : 1) पश्चमि बंगाल, 2) ओडशिा, तमलिनाडु एवं केरल तथा 3) महाराष्ट्रय 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 मछलयों ने फैटी एसडि बायोसथिसिस में सम्मलिति ट्रांसक्रप्टिोम की उच्च अभव्यिसक्त दर्शाई है।

पीनीयस जीनस का मॉल्यूटलर 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 परचियन (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, अवूरीवक्कम, 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 अध्यायन 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

Aquaculture has become the most promising sector that plays a crucial role in global food producing sector. Brackishwater aquaculture, which is dominated by shrimp farming, has been the mainstay of Indian aquaculture. ICAR-CIBA has been carrying out research and development along the whole value chain, from the growing system to the final grow-out phase: all phases of life cycle, animal nutrition, health and genetics. Our focus is continued to contribute for the improvement and refinement of the species, which already exist in the production phase, and to fill the research gap in the search for new species.

Success in captive rearing and breeding of Hilsa shad, *Tenualosa ilisha*

Tenualosa ilisha, commonly known as Hilsa, has been one of the most important fish species in south Asia in general and West Bengal in particular. Owing to the high market demand, indiscriminate exploitation and other anthropogenic pressures, the wild catches of this species have dwindled in aquatic systems. Although captive breeding has been attempted since 1900, the successful closing of the life cycle has been still enigmatic. Scientists in Kakdwip Research Centre standardized captive spawning of hilsa using wild caught broodstock. Further, for the development of broodstock, hilsa fry obtained from Muriganga River, West Bengal were reared in the brackishwater earthen pond at KRC. Hilsa fry of size (1.37 g, 52.97 mm) grew up to 383.80 g /339.33 (body weight and total length) within 32 months. Significant number of matured females (358.18 g- 425.52 g/352 mm-370 mm) with oocyte diameter (570 µm) corresponding to V th stage of oocyte maturation were obtained along with matured males (139.35 g/260 mm). The mature male and female fishes were observed during the period from November to February suggesting the possibility of captive maturation and reproduction for seed production. This is the first report of captive broodstock development in brackishwater ponds.

ICAR-CIBA moving on from the breakthrough in captive milkfish breeding towards refinement of technology for milkfish hatchery

Refinement of technology of captive milkfish breeding led to a production of 2,12,500 lakh eggs in the year 2016-17. Total spawn produced was 1,15,000 with 54% hatching rate. A milestone 45% larval survival percentage was also achieved. Seed were distributed to farmers from West Bengal, Kerala and Tamil Nadu for aquaculture in different brackishwater culture systems of the country. A broodbank of 200 fish are being maintained for creating domesticated stocks for potential entrepreneurs. The first batch of captive bred milkfish launched as 'Deccan Hilsa' in West Bengal was successfully harvested. Culture trial conducted in partnership with Mr. Amalesh Chattejee, AC Fish and Prawn farms at a cost of production of Rs. 90- 100/kg and a local market price of Rs. 150-170/kg.

Finfish hatchery of ICAR-CIBA produces and supply seabass seeds to the Indian farmers nearly for the past two decades

In keeping with its commitment of the past two decades, in current year also Asian seabass seed production by ICAR-CIBA reached out to the farmers throughout the country through quality VNN free supply to the tune of about 0.9 million. Institute has played a significant role in the emergence of short term seabass nursery production system in Machilipatanam district, Andhra Pradesh. It has been a model satellite nursery rearing activity that supplies fingerlings to the grow out production at various locations in the country. It also serves as model for livelihood generation for marginalized rural youth and how open

water resource can be utilized sustainably.

Larval production of grey mullet by induced breeding in farm based breeding system

A novel farm-based low volume system for grey mullet breeding was developed at farm site of a private entrepreneur. The breeding trials performed using this system resulted in final oocyte maturation and ovulation in 8 and 5 trials respectively resulting in eggs of 750-850 µm. About 0.5 million eggs per female were obtained through induced breeding, even though percentage of fertilization was relatively low. Larval production from the system was indicative of feasibility of this model.

Captive maturation and spawning of grey mullet

Induced spawning in grey mullet was successfully achieved during the current year. Induced spawning was observed in three fishes with intra ovarian oocyte diameter, 520, 525 and 535 µm. The fishes spawned in response to a combination of LHRHa and dopamine inhibitor. Over 2 million eggs were obtained with an egg diameter of 800 µm. However, the fertilization rate was observed to be low. Larvae collected from the incubation tanks had an average size of 2.4 mm (TL).

Pitutary gland extract found optimal for sexual maturation and induced breeding of *Liza parsia*

Pituitary gland extract alone or in combination with hCG was found to be a promising dose significantly increasing the oocyte diameter and inducing ovulation and spawning in *Liza parsia*. Through a study using osmotic pumps for hormone delivery in *Liza parsia,* pituitary gland extract was found to be more effective for sexual maturation of *L. parsia*

Optimisation of protocols for development of small scale hatchery system for *Mystus gulio*

A simple and cost effective protocol for hatchery production of *Mystus gulio* was developed. The dosage of hCG to be delivered for the induced spawning was optimized. Further it was found that a male biased sex ratio significantly increases the reproductive output. Oocytes diameter in range of 750- 850 µm required primary and secondary dose of hCG, whereas oocytes diameter above 850 µm required only one dose of hCG for successful spawning

Solid foundations for captive breeding of red snapper laid through development of captive broodstock

A strong foundation for captive breeding of red snapper *Lutjanus argentimaculatus*, was laid through development of domesticated pond and RCC tank based broodstock. Pond based grow-out trials indicate that pond based system with a feeding strategy using a combination of trash fish and pellet feeds showed better growth performance. The results also indicate a potential average body weight gain 865 g in a 10 months culture period.

Potential of pearlspot larval rearing on inert feeds as starter diets demonstrated

Experiments conducted for refining larval rearing protocols of pearlspot show the potential for pearlspot to be reared on inert feeds as starter diets. A starter feed of 100 µm gave significantly higher growth rates relative to 200 and 300 µm. Use of background micro-algae during use of inert feeds as starter diets gave superior growth performance (final avg body wt., 13.48±1.47 mg) over exclusive use of inert feeds(final avg body wt., 8.35±0.46 mg)after 15 days. Experiments on tank based nursery rearing of pearlspot indicated a stocking density of 1.5no per l and salinity of 15 ppt as optimal for nursery rearing of pearlspot.

A significant step in conservation of the endangered species Canara pearlspot *Etroplus canarensis*: captive breeding protocols standardised by ICAR-CIBA

Canara pearlspot (100 numbers, average length, 88.9± 8.9mm; average weight, 18.26± 6.79 g) procured from Karnataka and acclimatized to hatchery conditions (salinity: 5-8 ppt, temperature, 26-28 °C, pH-7.5-8.2) could be successfully bred in five trials. An average larval number of 75-100 per spawning was recorded. Approximately 300 numbers of F-1 generation are being maintained in the fish hatchery for domesticated broodstock development.

Integrated Multi-trophic Aquaculture (IMTA) tested as a viable aquaculture option in brackishwater eco-system

Evaluation of IMTA systems in 12 ponds (500 m^2 each) was done with four different species combinations as treatments: Tiger shrimp (*Penaeus monodon*) + mullets (*Mugilcephalus* and

Liza tade)- (C), Tiger shrimp + mullets + water spinach (*Ipomoea aquatica*)- (T1), Tiger shrimp + mullets + oyster (*Crassostrea cuttackensis*)- (T2), Tiger shrimp + mullets + water spinach + oyster- (T3) was carriedout for 150 days. A significantly higher production (1510±36 kg/ ha), better water quality, and significantly higher return (Rs.2.24 lakh/ ha) with BCR (2.14) was obtained in using both plants and oysters as extractive crops in combination with fish and shrimps as compared to all other treatments.

Farming demonstration of Indian white shrimp, *Penaeus indicus*

Pilot scale farming demonstrations were conducted at six different coastal states of India to evaluate the production performance of Indian white Shrimp *Penaeus indicus* in different agro-climatic zones**.** An average production of 4.4 ± 0.8 mt/ha at a stocking density (SD) of 35 PL/m^2 and 1.142 ± 0.20 tons/ha at SD of 10 PL/ m^2 were obtained in this trial at a salinity that varied from 2 to 12 ppt. At the end of 135 days grow out, a final body weight of 28-30 g and 17 -20 g was obtained at lower and higher stocking densities respectively.

Production characteristics of tiger shrimp, *P. monodon,* Pacific white shrimp, *P. vannamei* and Indian white shrimp, *P. indicus*

In order to compare the production characteristics of tiger shrimp, *P. monodon*, Pacific white shrimp, *P. vannamei* and Indian white shrimp, *P. indicus* a 120-day experimental trial was carried out at KRC field station. The growth pattern of *P. indicus* was similar to *P. vannamei* until 14 weeks, thereby indicating the potential of this species for the development of a domesticated crop.

High density clear water nursery rearing for *Penaeus indicus* under high feeding frequency regime

The nursery rearing, the intermediary step between hatchery production and grow out phase, is found to have several advantages such as improved growth, low FCR, shorter days of culture and low incidence of pathogenic infection. In this back drop, a high density nursery rearing protocol for *Penaeus indicus* was developed. The study demonstrated that up to 1000 no/m3 post larvae can be reared for 45 days with low protein diet (30%) without compromising final weight and survival.

Farming demonstration for Kuruma shrimp, *Penaeus japonicus* at Chirala, Andhra Pradesh, India

Kuruma shrimp, *P. japonicus*, has been the highest priced farmed shrimp, and it is known as king of seafood in Japan. As the shrimp tolerate long distance transportation, this species can be marketed in live condition that fetches a premium price. Against this background, culture experiments were carried out in farmer's pond to demonstrate the possibility of developing this species as a diversified crop. The grow-out trial in 600 m^2 lined pond with sand bottom substratum at a stocking density of 50 no/m^2 provided a production of 5000 kg/ ha with a 50% survival for a period of 150 days.

Low saline performance of Kuruma shrimp, *Penaeus japonicus*

The farming of *P. japonicus* is well documented in full strength seawater and near seawater salinity ranges. A 60-day indoor experiment demonstrated that *P. japonicus* could be grown at a lower salinity of 5-10 ppt without compromising the growth and survival rate contrary to the earlier research findings.

Periodic size grading in mud crab nursery for improved survival and size homogeneity of the juveniles

Social hierarchy and aggression of mud crab instar during nursery rearing is a function of the size of the animal, and which causes cannibalism, territorial behaviour and restricted feeding resulting in size heterogeneity and poor survival at harvest. A nursery rearing experiment was carried out to study the effect of size grading of mud crab instar on the growth and survival of juveniles. The study revealed that crabs reared under periodic size grading had a significantly higher survival rate, although there was no significant difference in the average weight between the treatment groups.

Effect of salinity on survival, and growth of *Scylla serrata*

Optimum salinity level for the growth and survival of mud crab, *S. serrata* was determined.

Four salinities, 5, 15, 25 and 35‰, were evaluated, and among the four salinity tested the highest survival was found at 35‰ (93.3%) followed by 25‰ (63%), 15‰ (46.7%) and 5‰ (40%). However, final body weight and carapace

width at lower salinity levels were comparable to the highest salinity tested. Although survival was higher at 35‰, the specific growth was not high at this salinity, therefore, for better growth and survival, salinity at the range of 15 to 25 could be recommended.

Reproductive performance of *Penaeus indicus* in near commercial trial runs

Documentation of inherent potential/constraints in the reproductive and seed production performance of wild Indian white shrimp is one of the major thrust areas in promotion of native indigenous stock for domestication and genetic improvement. Keeping this in view, reproductive performance and hatchery production perfomance of wild caught brooders obtained from various locations were traced. Additionally incidence of WSSV also was evaluated. Failures in captive mating and low percentage of male population in maturation tanks would cause poor spawning performance. The average successful cycle recorded nauplius to mysis survival at 60% (50-70%) whereas mysis to PL was found to be 25%. Incidence of WSSV infection revealed an average monthly incidence in *P. indicus* brooders at 72% (29-100%) with highest incidence in August to November (87.5-100%).

Seed transportation protocols for *Penaeus indicus* standardized

Stress mediated mortality is one of the major problems associated with long distance transport of PL. Standardizing seed transportation procedure of *P. indicus* is vital for ensuring high survival rate of PL on receipt at the farm. The study indicates that *P. indicus* of stage PL 9 is well suited for long distance transportation and stocking densities lower than 250 nos/l may be employed in the case of advanced PL.

Seed production and larval rearing of *Penaeus japonicus*

Seed production trials of *Penaeus japonicus* was carried out as a first step to diversify penaeid shrimp culture in India done. Spawning and larval rearing trials using wild caught brooder of *P. japonicus* were carried out. At the end of the larval cycle an average survival of 50% with highest up to 90% was achieved from the above larval rearing method. A total of 2 lakh larvae were produced from two cycles and seeds at PL_{20} stage were transported to farmer's pond for grow out studies.

Two- phase production system for large scale juvenile production mud crab *Scylla serrata*

Rearing experiments and mass production of *Scylla serrata* juveniles were carried out in order to optimize the hatchery production of this species. In two phase culture system Z1 larvae were reared up to megalopa stage in the indoor FRP tank and from megalopa on wards in the outdoor net cages erected in the earthen ponds. Further, the possibility of using large tank with higher density (> 150 no/L) and smaller tank with low stocking density (10 no/L) were evaluated. It was found that terminating the hatchery production at the megalopa stage at the indoor hatcheries is an efficient way to optimize the production. Although production from smaller tank is higher, use of larger tank with high stocking density is found to be more economically feasible.

Reducing the hatchery phase in mud crab seed production through outdoor rearing of Megalopa

Megalopa stage in the crab larval cycle is a crtical phase in mud crab seed production owing to its cannibalistic behaviour, changes in feeding pattern and gradual settlement resulting in high mortality in indoor tank systems. Megalopa can alternately be reared in net cages erected in the brackishwater ponds and it significantly reduces the duration of hatchery phase of mud crabs. The age of megalopa to be weaned from in door hatchery was evaluated in a 15 day experiment. Superior crab instar conversion rate of (Megalopa to Crab instar) of 62.33 ± 3.08 % and 69.66 ± 2.35 % were obtained using megalopa aged 3 days and 4 days (M3 and M4) respectively. The present trial reveals that stocking of megalopa aged 3 to 4 days in to outdoor system yields better results and this life stage may be supplied to farmers for crab farming.

Disease surveillance of shrimp farms

The study was carried out in 155 shrimp farms during 2016-17. The microsporidian parasite, *Enterocytozoon hepatopenaei* (EHP) continued to haunt brackishwater aquaculture during the year 2016-17. The prevalence of white spot disease (WSD) was 8.9%, hepatopancreatic microsporidosis

23.6% and infectious hypodermal and hematopoietic necrosis (IHHN) 1.3%. Other disease syndromes due to poor farm management such as stunted growth, white faeces syndrome (WFS), white muscle syndrome (WMS), chronic mortality syndrome (CMS) and black gill syndrome was observed in 15.17, 16.5, 3.4, 2.7, 7.5% of the farms respectively. The study confirmed that 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). During Feb- March 2017, infectious myonecrosis (IMN) was detected using OIE protocol in two *P. vannamei* farms of 55 and 70 DOC in East Godavari, AP. Mortality was about 15% in affected ponds. Affected shrimp were lethargic with whitish abdominal muscle, had muscle cramp and full gut with poor FCR of about 2.2, with slow growth (~4-5 g at 70 DOC). As part of aquaculture diversification plan, pathogen profiling of *Penaeus indicus* broodstock sourced from different locations in Tamil Nadu and Odisha to ascertain the suitability for breeding programme in CIBA hatchery was carried out. It was found that as high as 72% of 284 *P. indicus* broodstock were affected with WSSV and 3.87% were affected by IHHNV, indicating high endemicity of these pathogens in our brackishwater ecosystems. Among the diseases of finfish, dual infection with Irido (RSIVD) and viral nervous necrosis (VNN) was common in farmed and wild finfish such as seabass, mullet, red snapper and Tilapia.

Transmission of EHP

Investigations on the transmission of EHP indicated that it could be transmitted to healthy SPF vannamei shrimp on two weeks of cohabitation with infected shrimp and after seven days of feeding with hepatopancreas from the EHP affected shrimp. Another interesting observation was that EHP could be transmitted through soil as confirmed by PCR upon 15 days of exposure of healthy shrimp to pond-soil. Screening of other fauna such as polychaete worms, green mussel and clams suggested that these biota may not have a role in the transmission of EHP, as revealed by PCR tests.

Investigations of microbial diversity of white feaces

Microbial diversity of white faeces syndrome (WFS) affected shrimp pond using next generation sequencing (NGS) indicated significant variation in the fungal diversity at genus level compared to healthy pond. Fungal genera such as *Malassezia*, *Ganoderma* were present only in WFS affected pond. *Malassezia* is known to cause skin infection (dermatitis) in human and animals. *Candida* species was predominant genera in WFS affected pond. Many of its species are pathogenic in nature.

Improved WSSV diagnostic kit

An improved WSSV nested PCR diagnostic assay was developed with sensitivity of first step PCR being 200 copies / µl, 5 times more sensitive than other one step WSSV PCR assays. The sensitivity of nested WSSV PCR was 2 copies / µl, with 10 to 50 times more sensitive than other nested PCR assays. Highly sensitive visual loop mediated isothermal amplification (LAMP) assay was also developed for WSSV, EHP and IHHNV and efforts are underway to take these diagnostics to points of care.

Biocontrol of Vibriosis

Work on biocontrol of vibrios in shrimp hatcheries using phage therapy was continued. Phage production protocols were optimized. Phage therapy trial in commercial shrimp hatchery during luminescent bacterial disease (LBD) outbreak at mysis stage was carried out. A consortium of four phages was employed. Tanks treated with phage therapy showed average larval survival of 36% until PL 5 stage compared to 100% mortality in untreated tanks by PL3 stage. Additionally, there was 1 log reduction in vibrio counts and 2 log reduction of luminescent bacterial counts.

Effective inactivation of WSSV

Disinfection is one of the important tools in aquaculture biosecurity. The optimum dosage and the duration of chlorine application for effective inactivation of WSSV in simulated shrimp culture environment was found to be 10 ppm for inactivating the virus in the affected shrimp tissues in two days, while 20 ppm of chlorine was required to inactivate WSSV in soil. Farmed shrimp from 42 farms were analysed for antibiotics such as chloramphenicol, nitrofurans and its derivatives, nitrofuran metabolites, sulfonamides and its derivatives and tetracycline residues in revealed that only four soil samples were positive for Semicarbazide.

Capacity building and harmonization of PCR diagnosis of aquatic animal diseases

The objective of this exercise was to provide efficient and reliable PCR testing services on both East coast and West coasts of our country for the benefit of aquafarmers, where they can get their samples tested confidently to enable them to take appropriate decision through a certification process. In the first stage, PCR infrastructure available with laboratories was ascertained through inspection by team from CIBA and RGCA. This was followed by hands-on training programme during 3rd to 5th October 2016 for laboratory technicians at CIBA on PCR for a period of three days, covering theoretical and practical classes on nucleic acids, principles and practice of PCR for WSSV, EHP and an RNA virus, infectious myonecrosis virus (IMNV). A training manual was provided to the trainees having comprehensive information on important shrimp diseases, basics of nucleic acids and PCR, protocols for shrimp sampling, nucleic acid extraction, performing PCR, electrophoresis and reporting the PCR results, in addition to a section on trouble shooting. A total of 25 laboratories from Andhra Pradesh (11), Tamil Nadu (8), Karnataka (3) and Gujarat (3) had undergone this PCR ring test programme of 2016-17. Out of the 25 laboratories which participated in the ring test, 24 laboratories submitted the results, of which, 17 laboratories passed the ring test.

Aquaculture health camp

Aquaculture Health Camp was conducted at Chinnathumbur village in Nagapattinam district, Tamilnadu on 19th August, 2016, and in Ramanathapuram district of Tamil Nadu on 28th September, 2016. In the interest of shrimp farmers of the region, on-farm testing service was provided for WSD and EHP using PCR-DNA test free of cost. Tests on the pond soil condition and water quality parameters such as redox potential, pH, salinity, alkalinity, hardness etc., including bacterial load, which indicate the health of the aquaculture pond ecosystem, were also done and farmers were given reports and advise for remedial measures. Extension handouts prepared in vernacular language were distributed to the shrimp farmers on management of diseases such as WSD, EHP, acute hepatopancreatic necrosis disease (AHPND) and rational use of aquaculture inputs. For better pond soil and water quality management, handouts were also distributed on soil and water quality management, redox potential and application of minerals in shrimp culture.

Indigenous cost effective feed for *Penaeus vannamei*

CIBA's indigenous cost effective feed Vannami^{Plus} has been tested in a farmer's pond at Kodungallur in Thrissur District of Kerala. We demonstrated that feed cost to produce 1 kg of shrimp can be restricted to Rs. 91 to 98 by using "Vannami^{Plus}, it can go up to Rs.140 with commercial feeds.

Rice dried distillery grain as an ingredient in feed

Potential of rice dried distillery grain soluble (DDGS) as ingredient in feeds of *P. vannamei, P. monodon* and *Mugil cepahlus* was tested. `Results showed that DDGS incorporation at 10 % level in *P. monodon* and *Mugil cephalus* is promising without affecting the performance. In *P. vannamei,* DDGS can replace 10% of the soybean meal.

Special feed for Kuruma shrimp, *P. japonicus*

Thought the *P. japonicus* fed high protein feed (48%) showed better performance than the low protein (42%) feed, the low protein feed was cost effective in realising the maximum cost: benefit ratio.

Effect of fungal (*Aspergillus niger*) fermentation

Fungal fermentation on nutrient utilization of two oil meals (sunflower and ground nut) in feeds of shrimp indicated that incorporation can be increased up to 7.5% and 10% respectively from their raw meal inclusion limit of 2.5% in *P. indicus* diet.

Crab feed

Field trials testing the use of the dried formulated feeds for crab grow out showed promising growth as cost benefits compared to the conventional trash fish based farming both in mono culture as well as poly culture with fishes.

Fatty acid dynamics in grey mullets

Studies on variation in fatty acids of milkfish muscle and liver in relation to age and sex showed that, some of the reproductively

important fatty acid are much higher in male fish compared to female at early age, indicating the early maturation of males. There was also a clear tissue dependent variation in relation to age. This information will be useful in designing diets for different life stages of mullets.

Levels of dietary essential fatty acid in *P. vannamei*

Dietary modification with changing EFA levels increased the survival and growth performance of *P. vannamei* in hyper and hypo salinity stress environment.

Nursery rearing of milkfish fry at higher densities in green water conditions

Specialized nursery feeds for milkfish fry were developed and found to be efficient for realizing the maximum growth potential of milkfish. In 40 days of rearing 10 dph post flexion larvae reached 2.6 g.

Micro bound nursery feeds for pearlspot

Intensive nursery rearing of pearlspot juvenile using micro bound nursery feeds in microcosm tanks was perfected. At a density of 1000 fry/m^3 , we were able to produce 1 g (900 mg to 1200 mg) juveniles in 40 days of rearing with >95% survival and FCR of 0.8 to 1, using initial 80 to 100 mg fry of 20 dph.

Effect of stocking density in natural feed rich microcosm

Study on influence of shrimp stocking density on growth performance of vannamei in natural feed rich microcosm conditions showed that, the optimum density for better utilization of natural feeds and supplemental feed would be 50 shrimps/m^2 for better feed utilization.

Nutrient profiling in biofloc meal

Profiling of nutrients in biofloc meal produced in relation to varying C:N ratios revealed biofloc as a rich source of amino acid methionine, known as a limiting amino acid in aquafeed formulations.

Dietary protein requirement for *Mystus gulio*

Dietary protein requirement study with *Mystus gulio* has showed that, 25% crude protein would be the optimum for maximum performance. A low cost practical feed with 25% protein and 6% lipid is recommended for intensive farming of this high value fish in backyard type farming.

Biodiversity of microalgae

Extensive micro algal diversity analysis in Muttukadu backwaters revealed that, this brackishwater complex is rich in micro algal strains of aquaculture importance. Potential strains such *Arthrospira maxima* and *Spirulina subsalsa* were isolated for first the time from these waters and stocks are being maintained. Nutrient profiling and molecular taxonomy studies were attempted for better utilization of these resources for enrichment of live feeds and for direct feeding.

Genetic characterization of pearlspot

Populations of Pearlspot, *Etroplus suratensis*, in different locations (Pulicat lake:Tamil Nadu; Vellayani, Vembanad and Ashtamudi: Kerala) were genetically characterized using mitochondrial, ATPase 6/8. Population in Pulicat lake was found to be completely divergent from those of Vellayani, Vembanad and Ashtamudi lakes.

Genetic stocks of *Penaeus indicus*

Three distinct genetic stocks were documented based on mitochondrial DNA gene, 16S rRNA for Indian White Shrimp, *Penaeus indicus*: 1) West Bengal, 2) Odisha, Tamil Nadu and Kerala and 3) Maharashtra

Transcriptome profiling of *Penaeus vannamei*

Based on the transcriptome profiling of *P. vannamei* juveniles exposed to temperature stress, it may be inferred that the juvenile shrimp exposed to high temperature (31 and 33°C) displayed higher expression of transcripts involved in fatty acid biosynthesis compared to those maintained at 29°C.

Molecular phylogenetic analysis of genus *Penaeus*

The phylogenetic relationship inferred among shrimp species of genus *Penaeus sensu lato* utilizing complete mitochondrial genomes did not warrant splitting of genus to six separate genera as proposed by Perez Farfante and Kensely (1997).

Economic impact analysis of CIBA technologies and policy interventions

The economic impact of three selected aquaculture technologies viz., WSSV kit (2002-2009), the introduction of *Penaeus vannamei* (2009-2016) and the product CIBASTIM (2012-2016) were

evaluated. The total economic benefits that accrued to the national exchequer cumulatively from 2002 to 2016 was estimated at Rs. 34,413 crores.

Mera Gaon Mera Gaurav (MGMG) program

Ten meetings and awareness campaigns were conducted at tribal and coastal locations of Senjiamman, Tirupalaivanam and Kannvanthurai, Avoorivakkam, Tiruvallur dt. Interventions like kitchen garden, nutrition and hygiene, group formation, demonstration and adoption of technologies, skill development and problem handling during the adoption of technologies was conducted for the beneficiaries.

Investigations on the sustainability of shrimp farming systems

Sustainability of shrimp farming was studied in the states of Kerala, Tamil Nadu and West Bengal. A total of 28 indicators were identified based on a detailed methodology to measure the sustainability of shrimp farming systems. The findings of the study indicated that the mean sustainability index of shrimp farming was 0.74. Further, the semi-intensive and traditional shrimp farming had a sustainability index of 0.79 and 0.65 respectively. The results indicate that semi-intensive system is relatively more sustainable when compared to the traditional systems.

Launching of Vanami Shrimpapp by ICAR-CIBA

CIBA launched an Android based mobile app – "Vanami shrimpapp" for the dissemination of technical information related to technologies, products, markets, and policies related to shrimp farming to stake holders in the format of "Frequently Asked Questions (FAQs). The mobile app can be downloaded from the Google play store free of cost.

Introduction

It has been increasingly recognized that the future of food security largely depends on aquaculture production. With the world's population predicted to increase to 10.9 billion people by 2050, when India itself would be expected to have a population of 1.6 billion, the need for increased food production is a major challenge, particularly in areas that have high rates of food insecurity. Aquaculture is well acknowledged as one of the few options that contribute significantly at global and national level to food security and economic growth, if responsibly developed, practiced and maintained in a sustainable way. Aquaculture is therefore pinned with great hopes and expectations.

Brackishwater ecosystem comprising the estuaries backwater, coastal lakes and adjacent water bodies are the subset of coastal system. It is a transient zone, constantly communicating with both sea and freshwater ecosystem. The unique characteristic of this ecosystem provides home for many economically important fish and shell fish resources. These resources have been exploited for fisheries and aquaculture for centuries. Currently, brackishwater aquaculture, particularly shrimp culture, has been the most emotive and politically polarized aquaculture sector globally. Although a prototype aquaculture system has been in practice in coastal areas of many countries including India, modern aquaculture commenced during early 1980s. In early 1980s many developing countries, focused on export oriented agriculture crops to provide financial capital to uplift the economy of the country. The government support along with the market demand for high valued seafood fuelled the growth of brackishwater shrimp culture in India. During 2016-17, farmed shrimp alone contributed about 3 billion US$, which is more than half of the total marine product export of the country.

Opportunity rather than necessity is the major driver for development of aquaculture, particularly brackishwater aquaculture, and therefore it is market driven development. In aquaculture literature it has been referred as "immanent system". Therefore, the innovation or intervention from the public R&D may be minimal once it was established. On the contrary, the "interventionist aquaculture" is a system where public-funded R&D programs play a pivotal role in the popularization and establishment of aquaculture. In this form of aquaculture, the beneficiaries are small scale aqua farmers, who were marginalized in obtaining the direct benefit of brackishwater aquaculture development. In this form of aquaculture, social and environmental issues are addressed.

The institute is, therefore, focusing on both forms of aquaculture. In the immanent system CIBA plays a pivotal role in developing the policy level options for the regulation of aquaculture, certifications and developing innovative models for long term sustainability. Modern shrimp farming was born in an age where consumers are extremely conscious of quality of food they eat and how it is produced. Therefore, the Institute is concerned to develop environmentally benign and socially acceptable aquaculture system.

India has been extremely vulnerable to extreme climatic events, for example cyclones, storms, floods and drought. Saltwater intrusion is one of the likelihood scenarios of climate change, and therefore, using the newly formed system would be an opportunity for the expanding brackishwater aquaculture. Changes in salinity levels would affect the distribution of the brackishwater biota, and developing farming system according to the changes would be a challenge for brackishwater aquaculture development. Integrated multi-trophic aquaculture system has

been considered to be one of the adaptive strategies in coping with impact of climate change on brackishwater shrimp farming. ICAR-CIBA is a pioneer in India in carrying out research and development in this newly

emerging system diversification. Our on-station and on farm studies show the success and readiness of the people to adapt the IMTA system.

The major theme of research during the current year was diversification of brackishwater aquaculture. Our success in captive rearing and breeding of hilsa shad has been one of the important land marks in the history of brackishwater aquaculture. For the first time we have developed captive brood stock in the brackishwater system. The research team at the KRC successfully developed a protocol for induced spawning of wild hilsa shad.

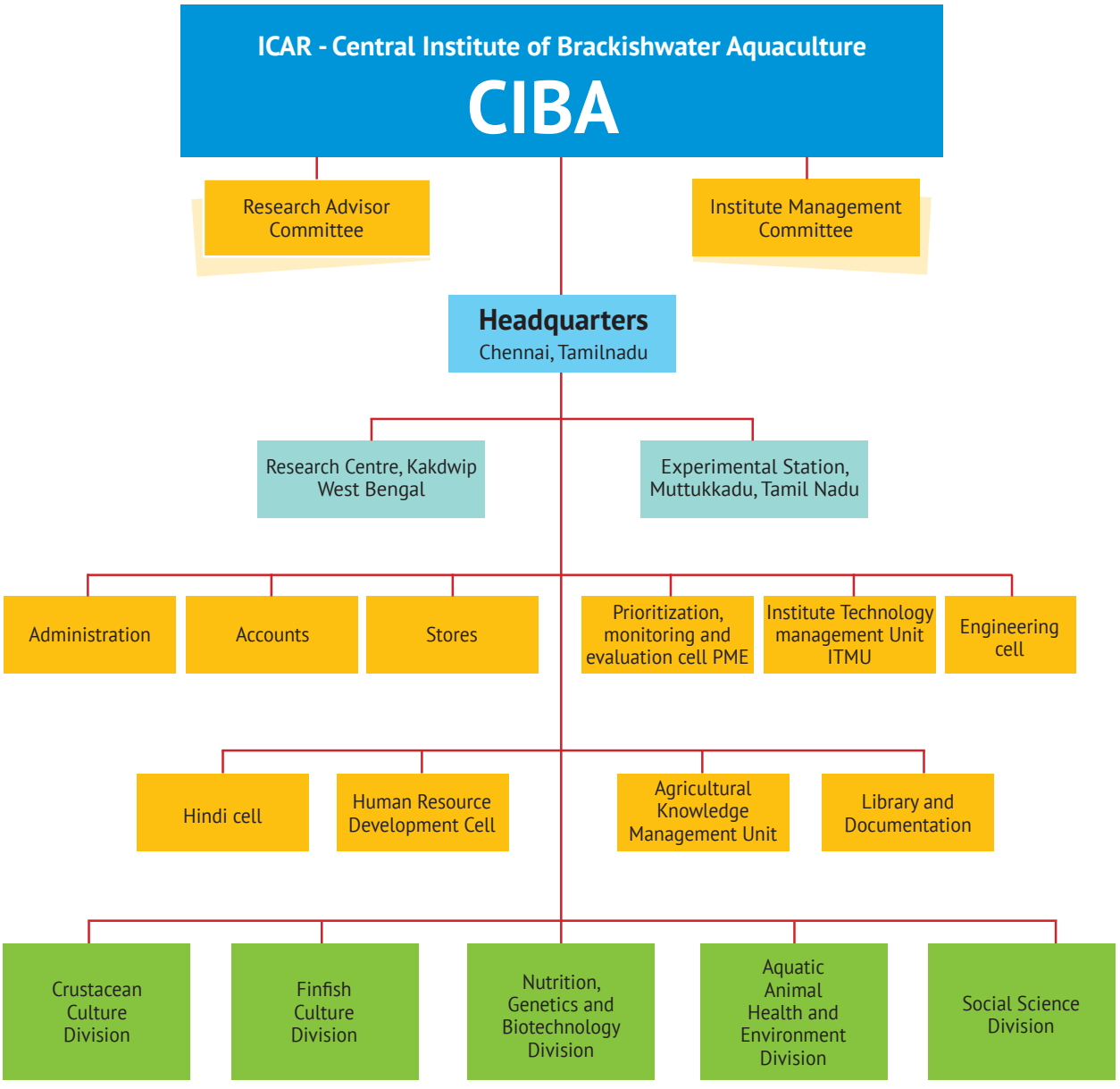
Considering the risk of exclusive dependence on imported *P. vannamei*, the institute has prioritized to develop an SPF broodstock for native penaeid species, *P. indicus*. As an introductory level study, we have carried out pilot scale farming demonstrations at six different coastal states of India to evaluate the production performance. The study reveals that this species has the potential for the development of spf stock.

The Central Institute of Brackishwater Aquaculture, Chennai was established in the year 1987 during the restructuring of ICAR Fishery Research Institutes, with its Headquarters at Chennai, experimental station at Muttukkadu and research centre at West Bengal. The Headquarters with the Office-cum-Laboratory building is located at Santhome, Chennai, since 2001. The Muttukadu Experimental Station (MES) is located about 30 km from Chennai and has finfish, shrimp and crab hatcheries along with a state of the art feed production unit. The Kakdwip Research Centre (KRC) located in West Bengal is situated about 100 km from Kolkata, has a fully developed farm facility, analytical laboratory, wet lab facilities, feed production unit and staff quarters

The research programs in CIBA which were carried out are diverse in nature. Last year the Institute had carried out 11 in-house and 26 externally funded projects. Our research programs are prioritized according to the fixed mandates:

- To develop economically viable, environmentally sustainable and socially acceptable culture technologies for finfish and shellfish in brackishwater systems in different agro-ecological regions.
- To meet emerging requirements of brackishwater aquaculture, carry out basic and strategic research.
- To evaluate economically important brackishwater natural resources for their economic utilization.
- To provide policy and planning support for socio-economic development through environmentally sustainable, brackishwater aquaculture.
- To undertake human resource development and transfer of technology programmes through training and extension and to provide consultancy services.

Organisation Chart



Financial Statement: 2016-17

(₹ in lakhs)

Sub-Head	BE	RE	Actual Expenditure
Plan			
Works	305.00	178.66	178.66
Equipments	130.00	130.00	130.00
Information Technology	40.00	32.50	32.50
Library Books and Journals	30.00	0.34	0.34
Vehicles & Vessels	0.00	0.00	0.00
Furniture & Fixtures	35.00	8.50	8.49
Others (TSP)	26.00	21.00	21.00
Establishment Expenses	0.00	0.00	0.00
Traveling Expenses	15.00	15.00	15.00
Research & Operational Expenses	99.00	108.00	108.00
Administrative Expenses	277.50	329.50	309.50
Miscellaneous Expenses (HRD & Others)	18.50	13.50	13.50
Total	**976.00**	**837.00**	**816.99**
Non-Plan			
Equipments	1.50	2.00	1.99
Vehicles & Vessels	0.00	0.00	0.00
Furniture & Fixtures	1.50	2.00	2.00
Establishment Expenses	1576.40	1483.70	1483.56
Traveling Allowance	8.00	7.00	7.00
Research & Operational Expenses	15.00	16.00	16.00
Administrative Expenses	363.00	389.00	389.00
Miscellaneous Expenses	2.00	2.54	2.54
Sub Total	**1967.4**	**1902.24**	**1902.09**
Pension & Other Retirement Benefits	1000.00	1235.00	1173.55
Grand Total	**2967.4**	**3137.24**	**3075.64**

Revenue Generation: 2016-17

Year	Revenue Receipts (₹ in lakhs)
2016-17	**137.50**

Official Language Implementation Programme

Official Language Implementation Committee meetings were held on 30.06.2016, 06.10.2016, 04.01.2017 and 30.03.2017 during the year 2016-17. Usage of Hindi in official correspondences, bilingual use of Hindi and English in files, publications in Hindi were reviewed in these meetings. Hindi week was celebrated during 8th to 14th September 2016. Dr.K.K.Vijayan, Director, CIBA in his inaugural speech emphasized the importance of Hindi and its use as an official language. In this occasion Dr.M.S.Shekhar, Principal Scientist and Officer-in-Charge, Hindi Cell gave an overview of the Institute activities being carried in Hindi. The celebrations were carried out to bring awareness and to encourage the staff and students of CIBA to use Hindi as a mode of communication. Institute organized several competitions such as noting and drafting, singing, poetry recitation etc. in which CBA staff and students actively participated Hindi Day (Diwas) was celebrated on 14th September, 2016. The Chief Guest Shri Uday Kumar Meghani, All India Radio, Chennai, delivered a lecture on "Official language implementation policy" on the occasion and released the second issue of in house Hindi magazine "Jal Tarang" and CIBA vision 2050 in hindi.

The Chief guest Shri Uday Kumar Meghani, All India Radio, Chennai releasing the second issue of in house Hindi magazine "Jal Tarang"

Staff Position

Category	Sanctioned	Filled	Vacant
RMP/Director	1	1	Nil
HOD/Principal Scientist	5	3	2
Senior Scientist	10	7	3
Scientist	52	59	-
Total	68	70	5
T-4	1	1	0
T-3	14	11	3
T-1	16	12	4
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	1	0
Personal Assistant	2	2	0
Stenographer Grade – III	1	2*	*1 excess
Assistants	7	4	3
Upper Division Clerk	3	3	0
Lower Division Clerk	5	4	1
Total	26	21*	6
Skilled Support Staff	55	26	29

The details of sanctioned, filled and vacant position as on 31.03.2017

On-going research projects

Crustacean Culture Division

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
1	Technology upgradation and refinement for sustainable development of diversified systems and species of penaeid shrimp	ICAR	**PI: Dr. C. Gopal** **Co-PIs:** Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. A. Panigrahi, Dr. P. Nila Rekha, Dr. S. Kannappan, Dr. P. Shyne Anand, Ms. L. Christina, Dr.M. Muralidhar, Dr. T.K. Ghoshal, Dr. D.D. Vimala, Dr. M. Kumaran, Dr.R.Saraswathy, Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. Sanjoy Das, Dr. P. Kumararaja, Shri K.P. Sandeep, Mr. Jose Antony, Dr. N.S. Sudheer, Mr. I.F. Biju, Mrs. M. Lini, Mr. R. Aravind, Dr. S. Sivagnanam, 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. N.S. Sudheer, Dr. M. Jayanthi, Dr. A. Panigrahi, Dr.S. Kannappan, Dr. P. Nila Rekha, Dr. P. Shyne Anand, Ms. Christina, Mr Jose Antony, Mr. I.F. Biju, Mr. R. Aravind
3	Demonstration of improved culture technologies in shell fish and finfishaquaculture and TSP programmes in Gujarat	ICAR	**PI: Dr. C. Gopal** **Co-PIs:** Dr. M. Kailasam, Dr. M.Muralidhar, Dr. P.K. Patil, Dr. P.Mahalakshmi, Shri Aritra Bera
	Externally Funded Projects		
4	Technology refinement of nutrient dense nursery rearing grow-out of *P. vannamei* in periphyton and biofloc based systems	NFDB	**PI: Dr. A. Panigrahi** **Co-PIs:** Dr. C. Gopal, Dr J. Syama Dayal, Dr R.Saraswathy, Dr Shyne Anand

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. Kumaraguru Vasagam, Dr. P. Mahalakshmi, Dr. K.Vinaya Kumar, Dr. Shyne Anand, Ms. L. Christina
6	Development of integrated multi-trophic aquaculture system	UNDP Mangrove Cell, Maharashtra	**PI: Dr.C.P.Balasubramanian** **Co-PIs**: Dr. K.K. Vijayan, Dr. A. Panigrahi, Dr. K. P. Kumaraguru Vasagam, Dr. Krishna Sukumaran, Dr. P. Kumararaja
7	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
8	Evaluation and refinement of indigenous automatic feed dispenser for shrimp farming	NFDB	**PI: Dr.P.Nila Rekha** **Co-PIs:** Dr. K. Ambasankar, Shri S. Stanline
9	Delineation of suitable areas for brackishwater aquaculture in Ramanathapuram district of Tamil Nadu with reference to environmental conditions and regulations using multi criteria decision support system	Fisheries Department, Govt. of Tamil Nadu	**PI: Dr. M. Jayanthi** **Co-PIs:** Shri J. Ashok Kumar, Dr. M. Kailasam, Dr. R. Saraswathy
10	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.K.P. Kumaraguru Vasagam, Dr. P. Nila Rekha, Dr. M. Shashi Shekhar

Finfish Culture Division

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
1	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.Satyanarayana Sethi, Dr.Krishna Sukumaran, Dr.G. Biswas, Dr. Premkumar, Shri Aritra Bera, Ms. Babita Mandal, Smt.M.U. Rekha, Dr. K. Ambasankar, Dr. Sherly Tomy, Dr. P. Kumararaja, Shri. K.P. Sandeep, Dr. T.K. Ghoshal, Shri Tanveer Hussain, Shri Dani Thomas, Dr. T.K. Ghoshal, Shri R. Subburaj

2	Development and refinement of finfish culture technologies for sustainable brackishwater aquaculture development	ICAR-CIBA	**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Kailasam, Dr. Satyanarayana Sethi, Dr.Krishnan Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Shri Aritra Bera, Ms. Babita Mandal, Smt. M.U. Rekha, Dr. K. Ambasankar, Dr. P. Kumararaja, Dr. T.K. Ghoshal, Shri Tanveer Hussain, Shri Dani Thomas, Shri R. Subburaj

Aquatic Animal Health and Environmental Division

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
1	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.PJithendran, Dr. M. Poornima, Dr.P.K.Patil, Dr. S. K. Otta, Dr. Sanjoy Das, Dr. P. Ezhil Praveena, Dr. R. Anand Raja, Dr. Sujeet Kumar, Dr. T. Bhuvaneswari, Dr. Satheesha Avunje, Dr. Vidya Rajendran, Shri T. Sathish Kumar, Dr. Aritra Bera, Shri Joseph Sahaya Rajan,
2	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
	Externally Funded Projects		
3	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. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja, Shri T. Sathish Kumar, Dr. Vidya Rajendran
4	Development of white spot syndrome virus free shrimp brooders for seed production: using indigenous shrimp, *Penaeus indicus* as a model	DBT	**PI: Dr. Subhendu Kumar Otta** **Co-PIs:** Dr. A. Panigrahi, Dr. P. Ezhil Praveena
5	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.K.P. Jithendran, Dr.S.K. Otta, Dr. Sanjoy Das, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. Satheesha Avunje, Dr. M. Makesh, Dr. M. Muralidhar, Dr.R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumara Raja, Dr. B. Sivamani, Dr. T. Ravisankar, Shri J. Ashok Kumar

6	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** **Dr. (Smt.) M. Poornima** **Co-PIs:** Dr. P.K. Patil, Dr.K.P. Jithendran Dr. Sujeet Kumar
	c. Biocontrol of vibrios in shrimp hatcheries using bacteriophages		**PI: Dr.S.V. Alavandi** **Co-PIs:** Dr. Satheesha Avunje, Smt. 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, Shri. Sathish Kumar, Dr. Vidya Rajendran
7	National Initiatives on Climate Resilient Agriculture-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. N .Lalitha, Shri J. Ashok Kumar, Dr. K. Vinay Kumar, Shri P. Kumararaja, Ms. C. Suvana Sukumaran, Dr.A.Nagavel
8	Environmental Impact Assessment (EIA) of mangrove crab (*Scylla serrata*) farming in the coastal villages of Sindhudurg District, Maharashtra and carrying capacity assessment of creeks for crab farming	UNDP Mangrove Cell, Maharashtra	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. C.P. Balasubramanian, Dr. M. Jayanthi, Dr. P. Kumararaja, Dr. A. Nagavel
9	Identification of etiology of Monodon Slow Growth Syndrome (MSGS) of black tiger shrimp in India and development of rapid diagnostic tools	DBT	**PI**: **Dr. M. Poornima** **Co-PIs:** Dr.S.V.Alavandi, Dr. P. Mahalakshmi
10	Defense genes of tiger shrimp (*Penaeus monodon*) with respect to bacteria (*Vibrio harveyi*) and white spot virus (WSSV) infection	NFBSFARA - ICAR	**PI: Dr. Subhendu Kumar Otta** **Co-PIs:** Dr. K.P. Jithendran, Dr. T. Bhuvaneswari

Nutrition, Genetics & Biotechnology Division

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
1	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.S. Shekhar, Dr. Sherly Tomy, Dr.K. Vinaya Kumar, Dr. B. Sivamani, Shri J. Ashok Kumar, Dr. (Smt.) Krishna Sukumaran, Ms. Babita Mandal, Smt. Vidya Rajendran, Shri Dani Thomas, Dr N.S. Sudheer, Ms. K.C. Neethu, Dr. C.P. Balasubramanian, Dr. S.N. Sethi, Smt. M.U. Rekha, Ms Misha Soman,
2	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, Shri K.P. Sandeep
	Externally Funded Projects		
3	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, Dr. (Smt.) P. Nila Rekha
4	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:** Dr. K. Ambasankar, Dr. K.P. Kumaraguru Vasagam, Mr. K.P. Sandeep, Mr. Aritra Bera
5	Outreach activity on fish genetic stocks (Lead Centre: NBFGR, Lucknow)	ICAR	**PI:** Dr. G. Gopikrishna **Co-PIs:** Dr. M.S. Shekhar, Dr. C.P. Balasubramanian, Dr.K.Vinaya Kumar, Dr.B. Sivamani, Ms. Misha Soman, Shri Dani Thomas
6	Assessment of productivity and variation in nutritional characteristics of bio-floc – a sustainable feed for farmed aquatic animals	DST	**PI: Dr. K.P. Kumaraguru Vasagam** **Co-PIs:** Dr. K. Ambasankar, Dr. J. Syama Dayal
7	Whole genome sequencing of Indian white shrimp *Penaeus indicus*	ICAR	**PI: Dr. M.S.Shekhar** **Co-PIs:** Dr. G. Gopikrishna, Dr. K. Vinaya Kumar, Shri J. Ashok Kumar, Dr. C. P. Balasubramanian, Dr. S.K. Otta, Dr. Santhosh J. Eapen (ICAR-IISR)
8	Poverty alleviation through prevention and future control of the two major socio-economically important diseases in Asian Aquaculture	DBT	**PI: Dr. M.S.Shekhar** **Co-PIs:** Dr. G. Gopikrishna, Dr. K. Vinaya Kumar, Shri T. Sathish Kumar

9	Molecular mechanisms of gonad inhibiting hormone action on the control of egg maturation in the penaeid shrimp	DBT	**PI: Dr. Sherly Tomy** **Co-PIs:** Dr. S.K. Otta, Dr.C.P. Balasubramanian Dr. T. Subramoniam

Social Sciences Division

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
1	Research and development interventions for sustainable brackishwater aquaculture	ICAR-CIBA	**PI**: **Dr.V.S.Chandrasekaran** **Co-PIs:** Dr.T.Ravisankar, Dr.B.Shanthi, Dr.D.Deboral Vimala, Dr.M.Kumaran, Dr. P.Mahalakshmi, Shri J. Ashok Kumar
	Externally Funded Projects		
2	Network Project on Agricultural Bioinformatics and Computational Biology	ICAR	**PI: Shri J. Ashok Kumar** **Co-PIs:** Dr. S.V. Alavandi, Dr. K. Vinaya Kumar, Dr. B. Sivamani, Dr. Satheesha Avunje, Dr. Monendra Grover (ICAR-IASRI)
3	Mapping the techno-economic and socio-personal patterns of traditional and scientific brackishwater aquaculture systems for enhancing their viability and sustainability	ICAR	**PI: Dr. M. Kumaran** **Co PI:** Dr.D. D.Vimala, Dr.T.K.Ghoshal, Dr.P.Kumararaja, Dr.R.Anandaraja, Dr Shyne Anand, Shri. K.P.Sandeep, Shri Aritra Bera

Kakdwip Research Centre

Sl. No.	Project Title	Funding	Project Team
	Institute Funded Projects		
	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
	Externally Funded Projects		
	Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)	NFBSFARA - ICAR	**PI:** Dr. Debasis De **Co-PI:** Dr. Prem Kumar

Other Projects

Sl. No.	Project Title	Funding	Project Team
	Externally Funded Projects		
1	Agri-Business Incubation centre (ABI) at CIBA, Chennai	NAIF - ICAR	**PI: Dr. T. Ravisankar** **Co-PI** : Dr.P.K.Patil
2	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

Research Highlights

Brackishwater production system research

Harvest of Indian White Shrimp at farmer's pond at West Bengal

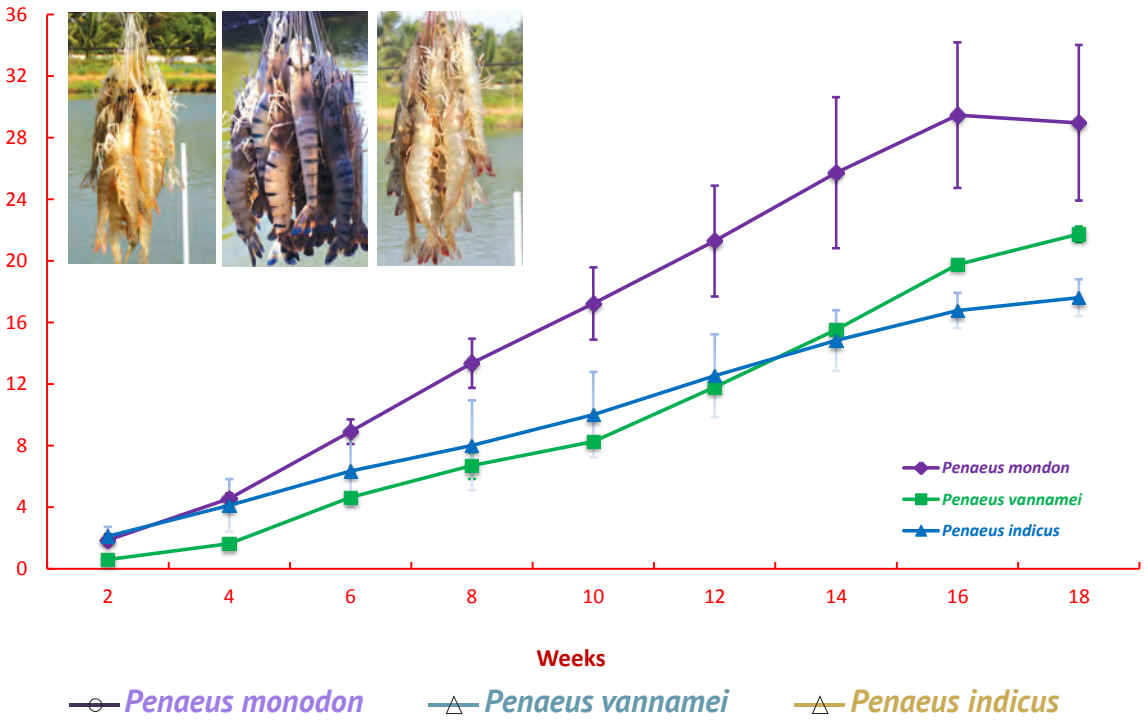
BRACKISHWATER PRODUCTION SYSTEM RESEARCH

Indian white shrimp - *Penaeus indicus*

Indian white shrimp, *Penaeus indicus,* is a high-valued commercial species in Indian waters. It has been widely fished throughout the Indo-Pacific, and aquaculture potential of this species has been well recognized as early as 1970s. In India, hatchery technology and initial trials on the domestication was carried out before 1980s. However, when shrimp farming became popularised in 1990s, the priority has been shifted to giant tiger shrimp, *P. monodon*, possibly due to the preference of South east Asian model of shrimp farming development. Subsequently this species has also been shifted by non –native *P. vannamei*. Development of native species for aquaculture offers several advantages such as protection of biodiversity, quarantine and biosecurity issues. Owing to the relative ease of captive reproduction of *P.indicus*, this species has been identified as a species of choice for the domestication and genetic improvement. Therefore, the Institute has taken up a research program to evaluate the production performance of this species at the hatchery as well as in the grow-out production system

Production characteristics of tiger shrimp, *P. monodon*, Pacific white shrimp, *P. vannamei* and Indian white shrimp, *P. indicus*

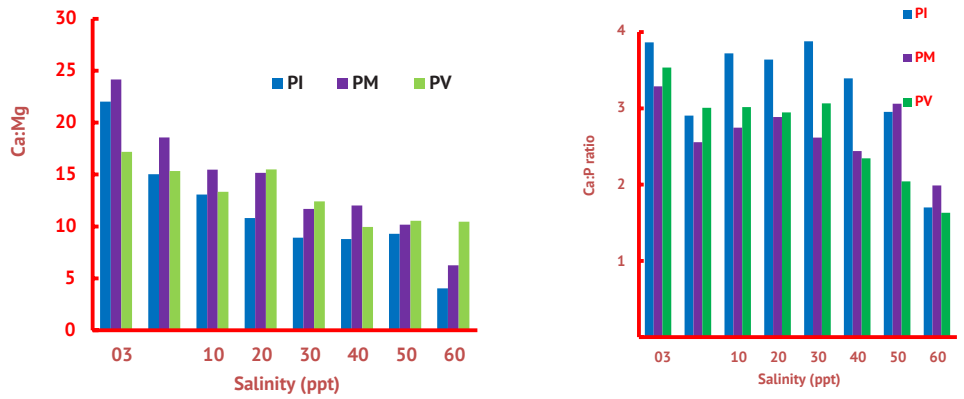
In order to compare the production characteristics of these three species, *P. monodon*, pacific white shrimp, *P. vannamei* and Indian white shrimp, *P. indicus* a 120-day experimental trial was carried out at KRC field station. Animals were stocked at a density 20 individuals per m^2, and fed with formulated feed (*P. monodon*: 40-38% crude protein; *P. vannamei* and *P. indicus*: 35 to 32% crude protein).
P. monodon attained 28.97 ± 5.05 g at the end of 120 days while *P. vannamei* and *P. indicus* attained 21.74 ± 0.50 g and 17.60 ± 1.20 g, respectively. Condition factor and exponent of length-weight relationship analysis indicated good condition in all ponds with an isometric growth curve for *P. monodon* and *P. vannamei* and a positive allometric growth of *P. indicus*. Survival rate (%) of shrimps varied significantly, and *P. vannamei* attained highest survival rate (96.6%) followed by *P. indicus* (68.5%) and *P. monodon* (63.4%). The productivity was highest in *P. vannamei* (5.2 t/ha) followed by *P. monodon* (4.4 t/ha) and *P. indicus* (2.9 t/ha). Economic analysis indicated significantly higher benefit cost ratio in *P. monodon* (1.93:1) compared to *P. vannamei* (1.40: 1) and *P. indicus* (1.30: 1) owing to the high ABW and market price for *P. monodon*.



Growth performance of three penaeid candidate species to evaluate the feasibility of culture potential of *Penaeus indicus*. The growth of *P. indicus* is similar to the growth of *P. vannamei* until 14th week

Salinity stress on survival, growth and mineral profiles in three penaeid shrimp species

The salinity of source and pond waters fluctuates considerably due to climate change events like heavy rains or floods and drought. In India, *P. vannamei* is being cultured in very low salinities (~0-2 ppt) in Godavari and Krishna districts of Andhra Pradesh and Thanjavur district of Tamil Nadu, and very high salinities (50-60 ppt) in Tamil Nadu and Gujarat, with varied production. The effect of water salinity (0, 3, 10, 20, 30, 40, 50 and 60 ppt) was evaluated on the survival, growth, and mineral compositions of three shrimp species in a 45 d indoor trial in 3-6 g size group shrimps. Complete mortality was observed in 0 ppt water for *P. monodon* and *P. indicus* by 15 days whereas, 12% of *P. vannamei* survived at the end of the experiment. Significantly higher growth of *P. monodon* and *P. vannamei* was observed at 10 - 30 ppt salinities whereas the growth of *P. indicus* was good at 20-40 salinity. Calcium level in whole shrimp was around 3% in shrimp grown at salinity ranging from 3 to 40 ppt, whereas it significantly ($P<0.05$) increased in shrimp grown in 0 ppt water and decreased in shrimp grown at 50 and 60 ppt reared shrimp. Sodium level was unaltered except those grown at 60 ppt salinity. Ca:P and Ca:Mg ratios were higher in shrimp reared in 0 ppt and lower in high salinity, 60 ppt. Based on the results, *P. vannamei* can tolerate even fresh water to a certain extent due to better Ca:Mg ratios compared to the other two species. Similarly better performance of *P. indicus* even at 50 ppt salinity might be due to the homeostasis of minerals as reflected by Ca:P and Ca: Mg ratios.



Effect of salinity on Calcium-Magnesium and Calcium-Phosphorus ratio

Farming demonstration of Indian *Penaeus indicus*

Pilot scale farming demonstrations were conducted at six different coastal states of India to evaluate the production performance of Indian white shrimp *Penaeus indicus* in different agro-climatic zones**.** The production performance of *P. indicus* in terms of growth, productivity and disease occurrences were carried out in these trials. In all the demonstration trials post larvae produced by WSSV free broodstocks were used. Farmers and stake-holders meets were conducted at each demonstration site to popularize the farming of *P. indicus* as an alternate indigenous species for diversification of shrimp aquaculture. In Odisha, *P. indicus* was farmed in earthen ponds of 2600 to 4000 m^2 at Dandapat Aquatics, Sahada, Balasore. An average production of 4.418 mt/ha at a stocking density (SD) of 35 PL/m^2 and 1.142 tons/ha at SD of 10 PL/m^2 were obtained in this trial at a salinity that varied from 2 to 12 ppt. The shrimps were fed with CIBA formulated feed 'Indicus *plus*' containing 35% crude protein. At the end of 135 days grow out, a final body weight of 28-30 g and 17 -20 g was obtained at lower and higher stocking densities respectively. The shrimps were sold at a rate of Rs.330 to Rs.410/ kg against a production cost of Rs.230/Kg.

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

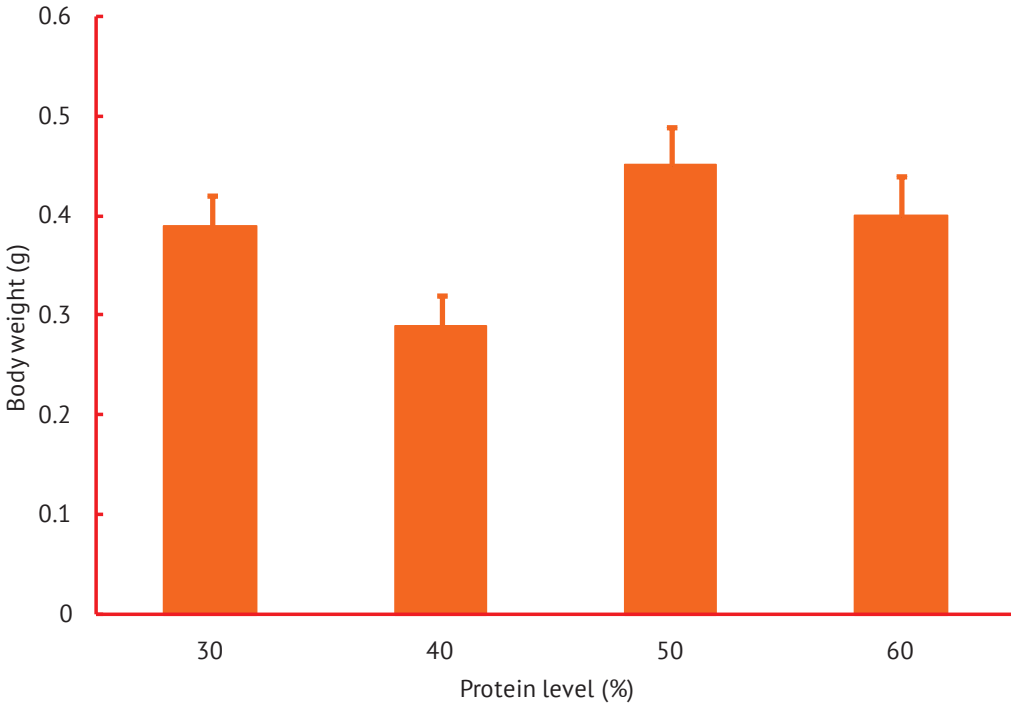
Demonstration trials of *Penaeus indicus* were carried out in five locations. In a farming trial in Odisha, average prduction of 4.2 mt per ha was obtained within 135 days

The farming demonstration in West Bengal was carried out under low saline conditions in Kakdwip wherein shrimps were stocked in earthen ponds at 25 PL/m2 and grown for 120 days. An average production of 3.08 tonnes/ha was obtained in this trial with a final ABW of 19 g which realized a price of Rs.330 /kg. The culture demonstration in Andhra Pradesh was undertaken at Gudur wherein after a grow out period of 72 -78 days, an ABW of 11 g was obtained. Maximum production of 3.35 tonnes/ha with a mean yield of 2.41 tonne/ha and survival of 89.99% was obtained within a short grow out period of 78 days. Interestingly, in this trial a low FCR of 1.13 was observed resulting in a low production cost of Rs 130-140/kg and a sale price of Rs.210-220/ kg resulting in a profit of about Rs.2.2 lakhs/ha/crop.

In Kerala (Narayanamangalam near Kodungallur, Thrissur district) a production of 1.8 tonne/ha was obtained post grow out of 108 days with an average body weight of 18 g which realized a price of Rs.340/ kg. At Navsari in Gujarat, the Indian white shrimp farming demonstration during the rabi season yielded a production of up to 1.53 tonnes/ha within a culture period of 89 days. A final ABW of 12.7 g under a stocking density of 25 PL/m2 was obtained. These demonstration trials resulted considerable interest among shrimp farmers and stakeholders. At most of the demonstration sites the Indian white shrimp performed at par with Pacific white shrimp, *Penaeus vannamei* in the same and adjacent farms with respect to ABW, production and profitability.

High density clear water nursery rearing for *Penaeus indicus* under high feeding frequency regime

Nursery rearing of shrimp PL improves growth, reduces FCR and shortens DOC. Further, the compensatory growth and large PL size provide greater tolerance to natural stressors in grow out ponds. Additionally, nursery phase is being viewed as a preventive step against WSSV and EMS. In this backdrop, a 45 days high density (1000 nos./ m^3) nursery rearing of post larvae of *Penaeus indicus* (PL 12) was carried with using feeds formulated to contain varying levels of protein (30, 40, 50 and 60%) in 500L FRP tanks in triplicate to optimize the protein requirement with increased feeding frequency (8 times) in nursery rearing system. At the end of the trial it was observed that low protein (30%) fed group showcased growth (0.39 g) and survival (89%) on par with the highest protein (60%) fed group (ABW 0.4 g; Survival 93%). Highest growth and survival (0.45 g with 92%) was recorded in the group fed with 50 % protein feed. Superior water quality and low level of TAN (1.57 ppm) was observed in the treatment with 30% feed compared to higher protein fed groups (2-3 ppm). The study demonstrates that increased feeding frequency (up to 8 times) can result in on par survival and growth of post larvae even with low protein diets (30% protein) for Indian white shrimp with the added advantage of better water quality and feed economics.



Final body weight of Indian white shrimp post larvae fed different dietary protein level

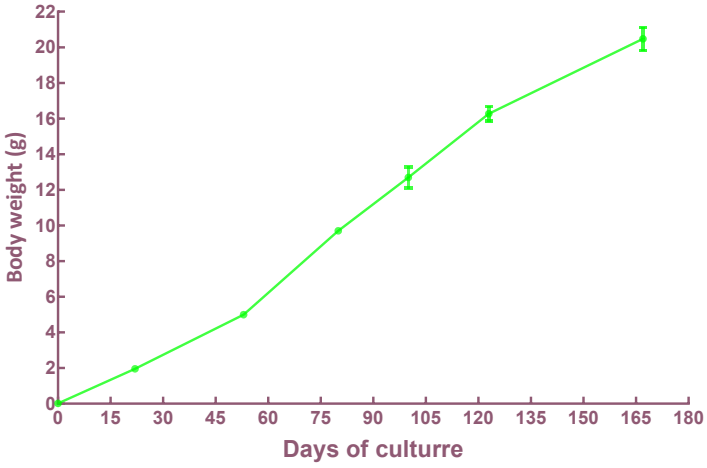
Penaeus japonicus

Kuruma shrimp, *P. japonicus*, is the highest priced farmed shrimp, and is known as king of seafood in Japan. As the shrimp tolerate long distance transportation, this species can be marketed in the living condition, and fetches a premium price. Thus, farming of this species for live export to Japan in recent years has become a successful industry in many countries. As a part of the diversification of brackishwater aquaculture in India, several research programmes have been initiated to evaluate the aquaculture potential and resolve the constraints in developing farming of this species.

Farming demonstration for Kuruma shrimp, *Penaeus japonicus* at Chirala, Andhra Pradesh, India

The production characteristics of this species were studied at a commercial shrimp farm (m/s Vasanthi Aqua Farm/Sai Aqua Tech) near Chirala in Prakasam Dist., of A.P. The grow out trial for Kuruma shrimp was carried out in a 600 m^2 lined pond provided with river sand as the bottom substrate. A total of 30,000 PL (PL 35, ~ 0.025 g**)** were stocked, and fed with specially formulated feed manufactured at the CIBA feed mill containing a crude protein level exceeding 40 %. The ABW of the animals attained the 18 g mark (legal size for export to Japan) by 150 DOC. The growth data indicated that the average weekly growth rate (AWR) and the average daily growth rate (ADR) of the species during the trial were 0.12 g/day and 0.86 g/week respectively. The ADR and AWR of the species clocked nearly 0.15 to 0.17 g/day and 1.0 to 1.2 g/week respectively between the body weight of 5 g to 16 g wherein the growth was fastest. It was observed that growth generally declines post the 18 g mark. The farming demonstration resulted in a production of 300 kg Kuruma shrimp with a mean survival rate of ~ 50 %. This study demonstrates that Kuruma shrimp could be a candidate species for brackishwater aquaculture in India

In the demonstration trial at the farmer's pond, *P. japonicus* grew up to an average of 18 g, the legal export size, within 150 days of culture

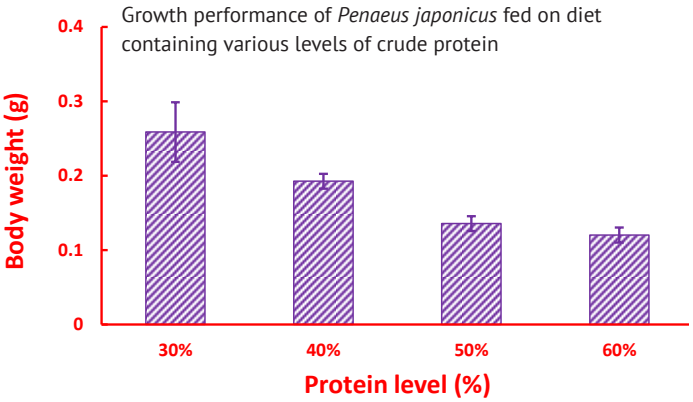


Production performance of *Penaeus japonicus*

Production performance of *Penaeus japonicus*

Optimising dietary crude protein levels for indigenous shrimp *Penaeus japonicus*

Penaeus japonicus, in general, is fed on a high protein diet with crude protein (CP) levels exceeding 45 %. As feed cost is a significant factor determining the profitability of a farming enterprise high CP would definitely transform in to higher production cost and reduce the rate of returns. An indoor trial was carried out to evaluate the protein requirements of the indigenous *P. japonicus* available along the coast of Tamil Nadu. Post larvae of *P. japonicus* were fed with diets containing various levels of crude protein (40, 50, 60 and 30 %) in triplicate for 60 days. At the end of the trial significantly higher growth (0.25 g) was observed in the groups fed with 30% CP and 40% CP levels (0.19 g). There was no significant difference in the survival rates observed among the treatments. The present study indicates that the indigenous Kuruma shrimp can be reared using feed with crude protein levels of 30 to 40 %.

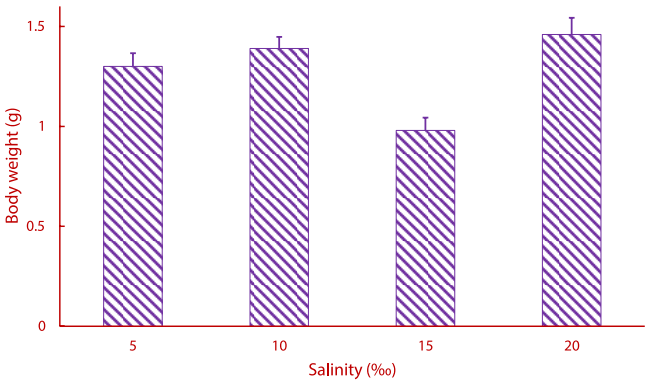


Growth performance of *Penaeus japonicus* fed on diet containing various levels of crude protein

Low saline performance of Kuruma shrimp, *Penaeus japonicus*

The farming of *P. japonicus* is well documented in full strength seawater and near seawater salinity ranges. There is little knowledge on the production characteristics of the species at low salinities. A 60 d indoor trial was carried out to study the effects of salinity on the growth performance of *P. japonicus* at different salinities: 5, 10, 15 and 25 ppt. A total of 30 salinity acclimatized PL (PL35~0.026 g) were stocked in to 100 l FRP tanks containing media of different salinities in triplicate. Survival at all salinities except 15 ppt was similar (P>0.01), however significantly lower survival was found at 15 ppt (51.11) than 25 ppt (79.99). The ABW of the animals at 15 ppt (0.98 g) was observed to be significantly lower than the other treatment groups. The ABW of the animals at 5 ppt (1.30 g), 10 ppt (1.39 g) and the seawater (1.46 g) did not show any significant difference. Overall the present study indicates that Kuruma shrimp PL can be acclimatized to low salinities and performs well in low salinities..

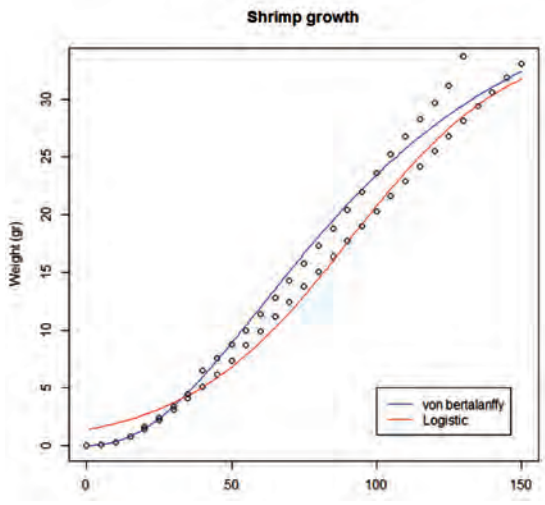
***Penaeus japonicus* is reported to be less tolerant to lower salinity. On the contrary the present study demonstrate that survival rate is similar in low saline (5 g/L) and higer saline conditions**



Growth of *Penaeus japonicus* PL at different salinities

Shrimp growth modelling

Developing simulation models for *P. vannamei* shrimp aquaculture has been initiated to understand the effect of different processes such as feeding, soil and water quality parameters, nitrogen dynamics in the pond, weather parameters etc. affecting shrimp growth. A relational diagram of different processes that affect shrimp growth has been prepared. Shrimp growth under two different densities was simulated for 150 days of culture using Von Bertalanffy, logistic, and gompertz models. Out of fitted models Von Bertalanffy model was found to be in good agreement with shrimp growth.



Von Bertalanffy shrimp growth model

Mud Crab: *Scylla serrata*

Periodic size grading in mud crab nursery for improved survival and size homogeneity of the juveniles

Social hierarchy and aggression of mud crab instar during nursery rearing is a function of the size of the animal which causes cannibalism, territorial behaviour and restricted feeding resulting in size heterogeneity and poor survival at harvest. A nursery rearing experiment was carried out to study the effect of size grading of mud crab instar on the growth and survival of juveniles. The experiment was carried out in 6 hapas (1x1x1 m) for 50 days to compare the growth and survival of juveniles obtained post rearing of a heterogenous size group of crab instars (T1) and a homogenous size group (T2) at 30 no/m^2. In both the treatments the crab instars were fed ad libitum thrice daily and size grading was performed once in a fortnight in treatment (T2). At the end of the experiment, it was noted that crab instar reared under periodic size grading resulted in a significantly higher survival of 59.55 % compared to instars reared without size grading (T1 - 45.55). Additionally, no significant differences in average body weight was noticed among T1 (15.08 g) and T2 (13.21 g) even in the presence of adlibitum feeding regime. Coefficient of variation for harvest weight revealed comparatively lower, CV (0.29) for the heterogenous size groups (T2) compared to heterogeneous size(T1) groups (0.73) indicating size homogeneity of the juveniles at harvest as a result of periodic grading. The study reveals that periodic size grading to maintain size homogeneity improves the survival of mud crabs during nursery phase.

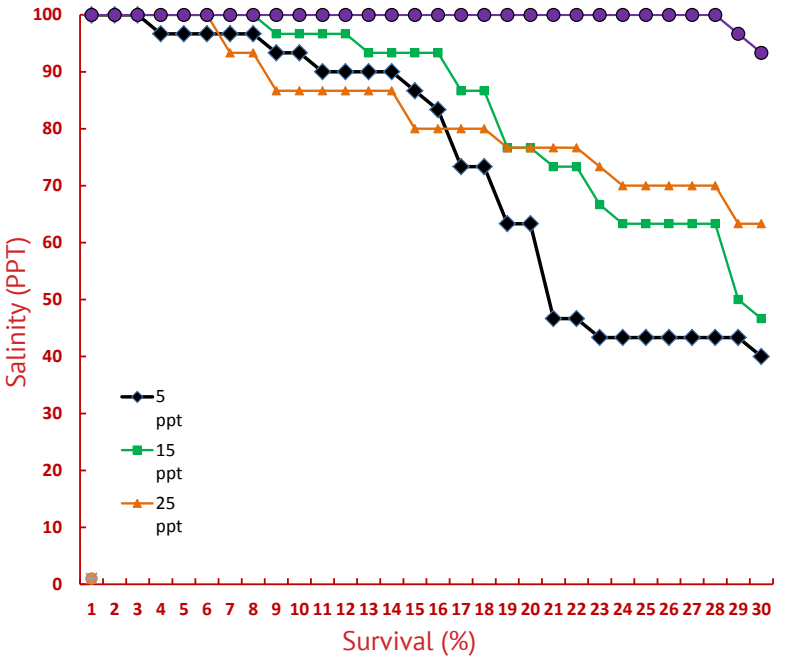
Periodic size grading during mud crab nursery rearing is found to be helpful to maintain the homogeneity of size. Further it improves survival of crabs in the rearing systems

Growth performance of *Scylla serrata* when the population is graded based on size

Parameters	Heterogenous size gp	Homogenous size group	Graded population separated
Initial mean wt (g)	0.09	0.1	0.54
Final mean wt (g)	15.08±1.35	13.21±0.62	6.32
Final carapace length (mm)	43.7±1.5	43.48±0.87	34.3
Daily wt gain (g)	0.29±0.03	0.26±0.01	0.17
Specific growth rate (g/day)	5.39±0.19	5.14±0.09	5.01
Coefficient of variation for harvest weight	0.73	0.29	0.24
Survival of harvested crabs (%)	45.55±6.76	59.55±4.79	65

Effect of salinity on survival, growth and hemolymph osmolality of *Scylla serrata*

Mud crabs, *Scylla serrata*, has been one of the most traded seafoods and it has been the focus of species diversification in aquaculture in India. A 30 day experiment was carried out to evaluate the effect of salinity on survival, growth and hemolymph osmolality of one-month nursery reared juveniles of mud crab, *Scylla serrata*. Four salinities, 5, 15, 25 and 35‰, were evaluated, and each treatment was replicated thrice with each replicate consisting of ten juveniles. Each animal was stocked in separate PVC containers. Mortality was recorded daily; carapace width and weight were recorded



Survival of early juvenile Scylla serrata under various salinity conditions

Although survival of juvenile mud crabs were higher at 35 ppt salinity, the growth was not higher at this salinity. Lower specific growth rate at 35 ppt indicates that weight gain does not occurre along with molting.

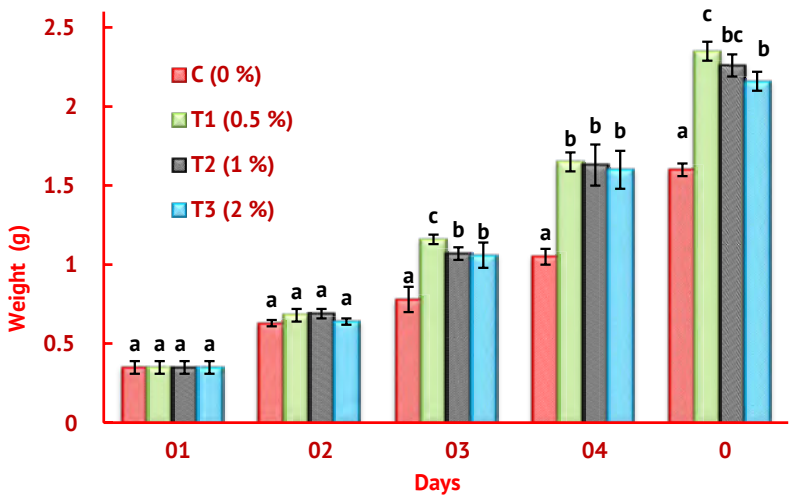
at each molt. Osmolality was measured at the end of the experiment. Among the four salinities tested, the highest survival was found at 35‰ (93.3%) followed by 25‰ (63%), 15‰ (46.7%) and 5‰ (40%). Final body weight and carapace width were also significantly higher in the 35‰ (1.61 g; 21.56 mm) followed by 5‰ (0.77) 15‰ (0.39) and 25‰ (0.31). Although slightly higher molt frequency was observed in 35‰, no significant difference in the molt frequency was noticed among the treatments. However, molt related death (molt death syndrome) was significantly higher at lower salinities particularly at 5‰. Apart from this, SGR was significantly lower at 35‰, although survival was higher at this salinity. It is generally accepted that survival and growth is inversely proportional as lower density provides more space and feed. However, in the present case, survival is not compromised by cannibalism, as animals are reared in separate containers. Therefore, it could be concluded that at 35‰, weight gain did not happen along with molting. Hemolymh osmolality of crabs reared under various salinity shows that there is a leaner significant relationship (r2 =0.6942) between hemolymph and medium osmolality. Iso osmatic point was found to be 1127 mOsm/kg. The present study shows that there is a significant effect of salinity on survival and growth, and although survival was higher at 35‰, growth was not high at this salinity, therefore, for better growth and survival, salinity in the range of 15 to 25 could be recommended.

Seabass - *Lates calcarifer*

Seabass has been an emerging species for brackishwater aquaculture in India. Owing to its relatively high market price, it has become an attractive commodity of both large scale and small scale aquaculture. The institute has been engaged in research and played a proactive role in development of the species since its inception.

Dietary probiotics as growth enhancers for Asian seabass

Probiotics have been used in aquaculture under diverse roles including the nutrition of host species through production of supplemental digestive enzymes. A 40 day experiment was conducted to investigate the effects



Nursery production performance of seabass fry administered with probiotics

of dietary probiotics on the growth and survival of Asian seabass. Lyophilized bacterial cells and yeast (*Bacillus subtilis, B. amyloliquefaciens, B. pumilus, Sacchromyces cerevisiae, S. boulardii*) were coated in seabass nursery feed at different concentrations of 0, 0.5, 1 and 2%. Thirty numbers of seabass fry (20.6 mm body length, and body weight 0.35 g) were stocked in 12 FRP tanks. Results indicated that the fry fed with a diet containing 0.5 and 1 % probiotics showed significantly higher growth compared to other treatments. The results indicate probiotic inclusion of 0.5 to 1% in nursery feeds has the potential for enhancing the growth of seabass fry.

Nursery, pre-grow out and grow-out culture of Asian seabass (*Lates calcarifer*) in open brackishwater

As a part of part of the Prime Minister's lab to land program, Mera Gaon Mera Gaurav (MGMG), hapa based nursery rearing and cage culture of seabass were initiated under at Vennangupattu Village, Marakanam. Self- help group members were trained on hapa fixing, seed stocking, feeding and grading. A total of 7500 seabass fry (1.0 cm size) were stocked in 3 phases and were cultured for 45 days. Fingerlings of 6.3 to 7.6 cm were produced for stocking in pre grow-out cages.

Pre-grow out and grow-out culture of Asian seabass in cages in open brackishwaters was taken up in partnership with the National Institute of Ocean Technology (NIOT), Chennai as an alternative livelihood option for the inland fisher youths**.** The fisher youths were given training on nursery rearing and grow out farming in cages. Location specific shallow pre-grow out cages of width 1.5 meters and 3 meter depth were designed and deployed for the cage farming of Asian Seabass. Fingerlings of 5-6 g size were stocked in the cages and fed with trash fish and CIBA feed. The fingerlings reached a size of 150 g juveniles in 105 days and the juveniles were in turn stocked in a grow out cage of size 5x4x3m. The juveniles reached an average size of 450 g in 120 days and the culture is in progress.

Open water cages of different volumes used rearing seabass in the three tier model at Vennangupattu Village, Marakanam

ICAR-CIBA makes new inroads in supporting livelihoods of tribal communities in Kutch region, Gujarat through Asian seabass nursery rearing

The arid regions of Kutch have limited scope for agriculture development. The tribal populations of Kutch are dependent on capture based fisheries for their livelihood and sustenance. The dwindling output from capture fisheries has affected these tribal populations to a great extent that the GOI has floated all options to uplift and sustain livelihood in these tribal settlements. ICAR-CIBA has made its mark in Gujarat by popularizing brackishwater aquaculture as an alternate livelihood option. CIBA has identified the potential brackishwater areas for finfish farming to support the livelihood of tribal communities of Kutch region. The work was done in collaboration with Gujarat Institute of Desert Ecology (GUIDE), Bhuj, Gujarat and Adani group. A novel floating model using bamboo rafts attached to barrels for floatation were used to fix hapas (2×1×1 m). Net cages (hapas) were installed in the creek and moored using anchors. One thousand acclimatized seabass seeds were released in to each of the six floating hapas at a stocking density of 1000 nos/ hapa. Freshly prepared minced dough of trash fish along with formulated feeds were fed to the fishes. Technical hands-on training was provided to the tribal personnel on seabass nursery rearing; size grading, feeding techniques, periodic hapa cleaning etc. The initial demonstration of seabass nursery rearing to tribal communities of Kutch region resulted in awareness and interest among the people for taking up seabass nursery and grows out farming as alternative livelihood option.

Installation of floating hapas

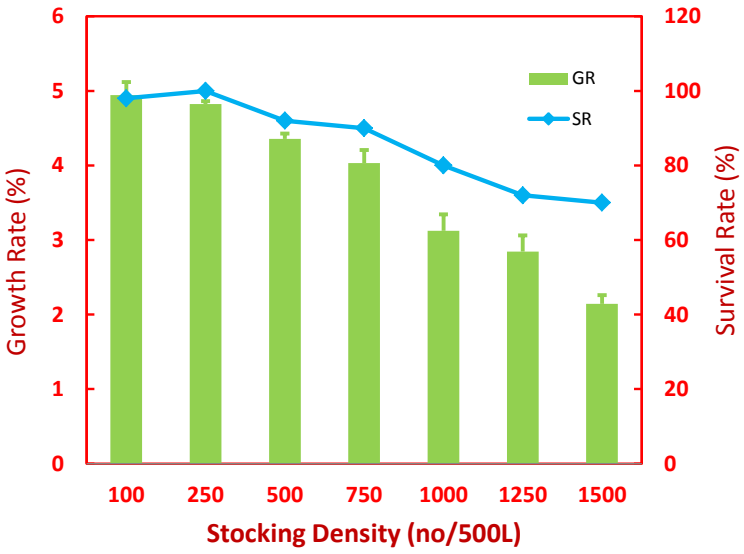
Collection of fry from hapas for grading

Pearlspot - *Etroplus suratensis*

Etroplus suratensis, is a high valued species in some regions of India, and the importance of this species as an ornamental fish has also been well acknowledged.

Growth enhancement in pearlspot, *Etroplus suratensis* by manipulating salinity and stocking density

One of the major challenges in farming of pearlspot is its slow growth rate in the nursery phase resulting in longer rearing duration. Experiments were conducted to optimize growth of pearlspot during the nursery rearing phase by manipulating the salinity and stocking density. A 30 day experiment was conducted to understand the effect of three different salinities; 0, 15 and 30 ppt on growth and survival of pearlspot fry. One hundred pearlspot fry were stocked in to 200 l FRP tanks.



Effect of salinity and stocking density on growth and survival of peal spot

Highest growth and survival of the fry was observed in 15 ppt. Another experiment was conducted to evaluate the effect of different stocking densities in pearlspot nursery rearing at 15 ppt using a re-circulatory system. The fry were stocked at varying SD of 100, 250, 500, 750, 1000, 1250 and 1500 nos in 500 l FRP tanks. The fishes stocked at a relatively high stocking density of 750 nos/tank attained a marketable size in 22 days with a marked reduction in the nursery rearing phase. The survival in tanks stocked with 750 nos of fry was also comparable to that in tanks with low stocking densities. Though the growth was higher at lower stocking densities, the performance of the fry at high density i.e. 750 nos/tank was comparable with a better economic feasibility in re-circulatory systems. The results indicate that a stocking density of 750 nos/500 l tank and salinity of 15 ppt is optimal for nursery rearing of pearlspot.

Modular pearlspot nursery rearing systems for women SHGs

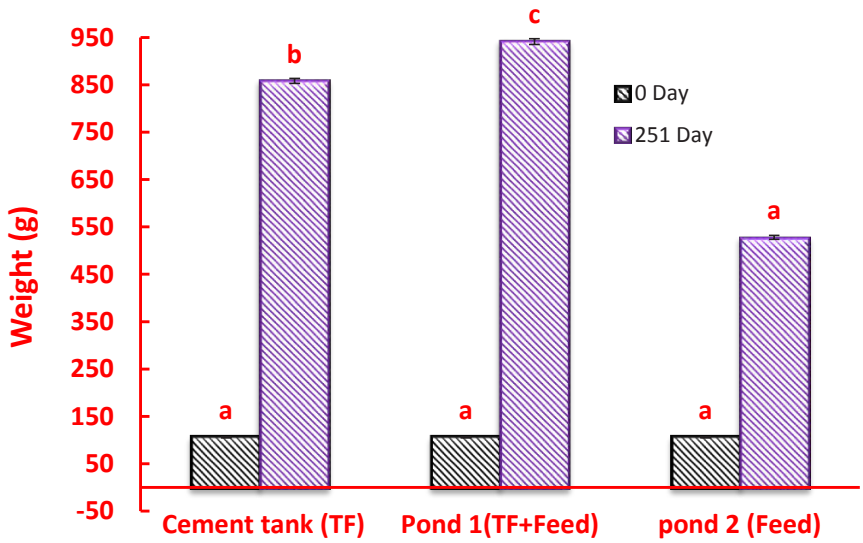
A re-circulatory nursery rearing system for pearlspot consisting of four 500 l tanks connected to a pressure sand filter was established at Thiruvidanthai village, Kanchipuram District, Tamil Nadu for operation by women SHGs in the village. Three successful nursery rearing trials were completed using the facility wherein a total of 4200 numbers of pearlspot fry were reared to marketable size.

Simple recirculating rearing system for pearlspot nursery rearing

Mangrove red snapper, *Lutjanus argentimaculatus* a new candidate species

As a step towards diversification of species in brackishwater aquaculture systems, ICAR-CIBA has initiated research programs for captive seed production of mangrove red snapper, *Lutjanus argentimaculatus*. The species is of high economic value and has high export potential. The fast growth of the species along with adaptability to wide salinity and temperature regimes make the species a novel yet highly suitable candidate for aquaculture. Wild caught juveniles of mean length 1653 mm and weight 105.9 g were stocked in cement tanks and earthen ponds in MES.

Three modes of farming were studied; cement tank based system with trash fish feeding; earthen pond fed with formulated feeds and earthen pond fed with a combination of formulated and trash fish. Feeding was done twice a day until satiation @ 10 % of body weight. After 250 DOC, red snappers fed with a combination of trash fish and pellet feed showed significantly higher growth i.e. 372.9 mm TL and 930.41 g ABW as compared to fishes fed exclusively with trash fish or pellet feed. The results indicate that pond based system with a feeding strategy using a combination of trash fish and pellet feeds yielded better growth performance. The results also indicate a potential average body weight gain of 865 g in 10 months rearing.



Growth performance of mangrove snapper reared under different management tactics

Milkfish, *Chanos chanos*

Milkfish, *Chanos chanos*, has been well acknowledged as a species of choice for diversification of brackishwater aquaculture in India. Recently ICAR CIBA has successfully developed captive breeding and larviculture technology of this species The Institute has been addressing the issues in the grow out production of this species.

Economics of Milkfish farming	
Total Production	404 kg
Sale at wholesale market	Rs. 190/kg
Total fish sale	Rs. 76760/-
Feed used	600 Kg
Cost of feed	Rs. 28/Kg
Total feed cost	Rs. 16800/-
Liming	Rs. 500/-
Feed additives	Rs. 1000/-
Harvesting	Rs. 3000/-
Post-harvest handling and transportation	Rs. 2500/-
Total Profit	Rs. 76700 – Rs. 23800 = Rs. 52900/-

Growout demonstration for hatchery produced milkfish 'Deccan Hilsa' in West Bengal

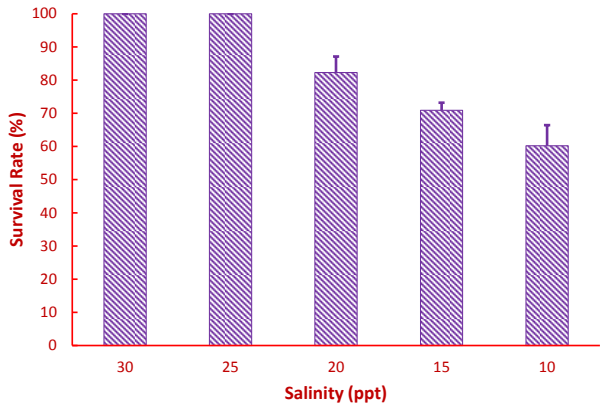
The state of West Bengal is blessed with vast resources of brackishwater suitable for fish and shrimp farming. As an initiative to promote scientific milkfish farming in the state, ICAR-CIBA supplied around 2500 hatchery produced seed to an entrepreneur in West Bengal. The milkfish seed was stocked in a 0.2 ha pond and fed on formulated diet. The fish attained a body weight of 300-350 g in 6 months of rearing. A total fish production of 400 Kg was achieved from the trial pond with an estimated cost of production of Rs. 90-100/kg against a market rate of Rs. 150-170/ kg making the system economically viable. Milkfish has tiny bones that resembles the intra-muscular bones of Hilsa and hence can be marketed as a'*Deccan Hilsa*'.

Pond reared milkfish during samplingmanagement tactics

Salinity tolerance of blue damsel, *Pomacentrus caeruleus*

The blue damsel, *Pomacentrus caeruleus* is a popular ornamental fish among marine aquarium enthusiasts. However, marine aquarium keeping is relatively expensive as compared to fresh and brackishwater aquaria. In order to explore the possibility of using blue damsel as a candidate species for brackishwater aquaria, a preliminary investigation was conducted to understand the salinity tolerance of blue damsel. The survival and general physiology of blue damsel fish, *Pomacentrus caeruleus* was tested at different salinities viz. 30, 25, 20, 15, 10 ppt in trplicate. The survival observed followed an inverse relation with salinity wherein highest and lowest survival values were at 30 and 10 ppt respectively. At 20 ppt, a survival value of more than 80% was observed indicating the suitability of blue damsel for brackishwater aquaria at salinities at or above 20 ppt. The current study emphasizes the suitability of rearing blue damsel in a brackishwater aquaria and also provides the basis for further studies in other marine ornamental fishes as well.

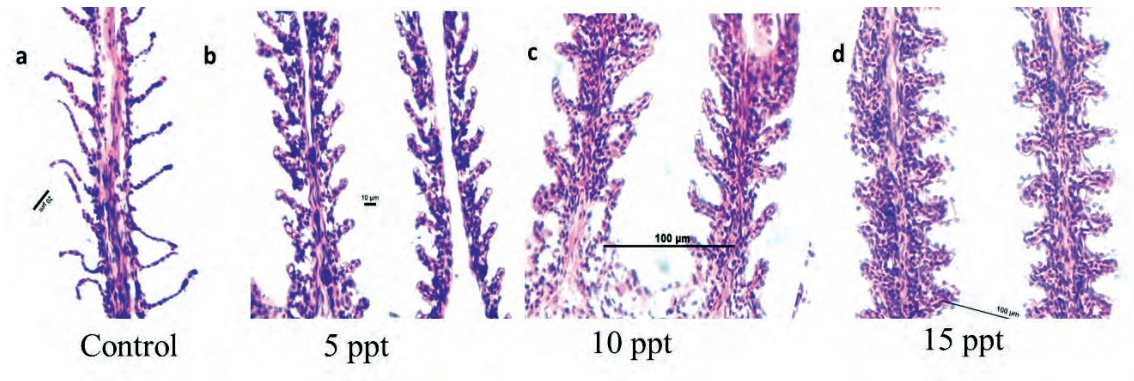
Survival rate of *Pomacentrus caeruleus* at different salinities



Survival of blue damsel in varying salinities

Salinity tolerance of Canara Pearlspot *Etroplus canarensis*

Canara pearlspot is predominantly stenohaline in nature and information on osmoregulation of the species is lacking. Acute and chronic salinity stress experiments were conducted to evaluate the candidature of the species to be listed under brackishwater ornamental fishes. Freshwater acclimated adult *E. canarensis* was directly transferred to low saline water (5, 10, 15 & 20 ppt) and monitored for 96 hours. The results indicated 100 % survival in 5, 10 and 15 ppt and complete mortality in 20 ppt.

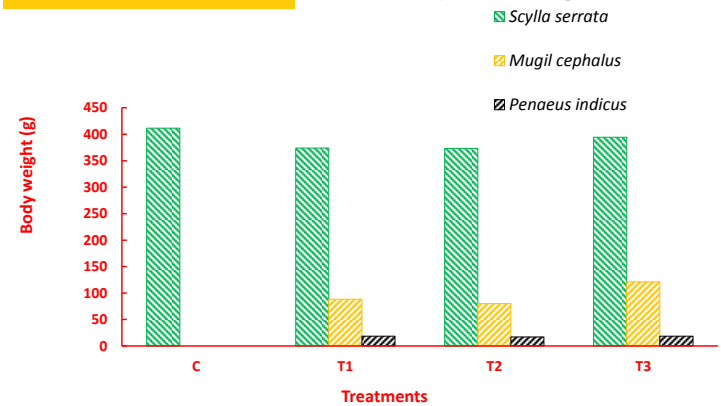


Farming system diversification

Growth performance of mud crab in polyculture and modified IMTA system

Integration of periphyton in the IMTA system improves production performance.

Diversification of production system has been one of the major strategies for the long-term sustainability of brackishwater aquaculture. A 180-day culture experiment was carried out to evaluate the production performance of different culture systems: polyculture, integrated multi-trophic aquaculture (IMTA) and IMTA with periphyton substratum with mud crab (*Scylla serrata*) as a major species. In polyculture treatment (T1), *S. serrata*, *P. indicus* and *Mugil cephalus*, in IMTA treatment (T2) in addition to these species, edible oyster (*Crassostrea cutteckensis*) were included as an extractive crop, and in IMTA system with periphyton substratum (T3), submerged nylon net (60×60 mesh, 0.5 m wide) substrate erected vertically. Monoculture of mud crab, was carried out as control group (C).The experiment was conducted in 100 m^2 ponds in triplicate, stocking density of mud crab was 0.5 individual/m^2 uniformly in all the experimental and control group. *Mugil cephalus* (5.92 ± 1.77 g and *P. indicus* (0.42 ± 0.09 g) were released after 45 days of stocking at a rearing density of 0. 5 and 2 individual/m^2. In IMTA system, edible oyster (225.5 ± 20.58 g) was stocked at a density of 1 individual/m^2 in hanging plastic trays. Animals were fed with low cost fish bycatch at the rate of 5-10% of estimated biomass. Highest production was observed in IMTA system with periphyton (T3). No significant difference was observed in the production of mud crab in any of the treatments. Significantly higher gross production was observed in the IMTA with periphyton experimental group. Similarly, *M. cephalus* attained highest body weight and survival (121.19 ± 2.09 g; 79.6 ± 3.4%) in the IMTA system with periphyton. The economic analysis showed a benefit cost ratio (BCR) of 1.90 in T3 which is highest while it is lowest (1.73) in control. It could therefore be concluded that the integration of oyster and periphyton improved the overall production and economic performance in IMTA.



Growth performance of crab, grey mullet and Indian white shrimp in polyculture and modified IMTA system

Modified IMTA system

Development of integrated Multi-Trophic Aquaculture System in Sindhudurg District, Maharashtra

IMTA is farming of species from different trophic levels. It is a possible option for system diversification and species diversification without compromising economic profitability of aquaculture

Integrated multi-trophic aquaculture farming of aquaculture species from different trophic levels and with complimentary ecosystem function, is regarded as a suitable approach to develop a sustainable aquaculture system. In order to establish an IMTA system, a study was carried out in Sindhudurg district (Maharashtra, India) for tropical brackishwater species. Two land based farming systems (Farm A and Farm B), and one open water system were developed for the study. Two pens of smaller sizes (250 m^2) were constructed for IMTA and control respectively in each land based system, and open water cages were set in estuary. Different combinations of fed species (*Chanos chanos, Etroplus suratensis, Mugil cephalus, Penaeus indicus*) and an extractive crop (*Crassostrea madrasensis*) were stocked in IMTA experimental system, whereas monoculture of *P. indicus* was control. Water quality characteristics were found to be within the admissible limit. Soil organic carbon was found to be lesser in the IMTA system compared to control. Initial weight gain, daily weight gain, final weight and specific growth rate are given in table. Initial weight of shrimp was taken as the weight at day 45, after rearing in hapa. As there is no difference in growth rate and yield between farm A farm B, data are clubbed together for analysis. The growth of shrimp in the IMTA and control pond is similar, and although higher growth was observed in the IMTA pen than control pen, no statistical difference was observed. Among finfishes *Mugil cephalus* showed higher growth followed by *E. suratensis*. Gross production and productivity of IMTA pens are higher than the shrimp monoculture pen. The productivity of IMTA pen was 3250 kg/ha compared to 2000 kg/ha of monoculture shrimp pen. The productivity of IMTA system was higher than control: 3250 kg/h versus 2000 kg/ha. Further, income and benefit-cost ratio was found to be higher in IMTA pens. The present study reveals that IMTA is a possible option for system and species diversification without compromising economic profitability of culture.

Species	Final body weight (g)	Daily weight gain (g)	Specific growth rate (%)	Production (kg/ha)
Penaeus indicus	14.20 ±2.80	0.14	1.77	216
Etroplus suratensis	81.72 ±10.7	0.42	2.44	800
Chanos chanos	211.4 ± 69.41	0.24	2.63	2800
Mugil cephalus	49.96± 6.28	0.47	2.93	200

IMTA at Sindhudurg district of Maharashtra

IMTA pond with [illegible] water


Fish and shrimp harvested from IMTA

Shrimp based IMTA systems were evaluated with four different species combination. Signifcantly higher production was obtained in treatment with tiger shrimp, mullet, oyster and water spinach combination

Pond-based IMTA systems on station trials at KRC

IMTA system involves incorporation of species from different trophic or nutritional levels in to an integrated system that results in higher production through synergistic interactions of co-cultured species with minimum negative environmental impacts. Shrimp based IMTA systems were evaluated in 12 ponds (500 m2 each) with four different species combinations i.e. Tiger shrimp (*Penaeus monodon*) + mullets (*Mugil cephalus* and *Liza tade*)- (C), Tiger shrimp + mullets + water spinach (*Ipomoea aquatica*)- (T1), Tiger shrimp + mullets + oyster (*Crassostrea cuttackensis*)- (T2), Tiger shrimp + mullets + water spinach + oyster- (T3). Stocking density of different species was kept uniform in different treatments i.e. *M. cephalus*- 2,000, *L. tade*- 10,000, *P. monodon*- 30,000, oyster- 2,000 no./ha and water spinach @ 300 kg/ha. The trial continued up to 150 days wherein mullets and tiger shrimp served as the fed species and oysters and water spinach served as the extractive species. A significantly higher production (1510 kg/ ha) with superior water quality was obtained in T3 (Tiger shrimp + mullets + water spinach + oyster) compared to other treatments. Economic analysis revealed a significantly higher return (Rs.2.24 lakh/ha) with BCR (2.14) in T3 followed by T1, T2 and C. The results of this trial clearly indicates that pond based IMTA systems are highly productive and environmentally sustainable.

Mapping of aquaculture resources: site suitability of selected brackishwater lagoons and aquaculture site suitability assessment

The suitability assessment of water bodies from an aquaculture perspective would ensure that the water body selected would support the biological requirement of the species under consideration. During the current year suitability of two lagoons, Muttukkadu and Pulikat, and resource mapping of one district (Ramnathapuram) of Tamil Nadu were evaluated.

Muttukadu Lake

The Muttukadu Lake with an area of 90 acres was assessed for its suitability for different aquaculture operations. Physical (water depth, wave speed); biological (water quality- pH, salinity, dissolved oxygen, ammonia, chlorophyll, temperature, nitrite, nitrate, phosphate) and social (regulatory, accessibility and ecological importance) factors were included in the suitability analysis. The parameters were assessed on a monthly basis. Weightages and criteria for most suitable, suitable and unsuitable for cage and pen aquaculture were arrived at based on the expert opinions. GIS based weighted overlay analysis indicated that an area of 17.46 ha and 1 ha was suitable for cage and pen culture operations respectively. The remaining area with shallow water depth can be used for crab farming.

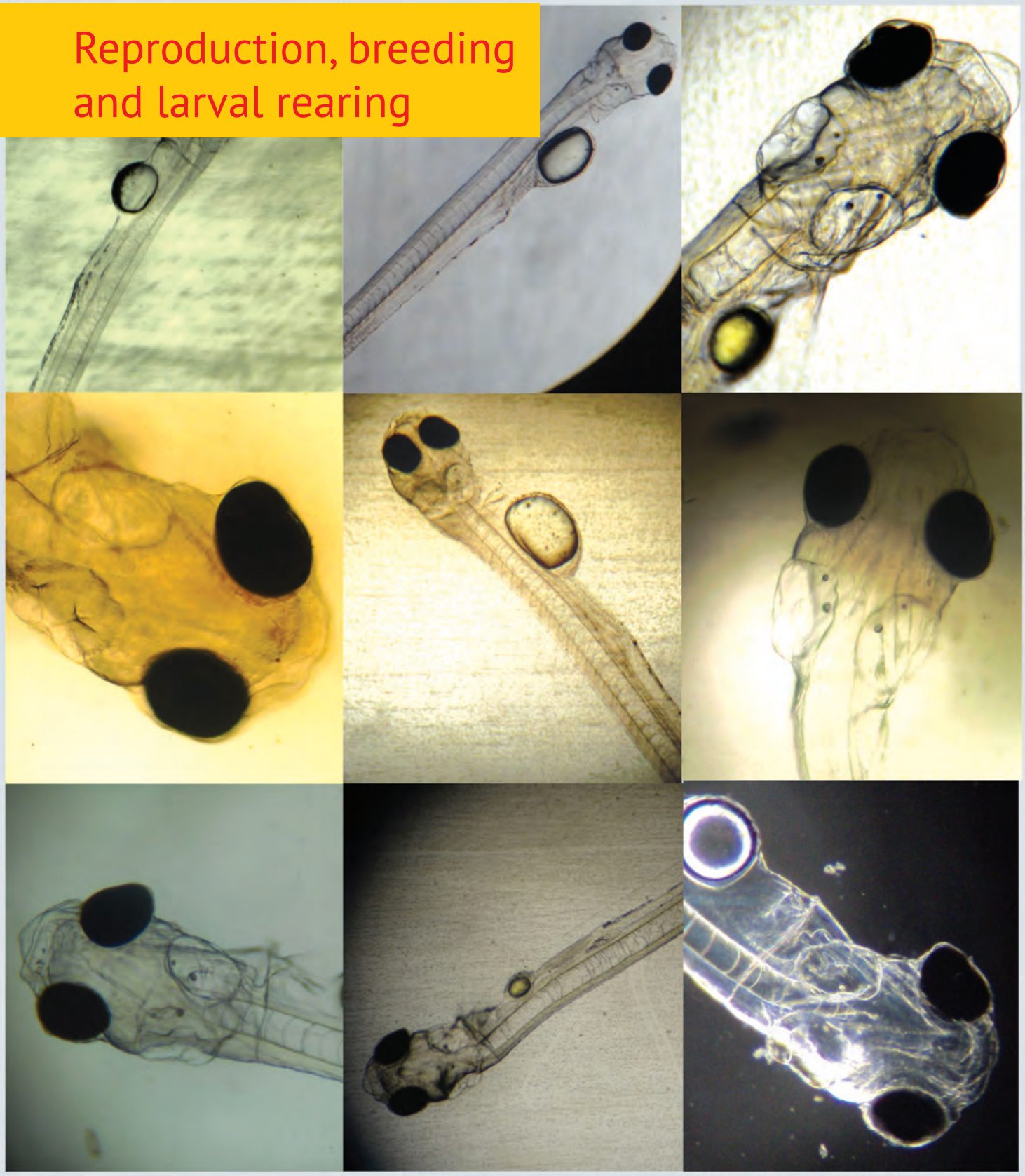
Pulicat lake

Pulicat is the second largest brackishwater lagoon in India. The water quality characteristics of Pulicat Lake were studied every month based on samples collected from 13 different locations from January to December 2016. The salinity of the lake varied from 25.84 to 31 ppt during 2016. A fuzzy logic with weightage algorithm for pH, salinity and water temperature was performed for identifying the vulnerable and suitable sites for pen and cage culture operations in the lake. As part of this study the seaweed diversity of Pulicat Lake has also been studied based on which a seaweed availability chart was developed. A digital information system involving the existing shrimp farms in Thiruvallur district was mapped at a scale of 1:25000 using RS and GIS technology. It was estimated that an area of 590 ha with 8 clusters in the district is under shrimp farming which included about 110 ponds.

Ramanathapuram District

The land and water resources map for Ramanathapuram dist. was prepared using satellite data of 2015, survey of India topographical maps with accuracy assessment through Arc GIS for delineating suitable sites for brackishwater aquaculture development. Agricultural land, fallow land, human settlement, water bodies and mudflat formed the five major land use pattern of the study area. The district has abandoned aquaculture ponds of 62 ha and operational aquaculture ponds of 921 ha currently. Additionally, the district has abandoned salt pan lands of 325 ha and salt affected soil area of 944 ha that are suitable for aquaculture development with buffer provision of 100 m. The water quality parameters such as pH, salinity, total ammonia, nitrite, nitrate, phosphate, carbonate, bicarbonate, biological oxygen demand, total alkalinity, calcium, magnesium and turbidity of water in the source creeks were studied for delineation of suitable creeks. The land use pattern map developed for coastal Ramanathapuram dist., can be used as an effective management tool for brackishwater aquaculture development of the district.

Reproduction, breeding and larval rearing



REPRODUCTION, BREEDING AND LARVAL REARING

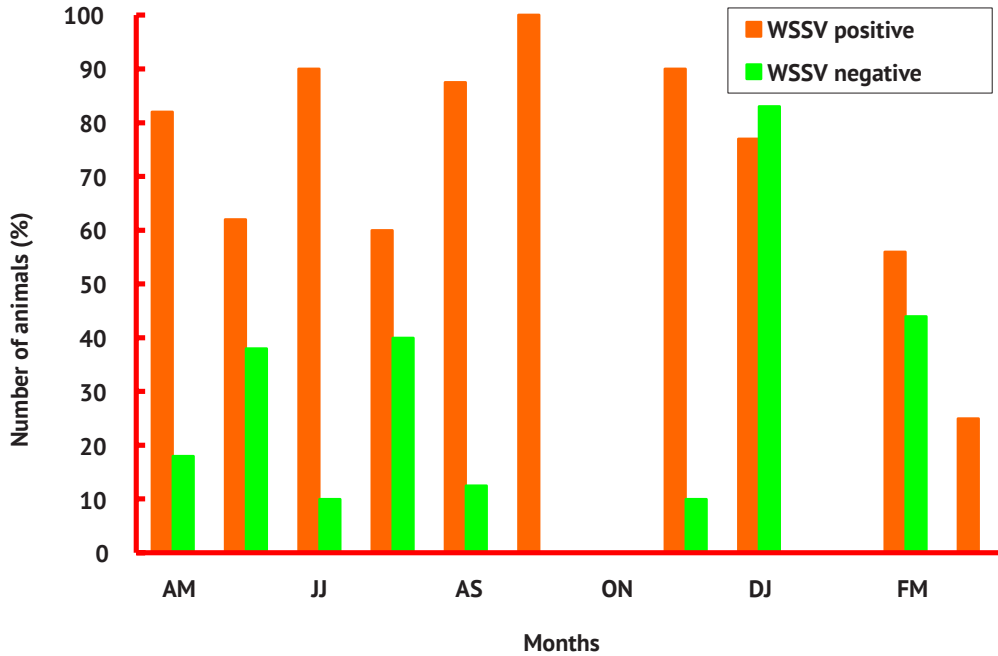
Precise control over captive spawning process of farmed species from onset of vitellogenesis to successful fertilization is essential for hatchery production, domestication and genetic improvement of the species. It is almost impossible to simulate natural stimuli and circumstances that trigger the species to spawn under hatchery conditions. Failures in captive maturation and spawning still remain to be enigmatic in many farmed species. Manipulation external stimuli (for example: photoperiod) or internal physiological process (through hormonal therapy) is required if captive broodstocks are to be propagated. The development of breeding techniques for a new species or refining the existing procedure often depends on the biology and life history traits of species to be farmed. The ICAR-CIBA continues to carry out basic and applied research that addresses the unresolved issues of captive breeding and larviculture.

Reproductive performance *of Penaeus indicus* in near commercial trial runs

Documentation of inherent potential/constraints in the reproductive and seed production performance of wild Indian white shrimp is one of the major thrust areas in promotion of native indigenous stock for domestication and genetic improvement. Keeping this in view, about 1175 numbers of *Penaeus indicus* brooders, *Penaeus indicus* were procured from Tamilnadu, Odisha, Kanyakumari and Chennai (Royapuram, Kasimedu, Kalpakkam, and Kanathur) during April to March 2016-17. The average weight and length of the *P. indicus* brooders were 39 g (20-91 g) and 158 mm (102-205 mm) whereas average male size groups were 28.1 g (17.2- 46.6) and 142.3 mm (12-17 mm). An average monthly incidence of WSSV in *P. Indicus* brooders was 72% (29-100%) with highest incidence from August to November (87.5-100%) and lowest incidence from Feburary –March period (30-56%). This study also revealed that only about 15-25% of ablated animals spawned successfully, and the quality and survival of wild spawners were found to be higher compared to ablated spawners. Average fecundity of spawners were 200,000 (80,000 to 370000). Wild gravid spawners had significantly higher fecundity (3560 eggs per gram body weight) compared to eyestalk ablated broodstocks. Similarly, the hatchability of wild spawners was higher compared to eyestock ablated broodstock. Failure in captive mating and low percentage of male population in maturation tanks would cause poor spawning performance. The average successful cycle recorded nauplius to mysis survival at 60% (50-70%) whereas mysis to PL was found to

be 25%. Zoea conversion mortality was below 5% during the initial six months except 33% noticed in June. About 75-80 % mortality in mysis to post larval conversion stage was recorded as a major challenge in PL survival in larval production. Mortality related to conversion of zoea to mysis was maximum (75%) in ablated spawners. However, in wild spawners mortality was maximum during the conversion of mysis to PL. Histological analysis of hepatopancreas of infected shrimps recorded intracellular inclusion bodies and ruptured hepatopancreatic cells which need further investigation. Length weight analysis of female and male brooders yielded the equation $Y=0.044 X^{2.5}$; $R^2=63$ and $Y=0.05 X^{2.4}$; $R^2=71$ which indicates female and male brooders exhibit negatively allometric growth where length of the brooders does not increase proportionately with weight.

Incidence of WSSV infection in the wild caught broodstock is high. In September all animals were WSSV positive. The minimum incidence of WSSV occurred in March



Incidence of WSSV infection in the wild caught adult Indian white shrimp

Penaeus indicus post larvae nine (PL9) were found to be well suited for long distance travel at a stocking density below 250 no/L

Summary of reproductive performance of Penaeus indicus at Muttukadu Experimental Station

Ablated spawners contributed in spawning	15 - 25%
Latency period after ablation	7-10 days
Fecundity (Lakhs)	1.5- 2; (0.8 -3.7)
Eggs/gram body weight ofablated spawners	1481 ± 863 (65000 -80000)
Eggs/gram body weight of wild spawners	3560 ± 970 eggs (1.3- 3.7 lakhs)
Gram per weight ration of wild brooders	2.38 ± 0.49
Egg hatchability of wild spawners	75 - 80%
Egg hatchability of ablated spawners	50 -70%
Zoea conversion problem	33%
Nauplius to mysis survival	60 % (50-70%)
Mysis to post larvae survival	25%
Mysis to PL mortality due to intra nuclear inclusion parasites	75-80%
Survival percent from nauplius to post larvae	25%

Standardizing seed transportation protocols for *Penaeus indicus*

Stress mediated mortality is one of the major problems associated with long distance transport of PL. Standardizing seed transportation procedure of *P. indicus* is vital for ensuring high survival rate of PL on receipt at the farm. A 16 h transportation trial of post larvae (PL 9) at two different densities 900 nos/l and 1100 nos/l in sea water (23^{0}C and 27 ppt) by train resulted in 100 % and 97% survival respectively. Seed quality assessment of PL 9 (7.5 mm) after 16 h transportation using stress test in 100 ppm, 200 ppm formalin and sudden exposure to 50% salinity drop (13.5 ppt) resulted in 88 %, 84 % and 90% survival values respectively. Another long distance transportation (16 h) trial employing advanced shrimp PL (PL 13) by train at different densities of 260 nos/l, 520 nos/l, 1040 nos/l and 1500 nos/l in triplicates resulted in survival rates of 73, 64.7, 43.2 and 40.8 % respectively. Stress quality assessment test using 100, 200 ppm formalin and sudden PL exposure to 50% salinity (12.5 ppt) resulted in 88, 85 and 26 % survival respectively. The study indicates that of stage PL 9 is well suited for long distance transportation and stocking densities lower than 250 nos/l may be employed in the case of advanced PL.

Transportation and stress test experiments of *Penaeus indicus* post larvae (PL13) for a period of 16 hours

No/L	Survival (%)	Formalin		Reduction of 50% salinity
		100 ppm	200 ppm	
260	73±10.1	100	95±7.07	90
520	64.7± 6.75	78 ±7	80±4.71	90
1040	43.2± 8.559	2 ± 2.4	88±2.35	90
1500	40.8± 24.8	85 ± 0.7	83±1.4	88

Artemia biomass as a potential broodstock maturation diet

A comparative study on the feed acceptability of live and frozen artemia biomass was evaluated in *P. indicus* brooders. The study revealed 100% feed acceptability of live artemia biomass by the broodstock compared to 60% acceptability for frozen artemia biomass. Proximate composition of the harvested biomass revealed 40-45% crude protein, 15-22% lipid and a good fatty acid profile of EPA (1.2 %) and DHA (0.5%). Adult artemia has bio-encapsulation property which can be used for delivery of reproductive hormones for shrimp maturation.

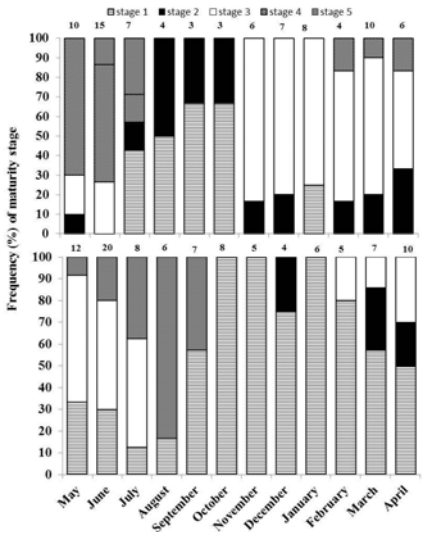
Seed production and larval rearing studies on the penaeid shrimp *Penaeus (Marsupenaeus) japonicus*

Seed production trials of *Penaeus japonicus* was carried out as a first step to diversify penaeid shrimp culture in India. The broodstock was procured in batches (*n*=50) from the SE coast of India, Chennai, Tamil Nadu. The average size of females and males were 65.71 g; 18.9 cm and 37.1 g, 15.7 cm respectively. Animals were diagnosed for WSSV infection, and 30% of animals were found to be positive. Only WSSV free animals were used for the breeding experiment. The brooders were fed on frozen squid meat @ 10% of body weight, and 100 % water exchange was carried out daily for maintaining the optimum water quality parameters. Brooders were unilaterally eyestalk ablated, and spawners recorded an average fecundity of 2 lakh. The nauplii produced were reared at a density of 100 no/L and water temperature was maintained at 28°C by using titanium heaters. Protozoea were fed with diatom *Chaetoceros* sp. (50-80,000 cells/ml). Along with microalgal diet, protozoea stage two onwards micro coated feeds (50-60 micron) were given two times a day @ 20 g/gm for 1 million larvae/day. Successful transformation of the larvae to mysis was achieved with this feeding schedule with an average 60-70% survival. Feeding in the mysis stage was carried out with microalgal diet and micro coated feeds of 100 micron size. Water exchange was carried out during post larval stage onwards @ 50% daily. The larvae took 8-10 days to reach the post larval stage. Artemia and micro feed (200-250 micron) was given during the post larval stages. At the end of the larval cycle an average survival of 50% with highest up to 90% was achieved by following the above larval rearing method. A total of 2 lakh larvae were produced from two cycles and seeds at PL_{20}stage were transported to farmer's pond for grow out studies.

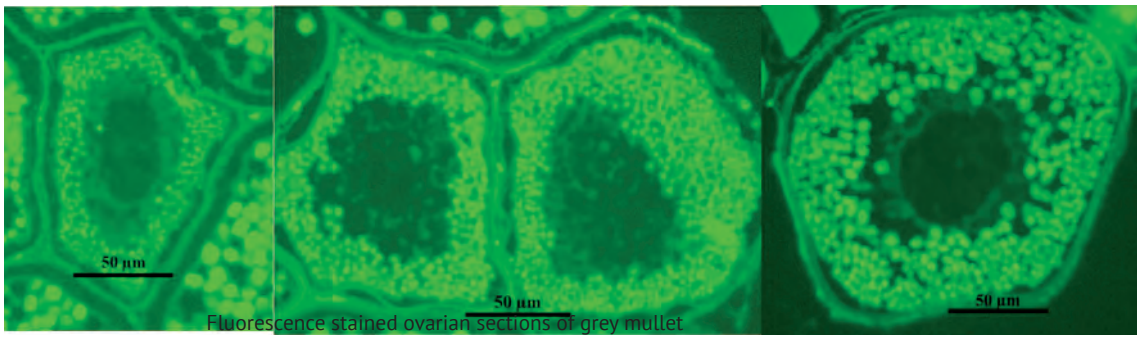
Penaeus japonicus early maturation stage

Reproductive biology of *Mugil cephalus* from south-west coast of India

Grey mullet, *Mugil cephalus*, *is* a prime candidate species for brackishwater aquaculture. However, there is a lack of information on the reproduction of the species in the Indian coast. A study was undertaken to understand the reproduction of the species in the wild so as to gain valuable leads for captive breeding of grey mullet. Live specimens of grey mullet obtained from the cast net and Chinese net fishery from Cochin backwaters, Kerala were used for the study. The morphology of gonads and developmental stages were recorded. The spawning season was inferred from the relative distribution of different gonadal maturity stages and gonado-somatic index values of both sexes. The length at first maturity was 437.6 mm for females and 349.3 mm for males. The individual fecundity ranged from 0.42 x 10^6 to 3.89 x 10^6 eggs with an average of 1.80 x 10^6 eggs and relative fecundity ranging from 595 eggs to 2168 eggs per gram. The intensive reproductive period was found out to be between May- July months coinciding with the south-west monsoon.



Reproductive period of grey mullet, *Mugil cephalus*, coincides with south west Monsoon in Kerala. Similarly, in Tamil Nadu it conicides with North East Monsoon.



Fluorescence stained ovarian sections of grey mullet

Captive maturation and spawning of grey mullets

Information on the reproductive biology of grey mullets in captivity is vital for developing captive maturation and reproduction protocols for the species. The captive maturity of forty grey mullets sourced from Kovalam, Chennai coast and maintained in 100 t RCC tanks under flow through system was recorded. The fish were fed twice daily with broodstock diet developed at the institute at 2.5 % of body weight. Each of these fish were tagged using PIT tags for ascertaining their identity. The highest number of milting males, and females with vitellogenic oocytes were observed in the month of November. The peak breeding season

for grey mullet in east coast was thus estimated to extend from October to December. In order to enhance maturation of the captive stock, fishes were given hormonal treatment in the month of October. Fishes were implanted with cholesterol pellets of 17-α-MT (10 mg) and LHRHa (200 µg) for males and females respectively. As a result of implantation a total maturity of 57.5 % was observed in the stock, which included 35 % females and 22.5 % males. Natural maturation was observed in 33 % of the non-hormone implanted stock which included 22 % females and 14 % males. The size at first maturity for males and females of grey mullet was observed to be above 600 g (640 g) and above 800 g (815 g) respectively.

In 2016-17 success was achieved in induction of spawning in grey mullet. In trials performed in the east coast, induced spawning was observed in three fishes with intra ovarian oocyte diameter, 520, 525 and 535 µm. The fishes spawned in response to a combination of LHRHa and dopamine inhibitor. Over 2 million eggs were obtained with an egg diameter of 800 µm. However, the fertilization rate was observed to be a meagre 5 %. Larvae collected from the incubation tanks had a TL of 2.4 mm.

Newly hatched grey mullet larvae collected from the incubation tank

Hormonal administration in *Mugil cephalus* accelerated reproductive maturation in both males and females. Combination of LHRHa and dopamine inhibitor induced spawning in female grey mullet.

In another breeding trial, a female grey mullet administered with a priming dose of hCG @ 10,000 IU/kg fish and resolving dose of LHRHa @200 µg/kg did not show signs of oocyte maturation. Further administration of 5 successive resolving doses at 24 h intervals resulted in an increase in intra ovarian oocyte diameter from 524 to 560 µm, after which dry stripping was performed, though no fertilization occurred.

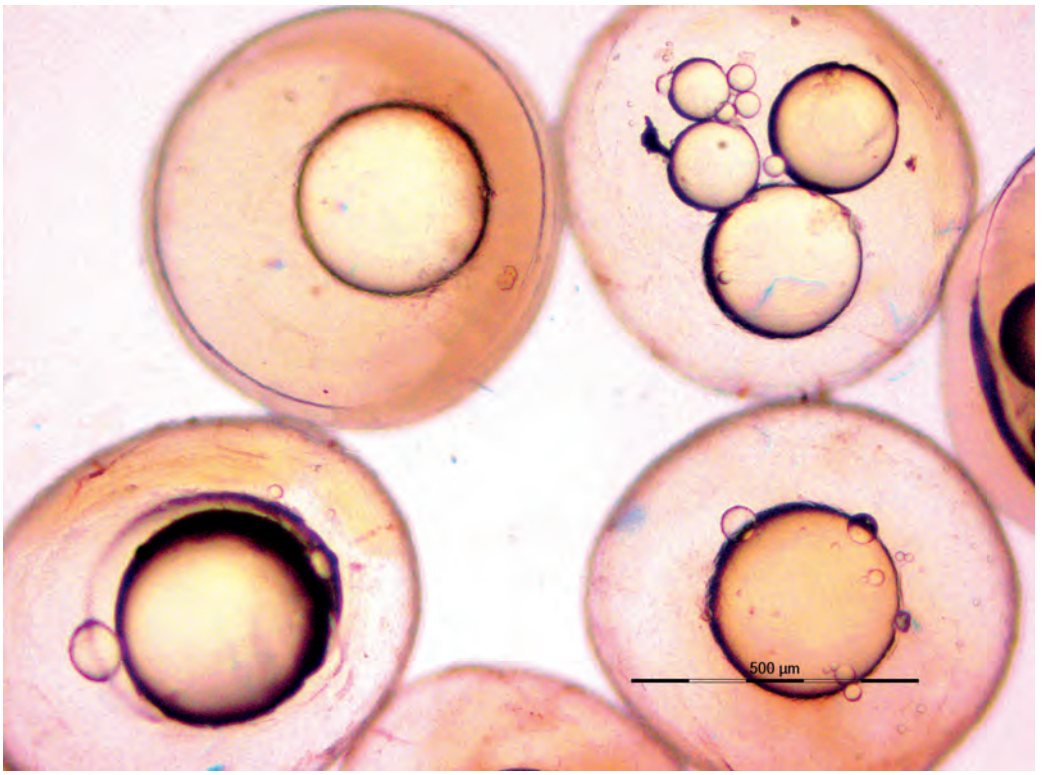
Development of farm based breeding system for grey mullet with farmer's participation

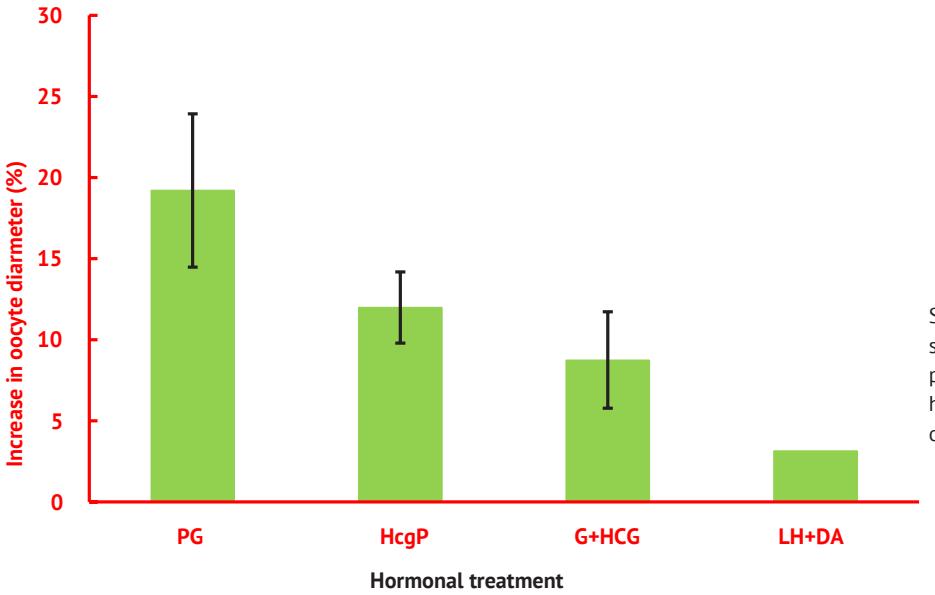
In 2016-17 an innovative farm based low volume breeding system for grey mullet *Mugil cephalus* was setup in a farm which comprised of 1 t FRP tanks with egg collection chamber and sand filter. The breeding trials performed using this system resulted in final oocyte maturation and ovulation in 8 females in 5 trials resulting in eggs of 750-850 µm. Approximately, 5 lakh eggs per female was obtained through induced breeding, though low percentage of fertilization (approximately 5%) was recorded. Larval production from the system was indicative of feasibility of this model.

Farm based simple RAS for broodstock maintenance

Standardization of hormonal doses for breeding of gold spot mullet, *Liza parsia*

Gold spot mullet, *Liza parsia*, is of high demand in West Bengal and preliminary trials were conducted to breed the species in captivity. Female fish with average oocyte diameter exceeding 500 (ABW: 70-90 g; sex ratio of M: F, 2:1) were acclimatized to 30‰ and were randomly subjected to PGE, hCG, PGE + hCG and LHRHa with DA administrations in triplicates. Males were administered with one dose at the time of second hormonal administration to the female. Control groups received 0.1 and 0.2 ml of 0.9% physiological saline as primary and secondary dose respectively. The maturity and the oocyte diameter of the females were staged by obtaining *in vivo* biopsy of ovary. Percentage increase in oocytes diameter was significantly higher in PGE group (19.2 ± 4.73) followed by hCG (11.98 ± 2.19), PGE + hCG (8.74 ± 2.97) and LHRHa + DA groups (3.14 ± 0.52). It could therefore be concluded that PGE alone or in combination with hCG as a priming dose significantly increases the oocyte diameter, induces ovulation and spawning in *L. parsia*.



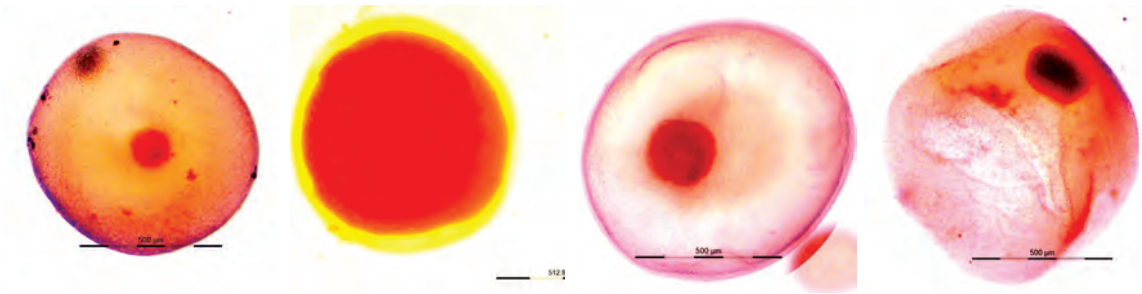


Spawned ova of gold spot mullet (upper panel) and effect of hormonal treatment on oocyte size

Osmotically controlled hormone delivery systems enable hormone delivery at the desired rate in animals. The use of osmotic pumps in *Liza parsia* helps to discharge a constant concentration of hormones for a period of 30 days. In this experiment, osmotic pumps filled with LHRHa, hCG and PGE were implanted in the body cavity through incision. Release rate for LHRHa, hCG and PGE were 0.11 µg, 55 IU and 1.1 mg per day respectively. Osmotic pump with 0.9 % physiological saline was used as control. At the end of 30 days, fishes were cut open to examine the gonadal development. Results showed that the mean gonadosomatic index (GSI) of the PGE loaded group, was significantly higher compared to the other groups.

Optimization breeding protocols for long whiskered catfish, *Mystus gulio*

A simple and cost effective hatchery technology for brackishwater catfish, *Mystus gulio* would facilitate easier adoption by the end users. Experiments were carried out to investigate the optimal oocyte diameter, dosage of hCG and the sex ratio for induced spawning of *M .gulio*. Results of the experiments suggest that a hCG dose of 10 IU g-1 body weight to female and half of this dose to male resulted in optimal breeding. Male biased sex ratio of 2M:1F resulted in higher fecundity, fertilization rate, hatching rate and larval survival. Females having oocytes diameter below 700 µm, did not spawn post hormonal adminstration. Oocytes diameter in range of 750- 850 µm required primary and secondary dose of hCG, whereas oocytes diameter above 850 µm required only one dose of hCG for successful spawning.



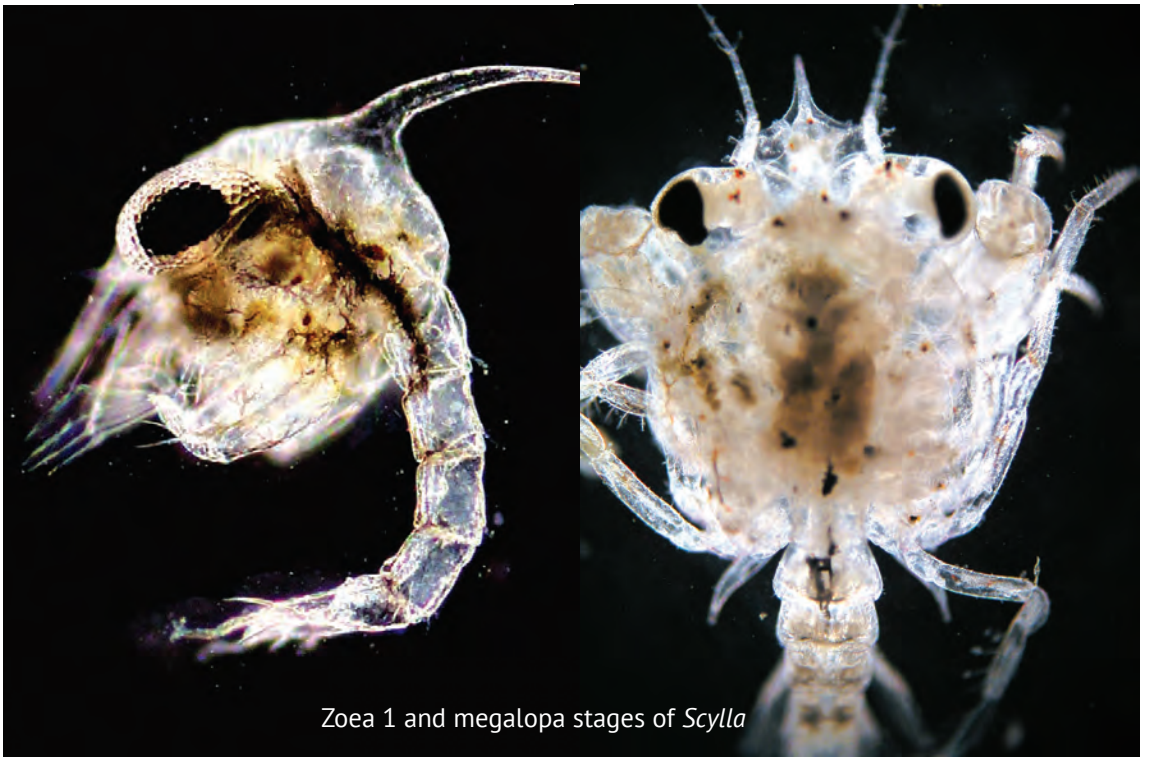
Size of oocytes and nucleus position (1) 750-800 (central nucleus) (2) 801-850 (migrating nucleus) (3) 851-900 (peripheral nucleus) and (4) 901-950 µm (GVBD)

Two- phase production system for large scale juvenile production of mud crab *Scylla serrata*

Rearing experiments and mass production of *Scylla serrata* juveniles were carried out in order to optimize the hatchery production of this species. During April 2016 through March 2017, forty broodstosck (female) were obtained from the coasts of Chennai and Andaman and Nicobar Islands. Of these 31 animals were from Chennai coast. These animals were reared at the recirculation maturation facility at mud crab experimental hatchery at MES, CIBA. Size and weight of the animals from Chennai coast is as significantly lower than the others from Andaman coast (155. 5 mm Vs 178.7 mm). Of the crabs procured, 11 animals spawned. Of these seven animals were used for the hatchery trial runs. The objective of the study was to evaluate the feasibility of two phase culture system versus single phase culture system. In two phase culture system Z1 larvae are reared up to megalopa stage in the indoor FRP tank and from megalopa on wards in the outdoor net cages erected in the earthen ponds. A total of 693 megalopa were reared in indoor and hapa constructed in the earthen pond (353 Vs 340) for a period of two weeks. At the end of the 14d experiment, 30% of megalopa metamorphosed to mud crab instar (CW: 6.01 ± 1. 2 mm; BW: 0.23 ± .05 g) in the group where megalopa were reared in hapa in the earthen pond. However in the indoor tank survival was significantly low (4%). It can be suggested that terminating the hatchery production at the megalopa stage in the indoor hatcheries is an efficient way to optimize the production

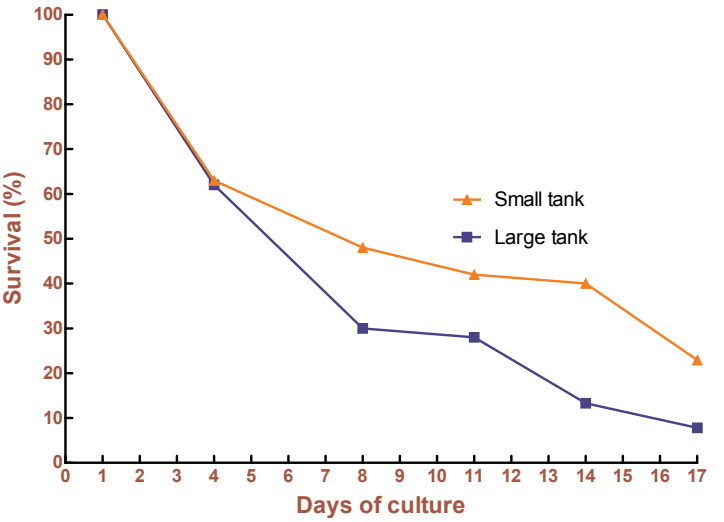
In the second trial feasibility of larger tank (5000 L) was evaluated against the smaller tank (100 L). In the larger tank the volume of the water increased during the progression of culture period. Zoea 1 were stocked at a density of 170 no/L in 1000 L water, and water level was increased up to 4000 L towards the end of the culture. In 100 L tank 1000 Zoea 1 were stocked and replicated thrice. The survival in the bigger tank was 7.76% with a production of 13500

megalopa per 4000 L water. On the contrary survival in the smaller tank was 22.6% with an average production of 226. However, the production rates both small tank system and big tank system were found to be similar: 3. 4 megalopa/ L in the big tank system and 4.4 megalopa/L in the smaller tanks. As the additional cost for the development of microalgae and live food organism is negligible, the use of larger tank system is economical and recommended. The possibility of larviculture using the diluted brine was also tried, however all the larvae died before metamorphosis to the second zoea.



Zoea 1 and megalopa stages of *Scylla*

A two -phase culture system for larviculture of mud crab was developed. In this system, zoea 1 to megalopa is reared in the indoor hatchery whereas megalopa is reared in the net cages erected in the earthen pond.

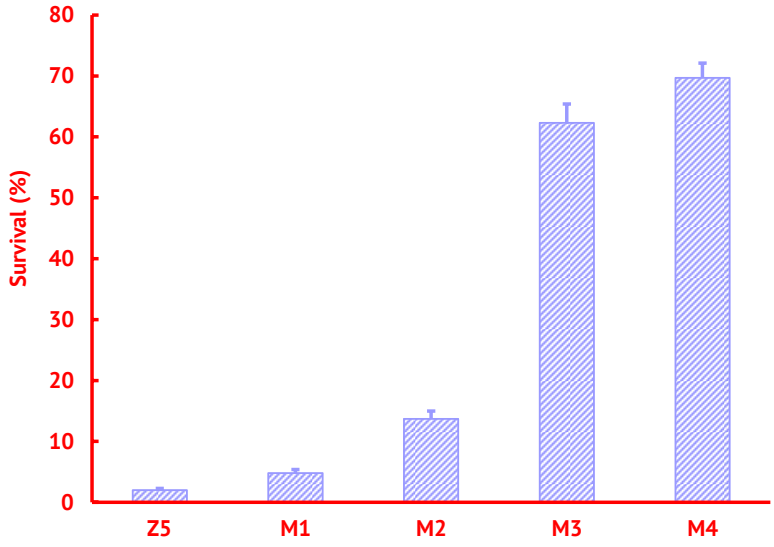


Survival of crab larvae in small and large volume tanks

Reducing the hatchery phase in mud crab seed production through outdoor rearing of megalopa

Megalopa stage in the crab larval cycle is a crtical phase in mud crab seed production owing to its cannibalistic behaviour, changes in feeding pattern and gradual settlement resulting in high mortality in indoor tank systems. Megalopa can alternately be reared in net cages lodged in brackishwater ponds and it significantly reduces the duration of hatchery phase of mud crabs. Megalopa can be easily transported and may be reared at the farm site to obtain crab instar. A 15 day trial was conducted to study the crab instar conversion rate of zoea 5 and megalopa at different ages reared in net cages erected in the earthen ponds. The objective was to ascertain the life stage that yields maximum crab instar conversion when stocked in outdoor net cages/ hapas. Two hundred numbers each of Zoea 5 (Z5) and megalopa were stocked in to different hapas (PE hapa – 1m X 1m X 1m) lodged in triplicate. The larvae were stocked in to the hapas in a sequential manner starting with Zoea 5 (Z5) and followed by megalopa as the larvae metamorphosed to the latter. Megalopa of age 1 day (Megalopa 1-M1), 2 days (Megalopa 2-M2), 3 days (Megalopa 3-M3) and 4 days (Megalopa 4-M4) were stocked in to individual hapas. The animals were fed on finely grated and sieved clam meat four times a day at satiation. At the end of the trial, significantly higher survival rate and average number of crab instars obtained was observed in case of treatments M3 and M4. The crab instar conversion rate was significantly lower for treatments M1, M2 and Z5. Superior crab instar conversion rate (megalopa to crab instar) of 62.33% and 69.66% were obtained using megalopa aged 3 days and 4 days (M3 and M4) respectively. The carapace width and average body weight of the crab instar did not vary significantly in any of the treatments. Zoea 5 and newly metamorphosed megalopa of age 1 to 2 days performed poorly in the study indicating that these life stages confront excessive mortality during outdoor rearing and should be retained in the LRTs. The present trial reveals that stocking of megalopa aged 3 to 4 days in to outdoor system yields better results and megalopa at this stage may be supplied to farmers for crab farming.

Megalopa stage in the crab larval cycle is the critical phase in the mud crab seed production. A 15-day expereiment conducted in net cages erected in earthen pond shows that megalopa in these system yield a better survival



Survival of Zoea1 and megalopa (1-4) in the net cages

Captive rearing and breeding of Hilsa shad, *Tenualosa ilisha*

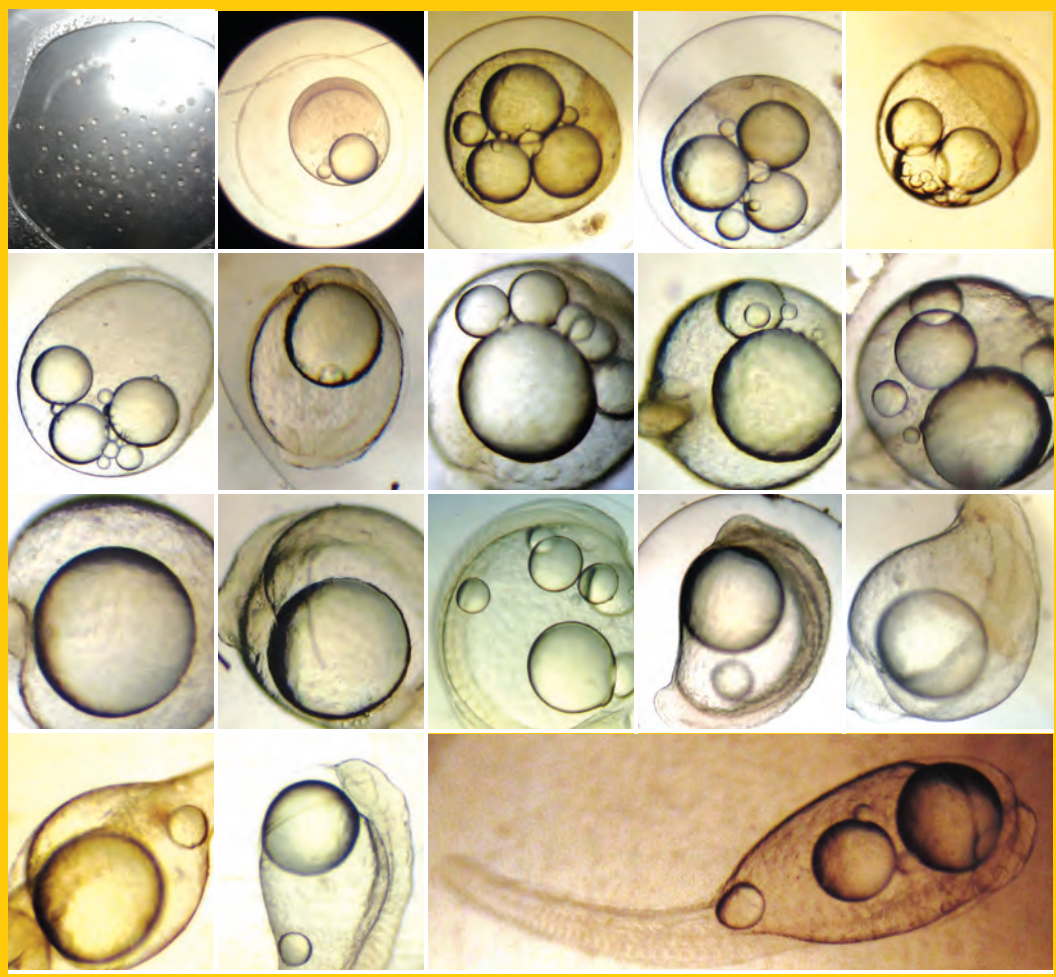
Tenualosa ilisha, commonly known as Hilsa, has been one of the most important fish species in south Asia in general and West Bengal in particular. Owing to the high market demand, indiscriminate exploitation and other anthropogenic pressures, the wild catches of this species have dwindled in aquatic systems. Experimental captive breeding trials were carried out using wild broodstock sourced from the Hooghly estuary at Odakhali, South 24 Parganas. (22°39′N, 88°14′E), West Bengal. Breeding trials were carried out onboard by using dry stripping method by using females with an average size of 660.5±25.5 g/376.5±3.5 mm and males of 225±52.33 g / 262.8±12.96 mm. Fertilization and hatching efficiency in different water source: estuarine water from treatment plant, filtered estuarine water (filtered through 50 µm), and deep tube-well water were used. It was found that estuarine water from treatment plant was found to be most suitable for fertilization as well as hatching for hilsa.

Although captive breeding has been attempted since 1900, the successful closing of the life cycle has been still enigmatic. Further, for the development of broodstock, hilsa fry obtained from Muriganga River, West Bengal were reared in the brackishwater earthen pond at KRC. Hilsa fry of size (1.37 g, 52.97 mm) grown up to 383.80 g /339.33 mm (body weight and total length) within 32 months. Significant number of matured females (358.18 g- 425.52 g/352 mm-370 mm) with oocyte diameter (570 µm) corresponding to V th stage of oocyte maturation were obtained along with matured males (139.35 g/260 mm). The matured male and female fishes were observed during the period from November to February suggesting the possibility of captive maturation and reproduction for seed production. This is the first report of captive broodstock development in the brackishwater ponds.

Hilsa shad (*Tenualosa ilisha*): onboard breeding (upper panel); ovary of pond reared broodstock with advanced stage of reproductive maturation (gross and histology)

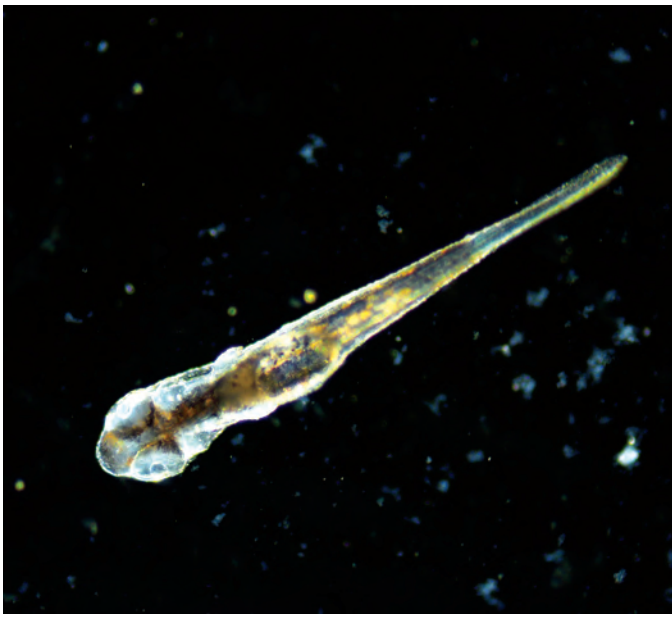
Developmental stages of fertilized egg

Embryonic developmental stages of fertilized egg were studied under microscope at different hours of incubation. At 5 to 6 hours egg entered in morula stage and started their gastrulation and epiboly at 7 hours. Closing of blastopore was observed at 10 hours. Development of tail, head and oil droplets were noticed at 12 to 17 hours. Notochord formation started at 17-19 hours. Eggs were ready for hatching at 21-23 hours and hatch-out took place at 22-24 hours. Significant morphological development of Hilsa larvae was studied at different days of hatching. On 5th day of hatching gut development was noticed and mouth opened on 7 to 8th day. Yolk sac got absorbed on 14th day of hatching.



Captive broodstock development of Spotted scat (*Scatophagus argus*)

Spotted scat is an economically important ornamental as well as a food fish. Spotted scat were collected from natural brackishwater habitats and maintained in earthen pond with provision for water exchange on a daily basis. Fishes were fed with commercial feed (crude protein, 35%) @ 3% body weight. Monthly sampling was conducted to assess health and maturity. Mature females with oocyte diameter greater than 350 µm were recorded in the months of August – November and again in April. Highest number of mature fishes was observed in the month of May wherein 27.53 % of the males and 24.63 % of females in the stock matured. Three spawning trials for the species were conducted. In one trial 4 female fishes were selected to make spawning pairs (M:F , 2:1) and induced using priming dose of hCG @3000 IU kg^{-1} body weight and resolving dose of LHRHa @400 µg/kg body weight. Female fishes were then dry stripped after 85 hours of resolving dose. Dry stripping of eggs was followed by artificial fertilization of eggs. A fertilization percentage of 1.54 % was recorded. Hatching was observed after 18 hour post fertilization.



0 dph Spotted scat larvae (Lateral view)
(Total Length 2.2 mm)

Captive breeding and seed production of the endangered Canara pearlspot, *Etroplus canarensis*

Etroplus canarensis, commonly known as Canara Pearlspot is an important ornamental fish species listed as Endangered in the IUCN Red list Threatened species 2013.2. (Endangered B1ab (iii)+2ab(iii) ver 3.1). The Cichlid, *E. canarensis* is an endemic species, and its availability restricted to only natural habitats, Kumaradhara and Nethravati Rivers of Karnataka. *E. canarensis* has been assessed as endangered by IUCN because of the restricted distribution to two locations, with an extent of occurrence (EOO) of less than 5,000 km^2 and an area of occupancy (AOO) of less than 500 km^2. This along with the concerns of natural habitat deterioration due to anthropogenic influences is the added challenge threatening the existence of the species. Besides its conservation value, the Canara pearlspot commands high export value in Europe (€17-20) and USA ($ 35-60) in USA. In the domestic market it fetches a price in the range of Rs.150-250/unit.

Canara pearlspot (100 numbers, average length, 88.9 mm; average weight, 18.26 g) were procured from Karnataka for the breeding trials. The fishes were acclimatized for one month (salinity: 5-8 ppt, temperature, 26-28 °C, pH-7.5-8.2) and fed on commercial pellet feeds. Spontaneous breeding of the species was observed between October to March. In five successive breeding trials, the number of larvae per spawning ranged from 75 to 100. The eggs are filamentous, stalked and attached to the substratum. Canara pearlspot exhibited biparental care. Fertilized eggs hatched after 4 days at a temperature of 28-30^{0}C. Larval rearing was carried out using low saline water of 5-10 ppt. Approximately 300 numbers of larvae were produced during 2016-17. Twelve days old larvae were separated from

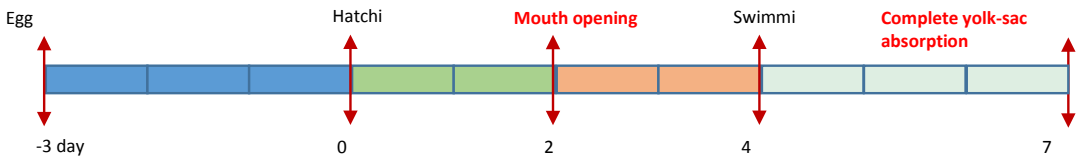
parents and stocked @ 5 nos./l in 100 liter FRP tanks and reared upto 60 days. Feeding was done on live feeds such as rotifers, green algae and Artemia.

Combined rotifer and green algae feeding was performed until 15 dph followed by *Artemia* nauplii up to 30 DPH.

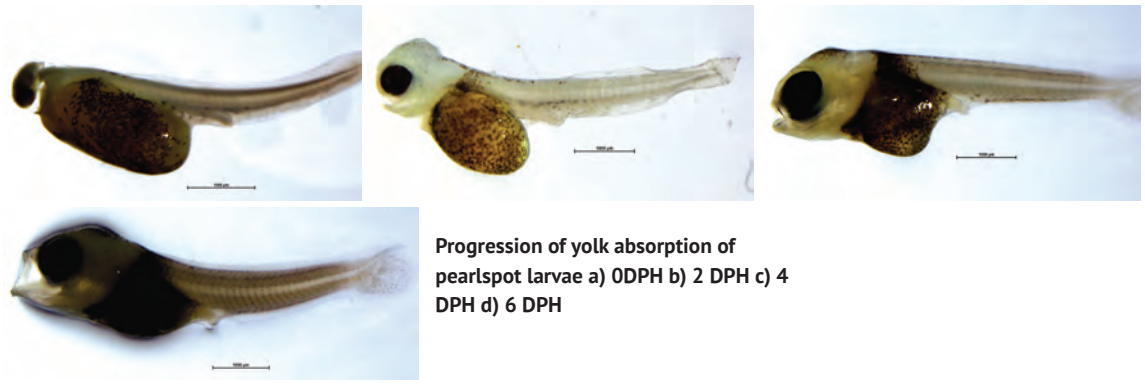
Adult and juveniles of hatchery reared Canara pearlspot

Refining larval rearing protocols of pearlspot *Etroplus suratensis*

Hatchery technology which makes use of live feeds would not be a viable option for small scale farmers with limited rearing setups. Therefore, experiments on larval rearing protocols were conducted to understand the optimal weaning age, micro-particulate feed size and feasibility of using background micro-algae with inert diets. Mouth opening of pearlspot happens by the second dph. The initial mouth size of pearlspot larvae was estimated to be 522.5 µm, and thus artemia nauplii was used as the first feed. An artemia consumption rate of approximately 50, 100, 150 and 300 numbers per h per larvae was observed at 10, 15, 20 and 35 days respectively. The artemia consumption per larvae per hour increased linearly with increasing dph with a relation of y=9.0714x-26.679 (R^2=0.99). The relation of body weight of larvae with respect to dph for pearlspot larvae reared on Artemia nauplii larvae was y=1.7779e0.1385x (R^2=0.99).

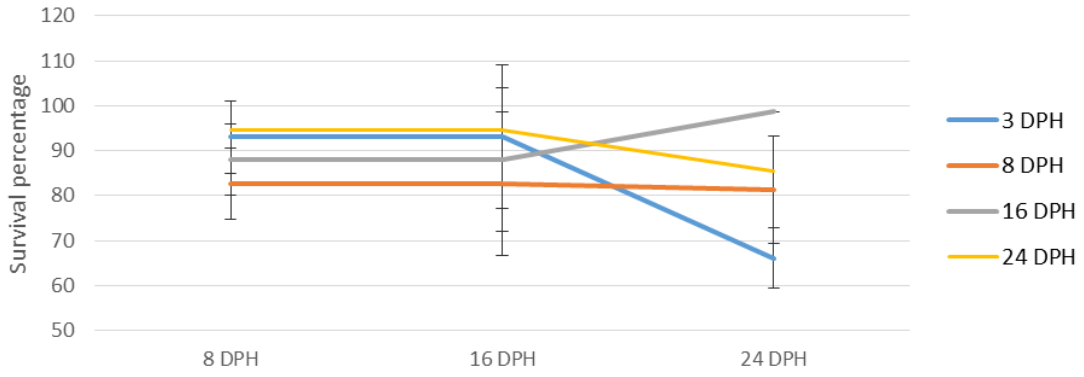


Time scale of important events following egg activation in pearlspot



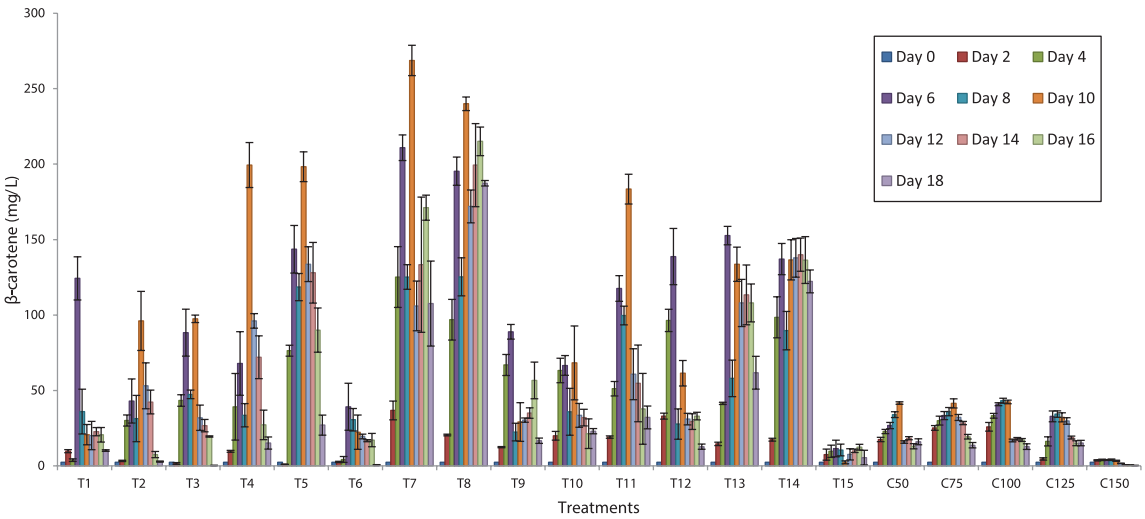
Progression of yolk absorption of pearlspot larvae a) 0DPH b) 2 DPH c) 4 DPH d) 6 DPH

Optimal weaning age of pearlspot larvae to inert feeds- A twenty four day experiment was conducted to understand the optimal time for weaning pearlspot. The experiment indicated the potential of larval rearing on inert feeds from 0 dph. Highest larval output was observed when weaning to inert diets started 16 dph resulting in a survival of 96 %.



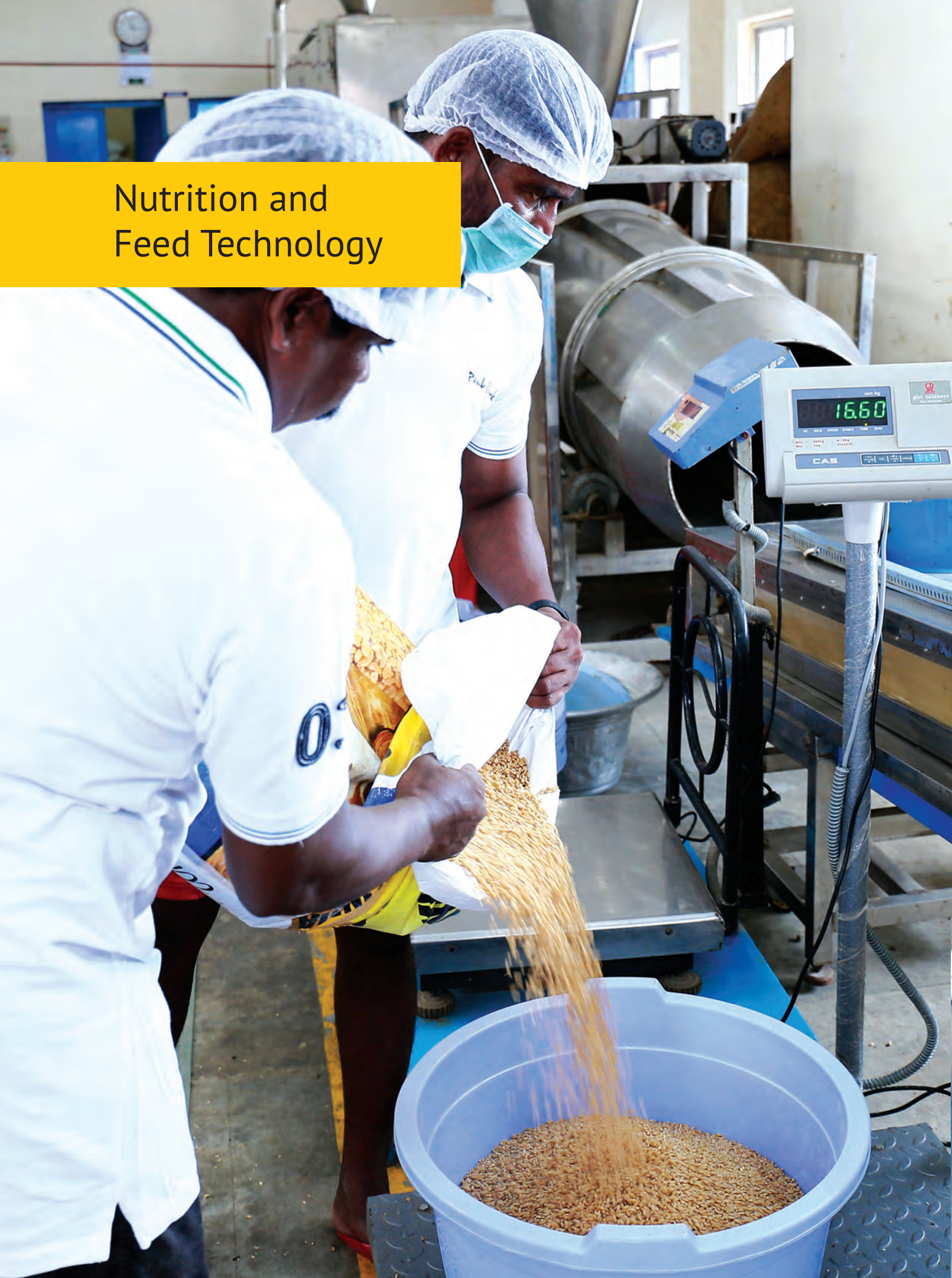
Cost effective technique for β-carotene production from *Dunaliella salina*

Dunaliella salina, di-flagellated green microalgae, is one of the ideal species for production of natural carotenoids owing to its tolerance to high saline environments. The microalgae produce large amounts of carotenoid pigment when subjected to stressors such as light, salinity, nutrients and temperature. Among the various stressors, salinity is the most commonly used means to produce stress which involves subjecting the algae to high saline environment. The objective of the trial was to induce carotenoid production in algae under comparatively lower salinity ranges. Keeping this in view, an outdoor experiment was conducted at different salinity ranges (50, 75, 100, 125 and 150 ppt) using cost effective fermented organic manure based media @ 5, 10 and 15 g per 100 litre of medium as the treatment group and Walne's medium as control. At the end of the 18 day trial, significantly higher **β**-carotene production was observed in the treatment groups compared to the control. The maximum carotenoid production (268.73 mg/L) was observed on the 10th day in the treatment with 5g of organic manure at 100 ppt salinity. Microscopic evaluation revealed deposition of **β**-carotene droplets in pigment vesicles. The overall results indicated that low cost fermented organic manure applied to 100 ppt saline water can be effectively used for large scale production of carotenoid **β**-carotene which can in turn be used as a dietary supplement during culture of shrimp larvae and adults.



Concentration of ß- carotene between different treatments during the culture periods

Nutrition and Feed Technology



NUTRITION AND FEED TECHNOLOGY

The rapid growth of aquaculture production must be supported by a corresponding increase in the cost effective production of formulated feeds for sustaining the growth of fish production. Multidimensional knowledge on nutrition is essential for formulating aqua feeds that ensure good health, minimum waste output and realize the maximum genetic potential at reasonable cost. The Central Institute of Brackishwater Aquaculture (CIBA) is the nodal research institute to cater to the needs of the abrackishwater aquaculture sector of the country. Considerable progress has been made in feeding of fish from mash feeding to pelleted feeds and use of modern highly digestible extruded pellets. CIBA has developed several feed technologies and successfully commercialized the indigenous shrimp and seabass feed technology. CIBA with its established feed manufacturing and analytical facilities is continuing its journey towards producing eco-friendly, cost effective and high performing feeds for all the life stages of finfishes and shellfishes.

Performance of CIBA's indigenous cost-effective feed Vannami^{Plus} in pond trials

Currently, a major share of Indian shrimp feed business is held by the multinational corporate companies or their joint ventures, where an upward trend in price has been noticed during the last few years. Visualizing this as a critical obstacle, CIBA has developed a cost-effective grow out feed using indigenous ingredients. This feed has been tested in farmer's pond at Kodungallur (Thrissur, Kerala) and compared against the commonly used commercial shrimp feed. The shrimps were stocked at a density of 24 no/m^2 and all other the management protocols were kept the same. At the end of 117 days of culture shrimps attained an average body weight of 29.5 g in the pond fed Vannami^{plus}. We demonstrated that, while feed cost to produce 1 kg of shrimp can be restricted to Rs. 91 to 98 by using "Vannami^{Plus}, it can go up to Rs.140 with commercial

Accessibility of feed as per requirement is a constraint to most small and medium farmers with supply regulated through the authorized chain. To address this problem, CIBA has developed a cost-effective feed, branded Vannami ^{plus}, made out of locally available ingredients and indigenous feed manufacturing technology

Workshop at Kodungallur during the final harvest of *Penaeus indicus*

feeds. The feed showed impressive performance and the farmers could reduce the cost of production by Rs.60 per kg of shrimp. These results showed that the indigenous *vannamei* grow-out feed, Vannami^{Plus}, developed by CIBA could be cost-effective, and was able to bring down the cost of production and increase the profitability of Indian shrimp farmers. This technology has already been commercialized in the states of Andhra Pradesh, Gujarat and Kerala on a non-exclusive basis.

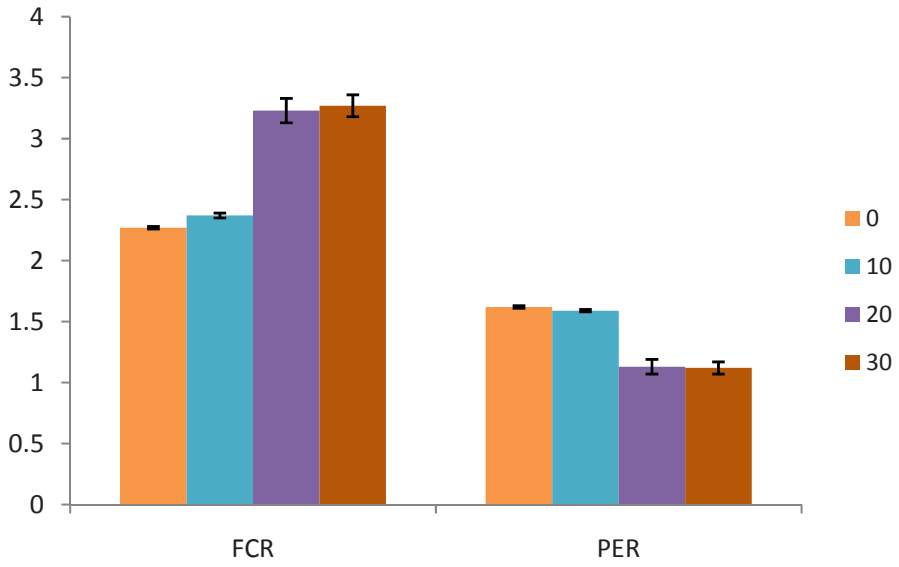
Potential of distiller's dried grains with solubles (DDGS) as feed ingredient for fish and shrimp

In addition to fishmeal, soybean also is an expensive ingredient in aqua feed formulations, therefore research for its replacement with cheaper alternates is essential. Distiller's dried grains with solubles (DDGS) is a by-product of alcohol manufacturing process from cereal grains, rich in essential proteins (60% DM basis) that are advantageous for aqua feed. In India, there is an increase in production of DDGS due to the enhanced ethanol production, therefore it is apt to evaluate DDGS as a feed ingredient in fish and shrimp feeds. An experiment was conducted to replace the soybean meal with rice DDGS at level of 10, 20 and 30% by replacing hi-protein soya on (W/W) basis in the diet of *P. vannamei*. A 45-day feeding experiment carried out indoors revealed that 10% replacement could be effective and there is a potential to further increase the inclusion level by suitable supplementation.

Distiller's dried grain with soluble (DDGS)

Mugil cephalus

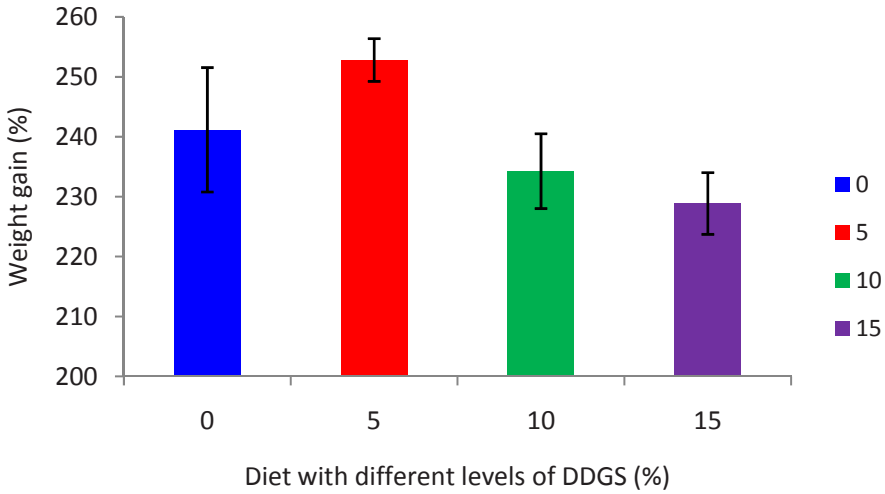
The feed was prepared with four different levels i.e. 0, 10, 20 & 30% of rice DDGS replacing different protein sources. All the feeds were isoproteinous (CP-27%) and isolipidic (EE-9%). After six weeks, it was found that average daily gain and percent weight gain of fish fed 10% DDGS was comparable with control in terms of FCR and protein efficiency ratio (PER). Digestive enzyme activity in the gut significantly ($P<0.01$) increased with the increasing level of DDGS in the feed but surprisingly digestibility of nutrients decreased with increasing level of DDGS. Therefore it can be concluded that DDGS has the potential to replace 30% fish meal and 15% mustard cake and can be incorporated at 10 % level in diet of *Mugil cephalus* without affecting the performance of fish.



Food conversion and Protein efficiency ratios (FCR and PER) of *Mugil celphalus* fed with formulated feed incorporated with DDGS

P. monodon

In tiger shrimp, *P. monodon*, four dietary inclusion levels of (0, 5, 10 & 15 %) of DDGS with isoproteinic (CP-40 %) and isolipidic (EE-7.5%) formula was tested in juveniles (1.35-1.36 g). After six weeks there was no significant difference in shrimps fed with or without DDGS incorporated feed. Protein efficiency ratio (PER) was significantly (P<0.05) higher and feed conversion ratio (FCR) was lower (P<0.05) when shrimps were fed diet with 5% DDGS. Gut digestive enzyme activity was significantly (P<0.01) higher in shrimps fed 10 % DDGS. Crude protein and ether extract digestibility were also significantly (P<0.05) higher in shrimps fed diet with 10% DDGS. Therefore, it can be concluded that DDGS can be incorporated up to 10 % level in diet of *P. monodon* and has potential to replace 10 % fish meal and 12 % soybean meal in the diet of shrimp.



Weight gain (%) in *Penaeus monodon* juvenile fed with or without DDGS

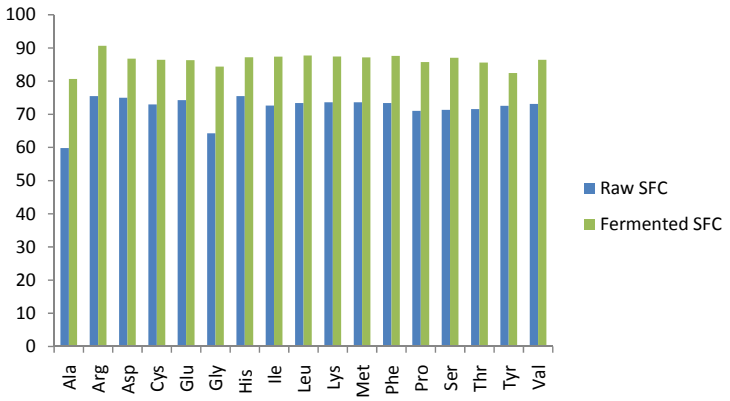
Development and testing of cost effective feed for Kuruma shrimp, *Penaeus japonicus*

CIBA has identified *P. japonicus* as an alternate species for diversification of shrimp farming in region-specific coastal waters of India. As in any other shrimp species, quality feed with optimum nutritional composition is an essential requirement for optimum production. A special feed was formulated and produced to meet the nutrient requirement of Kuruma shrimp. The feed was prepared as crumbled and pellets and tested for its efficacy in tanks and farmer's pond at Bapatla (Andhra Pradesh). The shrimps attained an average body weight of 22 g in four months of culture in ponds

Two feeds were containing 42 and 48% CP and tested for growth performance and survival of kuruma shrimp in 20 tons concrete tanks under semi-biofloc conditions. Three months' culture revealed that the feed having higher protein content has an advantage over the other counterpart. The pigmentation of the Kuruma shrimp grown in outdoor tanks system with a natural feed comprising, micro algae, biofloc and periphyton were darkly pigmented than the pond reared ones.

Effect of fungal *(Aspergillus niger)* fermented sunflower and groundnut oil cakes on shrimp growth, nutrient utilization and amino acid digestibility

The inclusion level of sunflower oil cake (SFC) and groundnut oil cake (GNC) are very limited (2.5-5%) in shrimp diets due to its high fibre fractions and anti-nutritional factors. The solid state fermentation offers several economical and practical advantages to the agricultural by-products by enriching their nutritional quality. To increase its digestibility and incorporation level, these oil cakes were fermented with *Aspergillus niger*. Both unprocessed and fermented SFC and GNC were incorporated at 0, 2.5, 5, 7.5 and 10% in the diet by replacing fish meal. The experimental feeds were tested in shrimp, *P. indicus* juveniles (2.5- 3.4 g) in a 45 day feeding trial. The weight gain % was significantly ($P < 0.05$) higher in shrimp fed diets having fermented ingredients compared to raw ingredients at all inclusion levels. Apparent digestibility coefficients of amino acids were in shrimp (15.05g) indicated that alanine, glycine, proline and threonine are having lowest digestibility values in both raw and fermented sunflower oil cakes whereas arginine is the best digestible amino acid in both (75.48 vs 90.68). The results indicated that incorporation can be increased up to 7.5% by using fermented sunflower oil cake in *P. indicus* diet compared to 2.5% with raw sunflower oil cake. Whereas the fermented GNC incorporation can be increased up to 7.5-10% *P. indicus* diet compared to 2.5-5% with raw GNC.



Effect of fermentation of sunflower oil cake on amino acid digestibility in *P. indicus*

Formulated feed for fattening of mud crabs *Scylla serrata* in individual cages

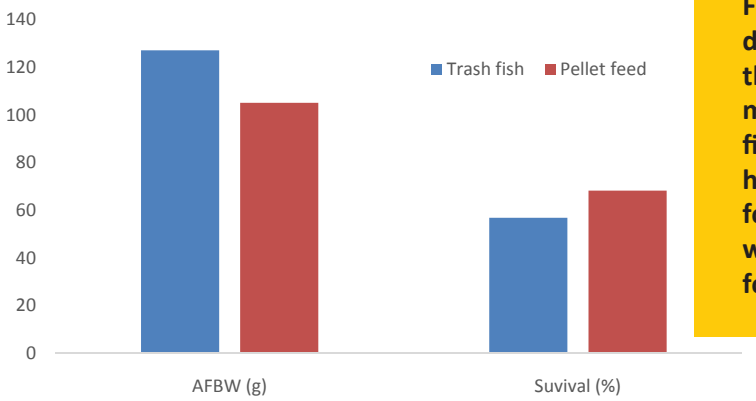
Trash fish is the only option practiced for fattening the mud crabs. CIBA developed two pelleted feeds with 36 and 32% crude protein. The crabs fed with 32% CP have taken longer duration (28 days) than the control and 36% CP pelleted feed (24 days) for hardening. The survival (%) is higher in crabs fed with pelleted feed than the trash fish fed crabs. This led to better biomass harvest in 36% CP pellet feed. Therefore, pelleted feeds can be used an option for profitable crab farming.

Growth monitoring of *Scylla serrata* during the experimental feeding

Effect of formulated feed on growth and survival of hatchery produced mud crabs, *Scylla serrata* reared in mangrove ecosystem

Tribal aquafarmer monitoring the growth of mud cab

The availability of formulated feed is the pre-requisite for the success of crab aquaculture. An experiment was carried out to evaluate the effect of formulated feed on growth and survival in culture of mud crabs. Hatchery produced crablets nursery reared (21.06 g) at Muttukadu Experimental Station (MES) of CIBA were transported to the experimental site at Sorlagondi (Nagayalanka, Krishna District, Andhra Pradesh), Pre-grow out culture demonstration was conducted in mangrove based ponds in six pens (125 m^2 each) at a stocking density of 0.68 m^2. The crabs were fed either with trash fish or formulated pellet feed (40% crude protein and 7.2% crude fat) with three replicates for each. At the end of 105-day culture period the crabs fed with trash fish had significantly higher final body weight (127 g) compared to the crabs fed with pellet fed (105 g), however, survival was significantly higher in the ponds fed with formulated pellet feed (68.2% vs 56.8%). The demonstration trial indicates that hatchery produced crablets can be successfully integrated with mangrove based ecosystem aquaculture by adapting to the formulated pelleted feed.

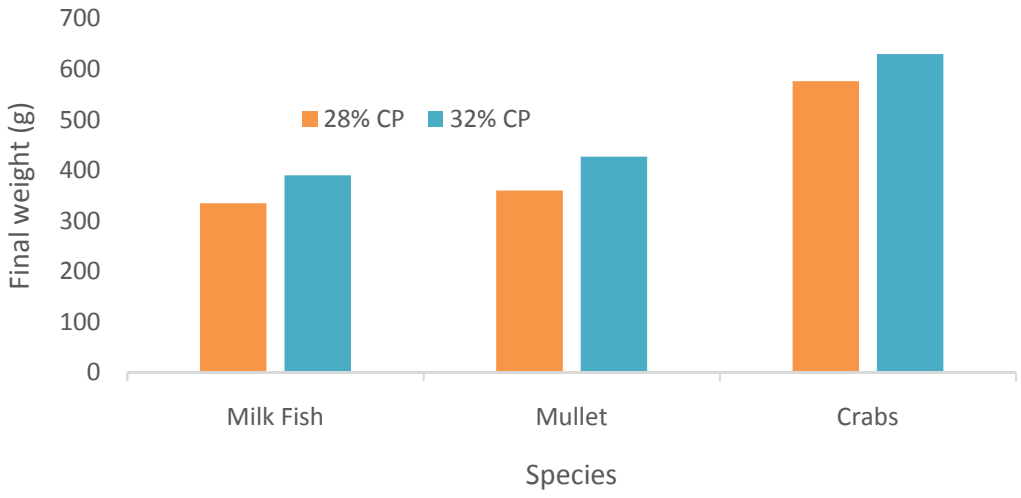


Comparison of growth and survival of mud crab fed trash and experimental formulated feed

Formulated feed has been developed and tested for the grow-out production of mud crab. Although trash fish provided comparatively higher production than the formulated feed, survival was higher in ponds fed formulated feed

Formulated pelleted feed for polyculture of milkfish, mullet and mud crabs

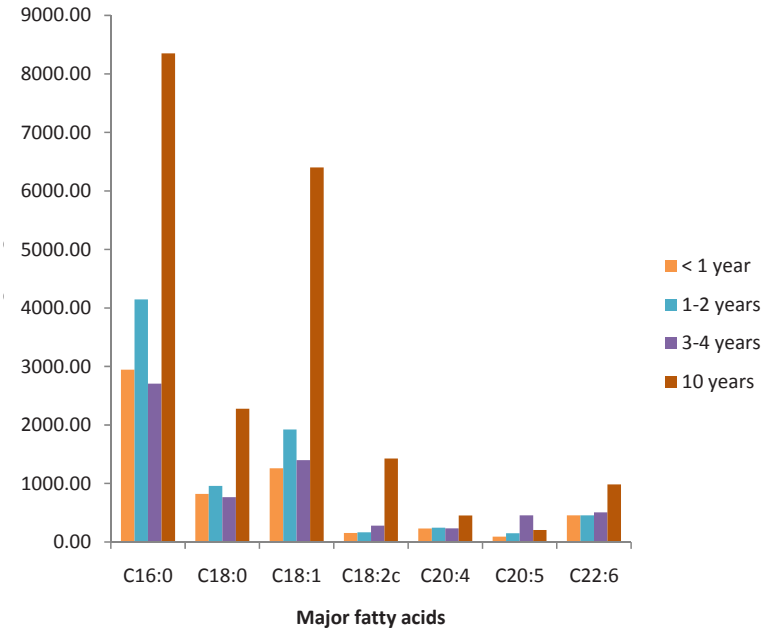
The hatchery produced fingerlings of milkfish, wild collected grey mullets and mud crabs were stocked in 250 m^2 compartments in a ratio of 1:1:0.5 at Sorlagondi (Nagayalanka, Krishna District, Andhra Pradesh). The animals were reared for eight months by feeding two pelleted feeds (28% CP and 32% CP) in three replications for each feed. The results indicated that, fishes fed 32% CP have shown better growth (390, 426 and 630g) compared to 28% CP fed animals (335, 360 and 577 g) for milkfish, mullet and mud crabs, respectively. The survival (%) was not different significantly in both milkfish and mullets fed two different feeds.



Effect of formulated feed on growth of polyculture of fish and crab

Variation in fatty acid profiles of milkfish muscle and liver in relation to age and sex

The fatty acid profiles of milkfish were analysed in relation to age and sex of the fish. The fatty acid content increased with the age in both muscle and liver and was much higher at age of 10 years. The eicosapentanoic acid (EPA) quantity in the liver of 3-4-year-old fish is much higher (457 mg/100g) compared to the 10 years old milkfish liver (205 mg/100g), indicating the liver as the receptacle of lipid reserve. The influence of sex on muscle and liver fatty acid profiles were analysed in 3-4 years age milkfish. The fatty acid profiles are much higher in male fish compared to female fish; indicating the early maturation of males in mullets. This information will be useful in designing diets for different life stages of the mullets.

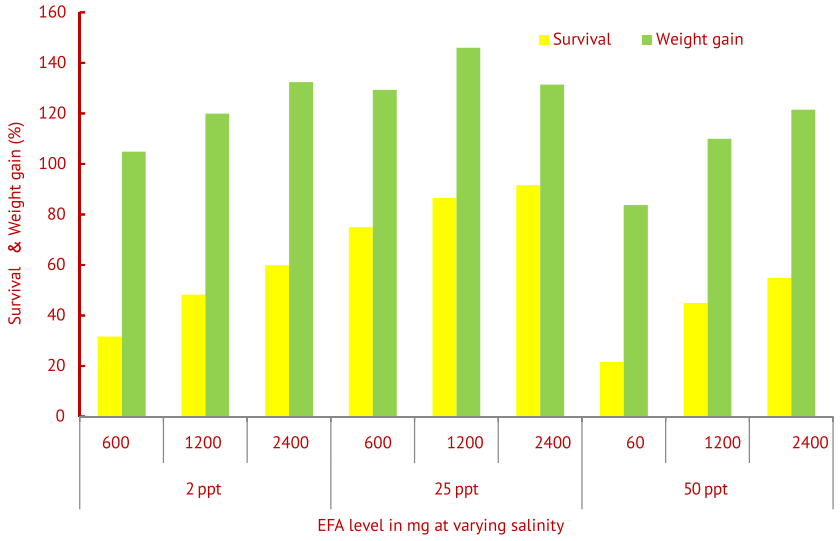


Influence of age on fatty acid profiles (mg/100g) in milkfish liver

Role of dietary essential fatty acid levels in amelioration of salinity stress in *P. vannamei*

During salinity adaptation, energy-demanding mechanisms for haemolymph osmotic and ionic regulation are activated and play a major role in the osmoregulation of shrimp. The objective of this experiment was to optimize the dietary essential fatty acids (EFA) level in osmotically stressed shrimp as these fatty acids are main components of phospholipids that control both 'limiting processes' acting on permeability properties of epithelial structures and 'compensatory processes' driving the active movement of water and ions which are the two mechanisms by which shrimp maintains osmoregulation. An experiment was conducted in a 3x3 factorial design with three salinity rearing regimes (2, 25 and 50 ‰) and three dietary levels of EFA (600, 1200 and 2400 mg/100g diet) with *P. vannamei* (6.44 ±0.31 g) for 45 days. The results indicated that the feed having higher level of EFA is

beneficial for amelioration of salinity stress in terms of higher survival (31.7 to 60 in hypo-osmotic stress and 21.7 to 55 in hyper osmotic stress). But higher level of EFA in shrimp reared in normal salinity (25‰) reduced the growth (145.99 to 131.53). Dietary modification with changing EFA levels increased the survival and growth performance of *P. vannamei* in hyper and hypo salinity stress environment.



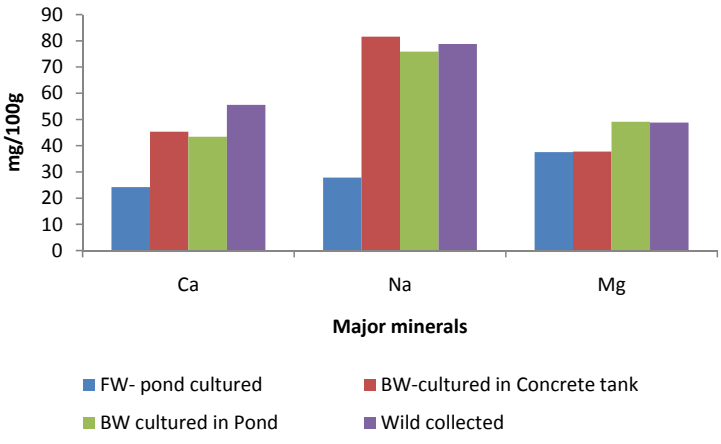
Effect of essential fatty acid on survival and weight gain in salinity stressed *P. vannamei*

Comparative fatty acid profiles of wild and farmed mud crabs

The fatty acid profile of body muscles was analysed from different culture system and were compared with wild collected mud crabs. Although the proportion of eicosapentanoic and docosahexaenoic acids were found to be low in farmed mud crabs, the absolute amounts were found to be significantly high in the crabs fed with formulated feed. This database helps for nutritional labelling, and, further, it forms the base for dietary prescriptions for doctors and dieticians. And also this information on the nutrient composition facilitates the processing, utilisation and marketing of mud crab products.

Mineral composition of different parts of milkfish from different systems

The milkfish, *Chanos chanos*, was collected from different rearing systems: tanks and ponds (brackishwater), near freshwater ponds and wild ecosystem. The mineral composition of different parts of the fish were analysed to understand the effect of environmental salinity on

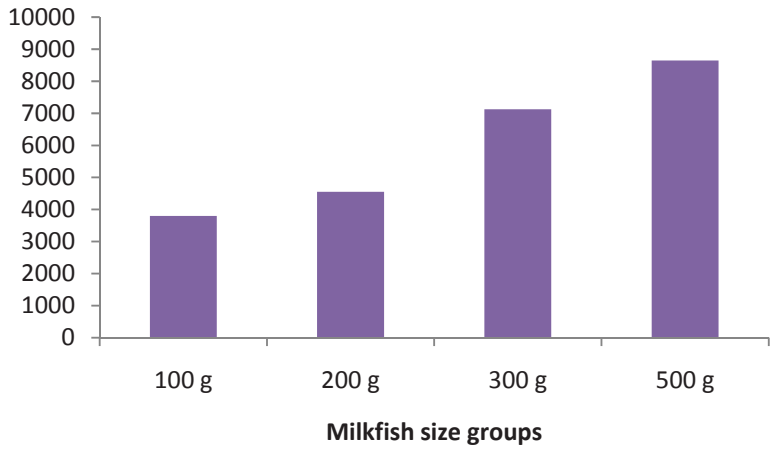


Milkfish muscle mineral composition (mg/100g) collected from different systems

mineralization. The calcium composition (mg/100g) in ~fresh water collected fish was significantly (P<0.05) lower in the muscle (24), head (1680) and spines (5980) whereas it was two times higher in the scales (4916). This higher calcification in scales in ~fresh water reared fish indicates the calcium reserves or the homeostatic mechanism. The potassium content in the muscle is almost similar in the fishes collected from different systems whereas it was 4 times lower in spine and 10 times lower in the scales in fishes reared in freshwater system. The sodium content is significantly (P<0.05) lower in the muscle and scales in fishes reared in freshwater system. This database helps not only for feed formulations but also for nutrient profiling.

Effect of fish size on mineral composition of spines in milkfish

One of the major hurdles in milkfish consumption is its intramuscular spines. These spines are very long and sharp. In the present study the mineral profiles of milkfish muscle and spines were analysed to understand the correlation of size and calcification of spines. The mineral data indicated that the calcium content increased with the increase of size of the fish but the increase is not uniform. Very marginal increase (20%) was observed with the increase of fish size from 100 g to 200 g whereas the increase is very sharp (56%) from 200 g to 300 g size.



Calcium content (mg/100g) in the spines of milkfish from different size groups

Fish silage and its use as an alternate for fishmeal in aqua feeds

Fish waste was minced and fermented with formic acid at different level (V/W) i.e., 3, 4, 5, 6, 7, 8, 9, 10 and 20% formic acid (85%) in a concrete tank at ambient temperature (31.7 to 33 °C) for 15 days. Proximate analysis revealed that crude protein (CP) and ether extract (EE) content were significantly (P<0.01) higher

A cost effective system for fish silage production

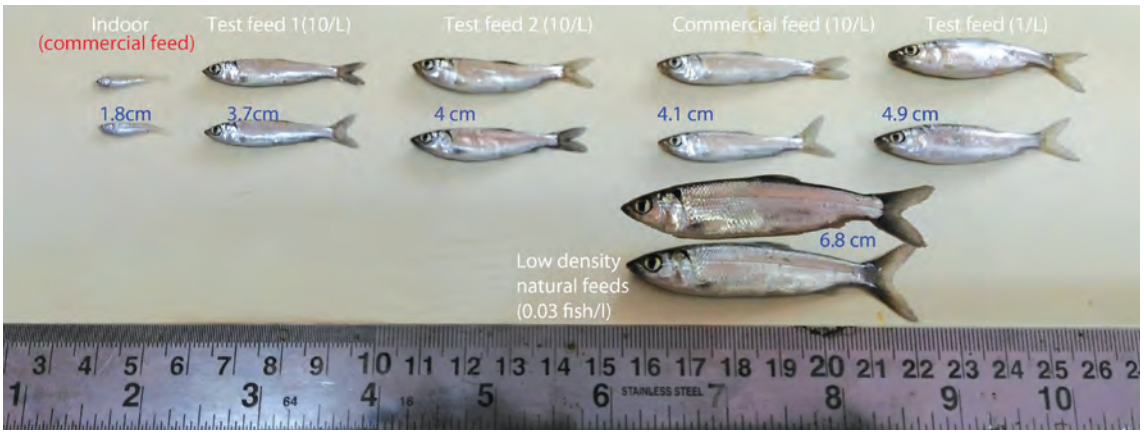
Dried fish silage

when fish waste was fermented with 3% formic acid. After specified period of fermentation fish silage was treated with sodium hydroxide (0.05 M) to bring the pH in neutral range. Fish silage was dried at 50 °C in electrical drier and then ground to powder form. Amino acid profile, fatty acid profile, mineral and vitamin composition of fish silage, prepared with 3 % formic acid and fermented for 15 days, was analysed. Dry matter, CP and EE digestibility of fish silage in *Penaeus monodon* and *Mugil cephalus* has been estimated and were found to be in the range of 44.89-58.58, 60.58-78.10 and 88.04-91.02, respectively. From the results of the growth trial, it can be concluded that fish silage can be incorporated at 10 % level in diet of both *P. monodon and M. cephalus.*

Nursery rearing of milkfish using formulated nursery feeds in outdoor green water system

Efficacy of green water system for rearing of milkfish larvae was evaluated using commercial feed and micro particulate feed developed by CIBA. While growth performance of commercial feed and experimental feed was similar, significantly higher growth and survival was observed in the green water culture system.

Availability of appropriate sized seed has been a bottleneck in milkfish farming. Development of feed for larval and nursery rearing is the next critical step, to scale up seed production and commercialize the milkfish production. We developed micro particulate dry feeds and feeding strategy for mass rearing of milkfish fry in outdoor green water system. Micro particulate larval feeds were formulated and prepared by cold extrusion and spheronization to contain 42% protein and 8% lipid. Milkfish larvae (12 mm TL; 10 mg BW) were reared in floating baskets (10 L) in outdoor green water tanks at a stocking density of 10 number/L for 40 days. Similar system in the clear water was kept at indoors as control. At the end of 40 days there were no significant differences in growth performances of milkfish fry fed imported commercial feed and CIBA's micro particulate feed. However, there was significant difference in the final body and survival of milkfish reared on formulated feed alone in clear water and those which had access to natural feed and supplementary feed. It clearly indicated that natural feeds in the form of biofloc, periphyton and micro algae have certainly contributed nutrition to the fish fry in addition to keeping clean the water. Therefore, green water is not only cost effective, but also efficient for realizing the maximum growth potential of the milkfish fry.

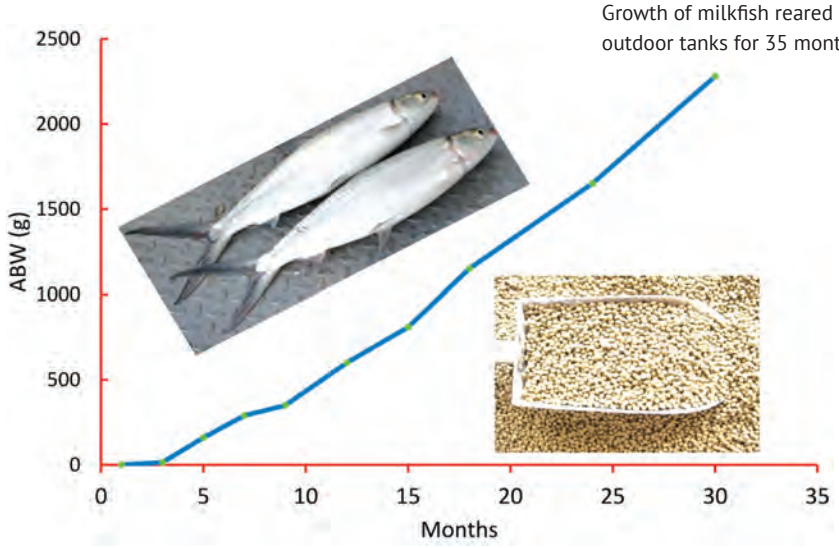


Differential growth of milkfish fry under varying feed and feed management strategies

Diet related changes in growth and blood chemistry of milkfish reared under tank conditions for two years

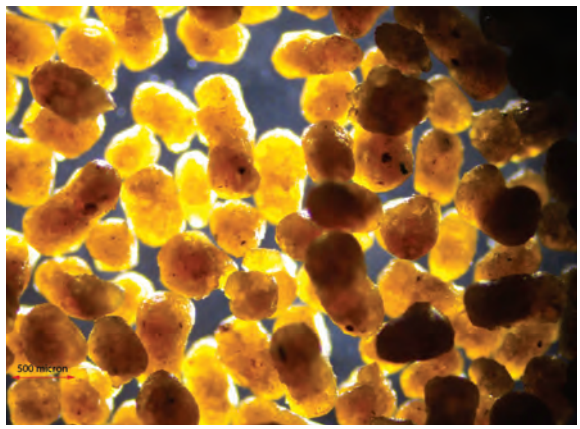
Milkfish reaches maturity at the age of 4 to 5 years in wild conditions. Getting adequate number of broodstock of right age is critical part in milkfish breeding. As approach towards captive maturation, we attempted to test the possibilities of getting rapid maturation in captivity by dietary interventions in milkfish. Wild seeds reared in captivity for 2.5 years in different rearing systems such as small FRP tanks, floating cages, and finally elevated concrete tanks of 500 L, 2 m3 and 20,000 L respectively. The fishes were fed regular grow-out diets in the up to the size of 250 g obtained in cages. Latter they were stocked in RCC tanks of 20 ton size and fed speciality diet with higher dietary lipids. After 2.5 years average final body weight obtained was 2.3 kg in 30 months which is much lower than what normally reported in pond conditions. There was significant difference in the blood lipid profiles among the dietary treatments. However, there was no differential gonad formation among the dietary treatments. Thirty nine harvested fishes were given to fish culture division and were stocked in ponds for developing them as next brood stocks lines.

Growth of milkfish reared in outdoor tanks for 35 months



Intensive nursery rearing of pearlspot juvenile using micro bound nursery feeds in microcosm tanks

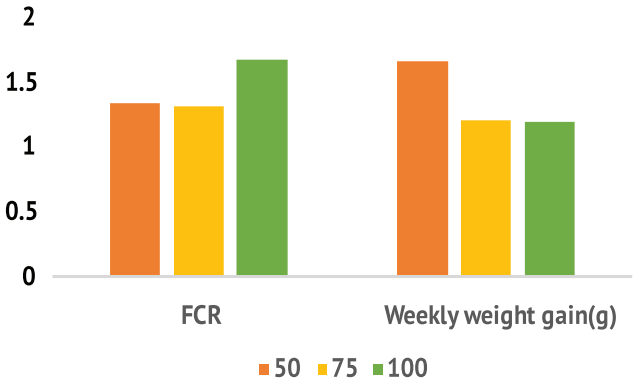
Juvenile pearlsspot reared using micro bound feed



Spheronized micro bound diet viewed under microscope (10X)

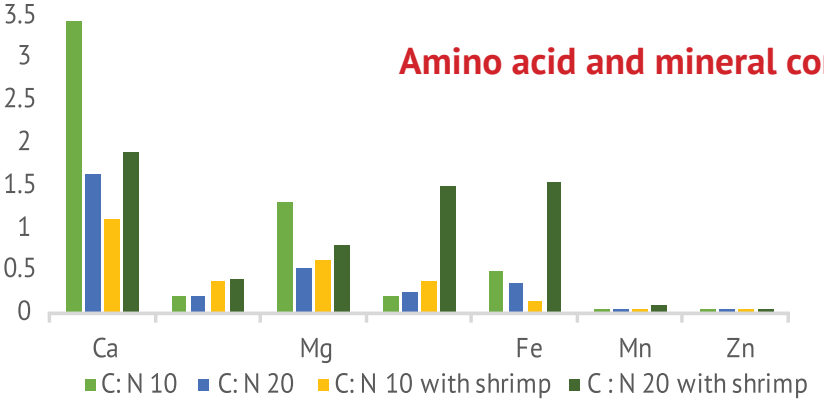
We have already perfected feed for breeding and larval rearing in a cost effective way; the next step is optimisation of intensive nursery rearing which could significantly reduce the farming duration in the ponds and cages and assure a good yield in short duration. We aimed to produce 1 g size juveniles from late fry of 80 to 120 mg size, and optimize feed and feed management against high stocking density 1000/m^3 in microcosm tanks. Nursery feed of 32% protein was offered thrice daily at fixed feeding ration according to our own feeding chart. Sampling was done regularly to know the survival and weight increment. At this density, we were able to produce 1 g (900 mg to 1200 mg) juvenile within 40 days of rearing with >95% survival and FCR of 0.8 to 1.

Influence of shrimp stocking density on growth performance of *P. vannamei* in microcosm conditions rich in natural feeds



Growth performance of *P. vannamei* stocked in different densities in microcosm tanks

Nutritional needs of selectively bred vannamei differ from wild, and it needs an improved feed and management strategy to realize its revised genetic potential. Studies in our own labs and outside have shown that vannamei have great potential to feed in the water column and utilize the suspended biofloc and periphyton as natural feeds. This study was conducted (70 days) to know the influence of different shrimp (0.84 g) stocking density and feed utilization on the presence of natural feeds at densities of 50, 75 and 100 shrimps/m^3 in microcosm tanks in 3 replications/ treatment. All the husbandry management in microcosm tanks was adopted as standardised earlier in this system by our lab. Overall performance of the shrimp growth was similar to reported in pond system. Among the three different densities, 50 shrimp/m^3 recorded a significantly higher weekly gain (1.65 g/week) indicating a better utilization of the nutrient resources. However, the weight gain obtained with 75 and 100 densities was almost similar (1.2g/week) indicating the limited potential of formulated feed in realizing the shrimp genetic potential. Around 1 g weekly weight gains even in high density around 100 shrimps/m^3. This study indicates that the optimum density for better utilization of natural feeds and supplemental feed would be 50 shrimps/m^2.



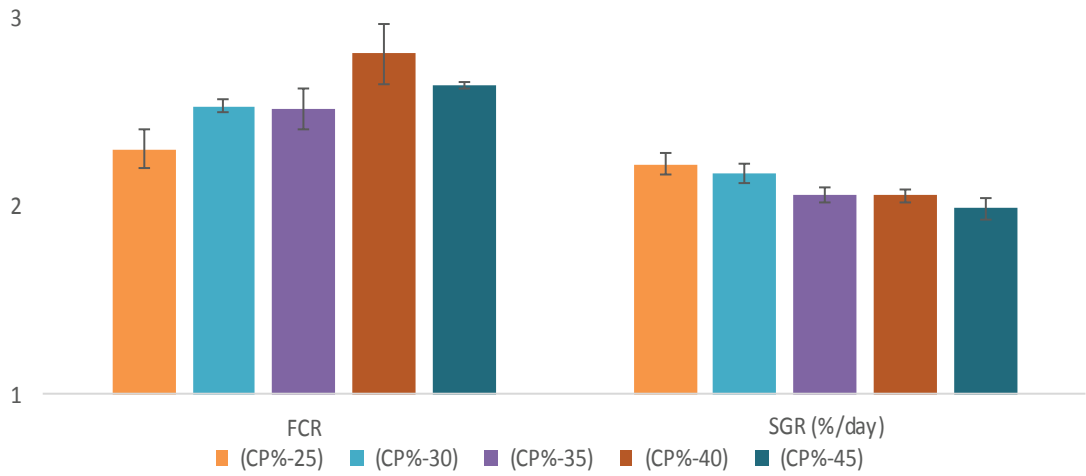
Amino acid and mineral composition of biofloc

Use of biofloc for *in situ* feeding of aquatic animals and for treating the rearing water is a growing trend, and also there is a potential for using it as feed ingredient after separation from water. It needs a

thorough study on the variation in nutritional quality of biofloc meal. We studied proximate composition, amino acid and mineral content in relation to varying C: N ratios. Results showed average protein content of the dried biofloc meal was 31.5% and is highly variable. Ash content was >20% irrespective of C: N ratio. Amino acid and mineral composition was showed a significant variation an relation to C: N ratio. Methionine content in all the biofloc samples (3.5% of the protein) were in the level more than its level in fishmeal (2.9% of the protein), as an added benefit.

Dietary protein requirement for *Mystus gulio* fry

Protein is a costliest and critical nutrient in larval feed. In order to determine precise requirement of protein in the diet of *M. gulio*, a 42-day feeding experiment was conducted. Five practical diets containing graded levels of protein (25, 30, 35, 40 and 45%) were fed to *M. gulio* fry. The experiment was conducted in 100 L FRP tanks with five treatments and three replicates containing fifteen *M. gulio* fry in each with an average body weight of 0.46 g. Although no significant difference in average daily gain (ADG; mg/day), feed conversion ratio (FCR) and specific growth rate (SGR; %/day) were observed among treatments. Significantly higher survival rate was observed with 25% protein treatment. This result suggests that 25 % dietary protein level is optimum for this species.



Growth performance of *M. gulio* fed varying dietary protein levels

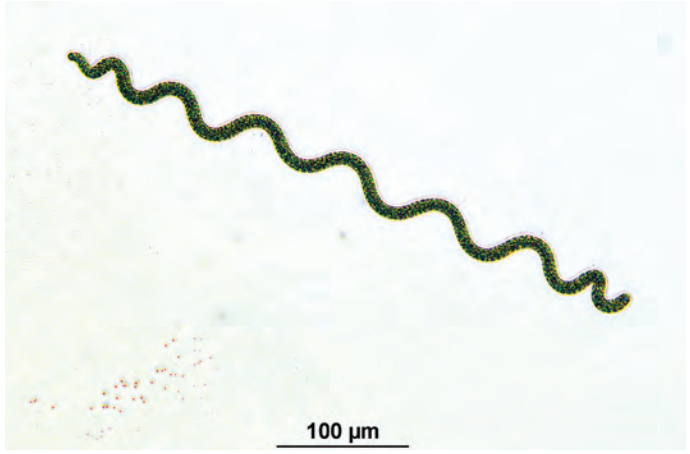
Development of grow-out feed for *Mystus gulio*

Feed for *M. gulio* was formulated with 25 % protein and 6% fat and evaluated in high density culture with feeding @ 8-5% of biomass in earthen pond. In a 6-month culture, fish attained average marketable size of 50 to 60 g with production of 700-1000 Kg/ha with 20 ps/sq m stocking density. Cost of production was Rs. 90/ kg and marketed @ Rs. 250/ kg, which is economically lucrative. High density farming (10-20 nos./sq m) in small backyard ponds (300 to 500 sq m) with low cost formulated feed is recommended to the farmers.

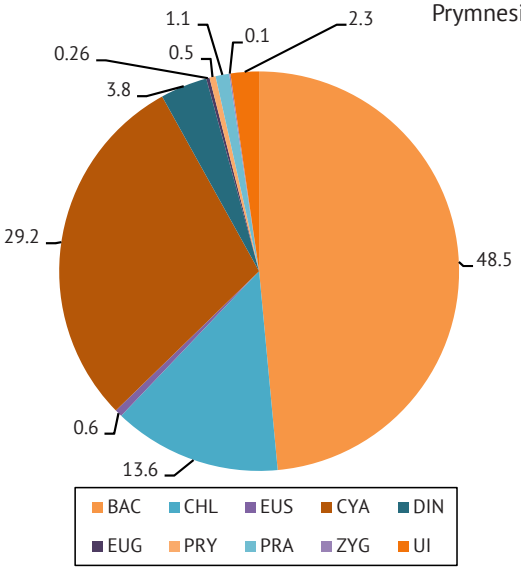
Diversity of potential microalgae of aquaculture importance from Muttukadu Backwater

Use of microalgae as live feed is key element in hatchery production fish seeds. A detailed study was conducted to unravel the dynamics of microalgae diversity in a tropical estuarine ecosystem, Muttukadu backwater, Kanchipuram district, Tamil Nadu for a period of 18 months (May 2015-October 2016). Selected diversity indices (Simpson index, Dominance index, Shannon- Weiner index, Pielou's evenness index and Margalef richness index) represented the pattern of diversity in the backwater during the study period. Eighteen potential microalgae strains were isolated from the waters during the study period. *Chaetoceros gracilis*, *Thalassiosira weissflogii*, *Chlorella vulgaris, Tetraselmis* sp, *Isochrysis galbana, Cylindrotheca* sp, *Amphora* sp, *Nitzschia* sp *Arthrospira maxima* and *Spirulina subsalsa* are some of the important strains isolated. The selected strains were subjected to nutrient profiling to find out the best combination to use as live feed in larviculture. *Isochrysis galbana*, *Chaetoceros gracilis*, *Tetraselmis* sp, *Chlorella vulgaris*, *Thalassiosira weissflogii* are being utilizing in mud crab (*Scylla serrata*), shrimp (*Penaeus indicus/ Marsupenaeus japonicus*) and fish (*Chanos chanos*) larval rearing.

Arthrospira maxima



Arthrospira Platensis



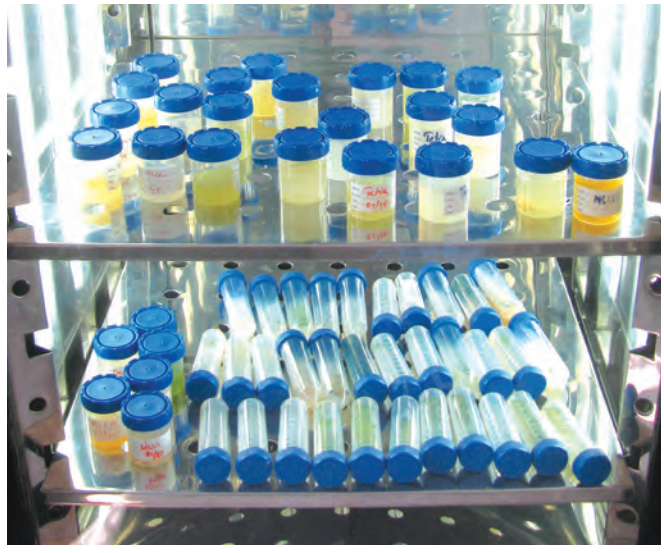
Abundance of microalgae groups in Muttukadu during study period

BAC: Bacillariophyceae, CHL: Chlorophyceae, EUS: Eustigmatophyceae, CYA: Cyanophyceae, DIN: Dinophyceae, EUG: Euglenophyceae, PRY: Prymnesiophyceae, PRA: Prasinophyceae, ZYG: Zygnematophyceae

Dynamics of microalgae in Muttukadu lagoon (Kancheepuram, Tamil Nadu), was studied, and 18 potential microalgal strains were identified. *Isochrysis galbana, Chaetoceros gracilis, Tetraselmis* sp, *Chlorella vulgaris, Thalassiosira weissflogii* are being utilizing in mud crab (*Scylla serrata*), shrimp (*Penaeus indicus/ Marsupenaeus japonicus*) and fish (*Chanos chanos*) larval rearing. nutrient profiling of five selected microalgae revealed that they have potential to be used as live feeds in larval rearing of finfish and shellfish. Highest protein content was noticed in *Thalassiosira weissflogii* (42.08 %) followed by *Nannochloropsis* sp (38.4 %). Meanwhile, the lipid content of Isochrysis galbana (26.8%) was highest among other species followed by *Thalassiosira weissflogii* (20 %). The fatty acid analysis of selected microalgae revealed the percentage of essential fatty acids (eg EPA and DHA). EPA level was highest in *Nannochloropsis* sp (25.02 % of total fatty acids) followed by *Thalassiosira weissflogii* (17.77 %). Highest percentage of DHA was in *Isochrysis galbana* (7.37 %)

Identification of microalgal strains using molecular taxonomy

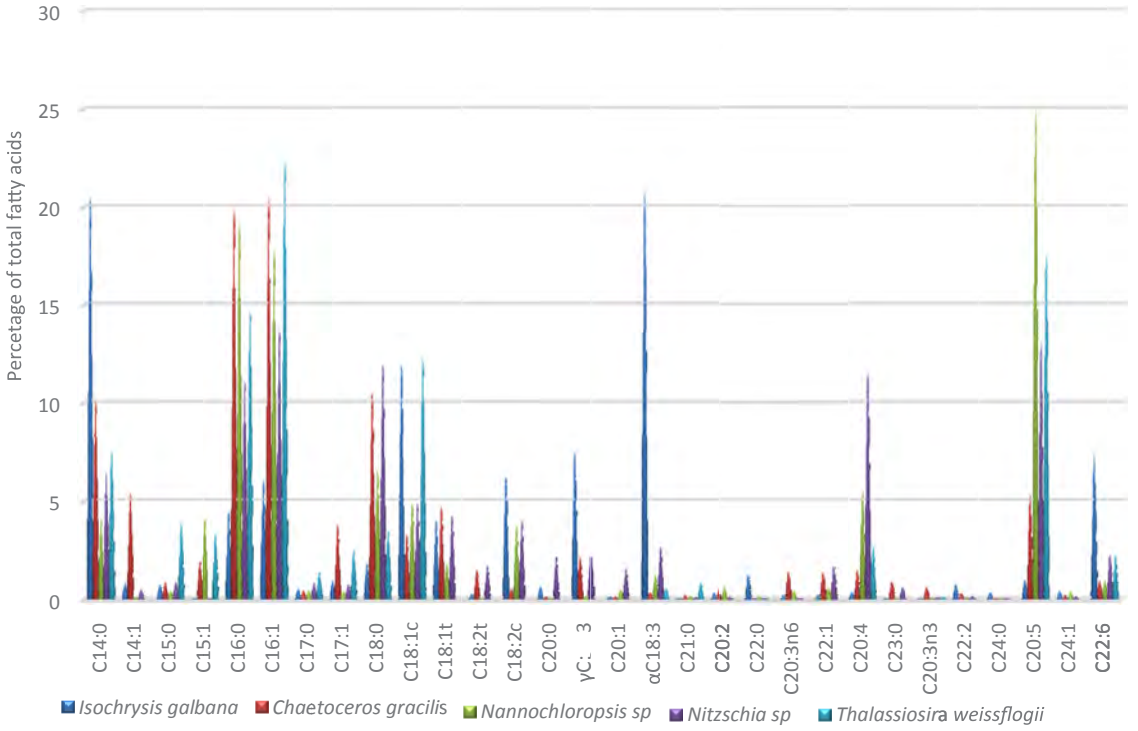
Identification of micro algal strains in species level is a challenging task. To solve the taxonomic ambiguity of these isolates some molecular techniques were administrated along with classic morphology. The molecular taxonomy is based on small subunits (SSU) rRNA gene (18s for eukaryotes and 16s for prokaryotes). PCR amplification of desired gene and its sequence BLAST analysis against the submissions present in the universal database gave the taxonomic clarity in microalgal isolates. *Chaetoceros gracilis*, *Thalassiosira weissflogii*, *Isochrysis galbana, Cylindrotheca closterium,*



Amphora sp *and Nitzschia* sp are some of the important strains identified. These identified isolates are maintained CIBA's micro algal lab for further studies and mass culture.

Nutrient profile of microalgae

Micro algae are known to synthesize some unique nutrients such as essential fatty acids in the food chain, and they have immense potential in human and fish nutrition. In this context, nutrient profiling of five selected microalgae revealed that they have potential to be used as live feeds in larval rearing of finfish and shellfish. Highest protein content was noticed in *Thalassiosira weissflogii* (42.08 %) followed by *Nannochloropsis* sp (38.4 %). Meanwhile, the lipid content of Isochrysis galbana (26.8%) was highest among other species followed by *Thalassiosira weissflogii* (20 %). The fatty acid analysis of selected microalgae revealed the percentage of essential fatty acids (eg EPA and DHA). EPA level was highest in Nannochloropsis sp (25.02 % of total fatty acids) followed by *Thalassiosira weissflogii* (17.77 %). Highest percentage of DHA was in Isochrysis galbana (7.37 %).

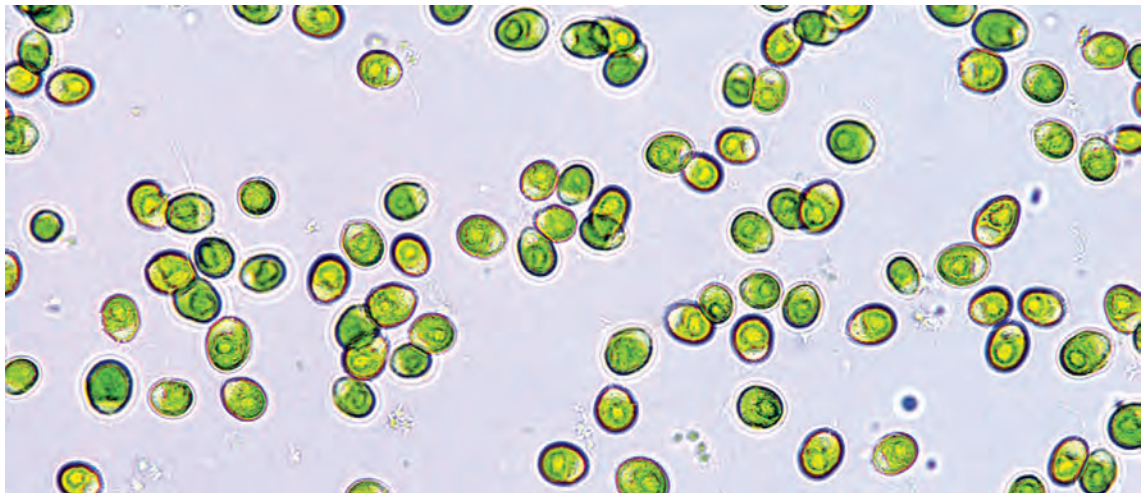


Fatty acid profiling of locally isolated strains

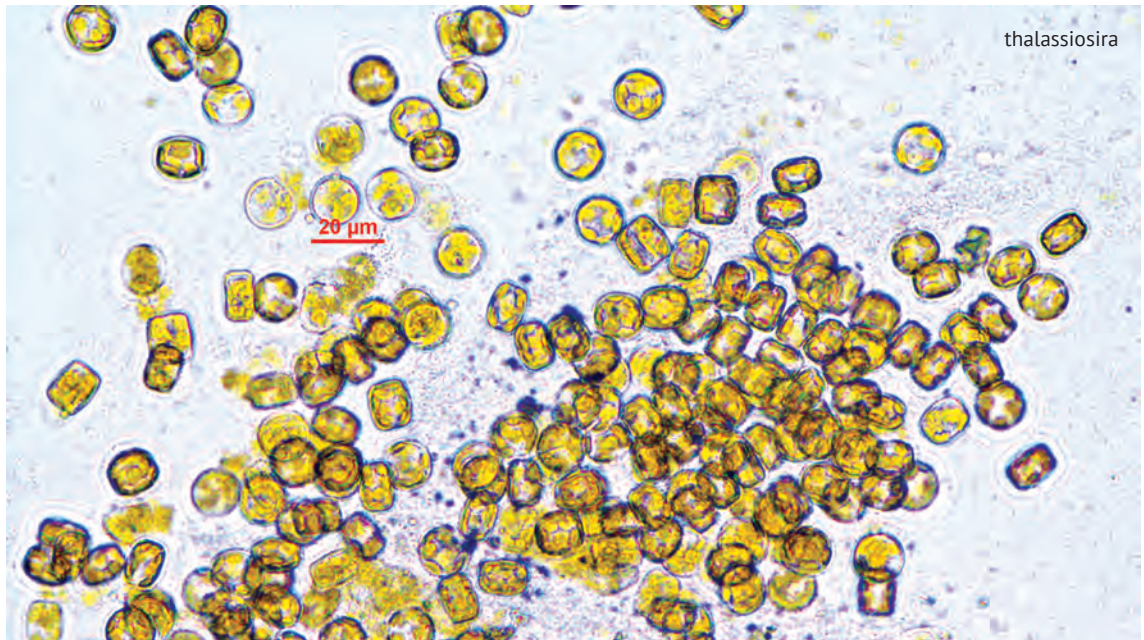
Two potential spirulina species from Muttukadu backwaters

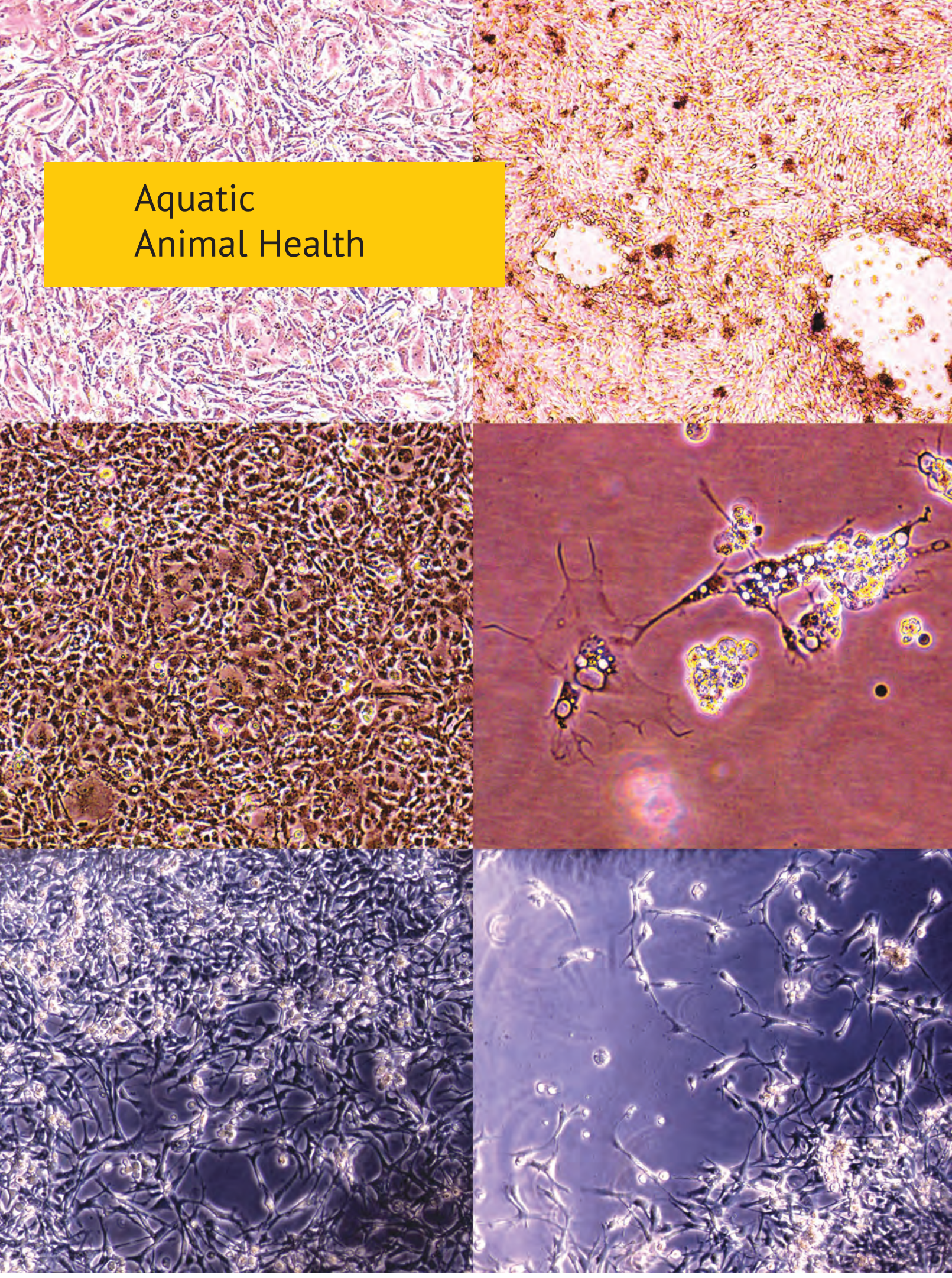
Spirulina are widely known for their nutraceutical value. Two species of spirulina has been isolated from Muttukadu backwater (*Arthrospira platensis* and *Spirulina subsalsa*). Isolated strains are developed in mNRC and Zurroucks medium. This is the first report on the isolation of commercially important spirulina species (*Arthrospira maxima*) from east coast of India. The growth potential of the isolates was studied under laboratory conditions. *Arthrospira maxima* showed better growth than *Spirulina subsalsa*. *Arthrospira maxima* isolate was acclimatized to indoor and outdoor culture systems in suitable cost-effective media. The biomass was harvested and to be utilized for experimental feed preparations. The quality of biomass in terms of proteins and pigments has been compared with reference strains and it is found to be par with them.

Stock of *Arthrospira maxima* isolates



Dunaliella 1





Aquatic Animal Health

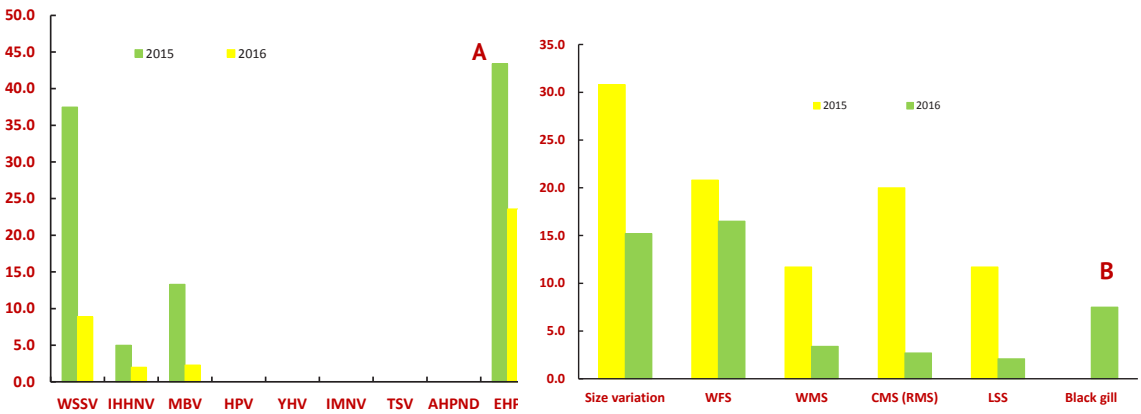
AQUATIC ANIMAL HEALTH

Enterocytozoon hepatopenaei (EHP) continues to haunt brackishwater aquaculture in India

During the year 2016-17, Disease surveillance was carried out in 155 shrimp farms. The prevalence of hepatopancreatic microsporidosis (HPM) caused by *Enterocytozoon hepatopenaei* (EHP) was recorded in 23.6% of the shrimp farms. It was interesting to note that the larval samples from 27 shrimp hatcheries including mysis and PLs of *P. vannamei* and *P. monodon* from AP, TN and Kerala were free from EHP by PCR. The prevalence of the devastating white spot disease (WSD) was found to be relatively lower than the previous year and was recorded in 8.9% of the farms investigated. The prevalence of infectious hypodermal and hematopoietic necrosis (IHHN) was also low with 1.3% of farms being affected during the year. Other disease syndromes attributable to poor farm management such as stunted growth, white faeces syndrome (WFS), white muscle syndrome (WMS), running / chronic mortality syndrome (CMS) and black gill syndrome were observed in 15.17, 16.5, 3.4, 2.7% and 7.5% of the farms respectively.

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 of 55 and 70 DOC in East Godavari, Andhra Pradesh (AP) and a farm in Nagapattinam, Tamilnadu (TN). Mortality due to IMNV was about 15% in affected ponds as per the farmers. Among the finfish diseases, dual infection with Irido (RSIVD) and VNN was common in farmed and wild finfish such as seabass, mullet, red snapper and Tilapia.

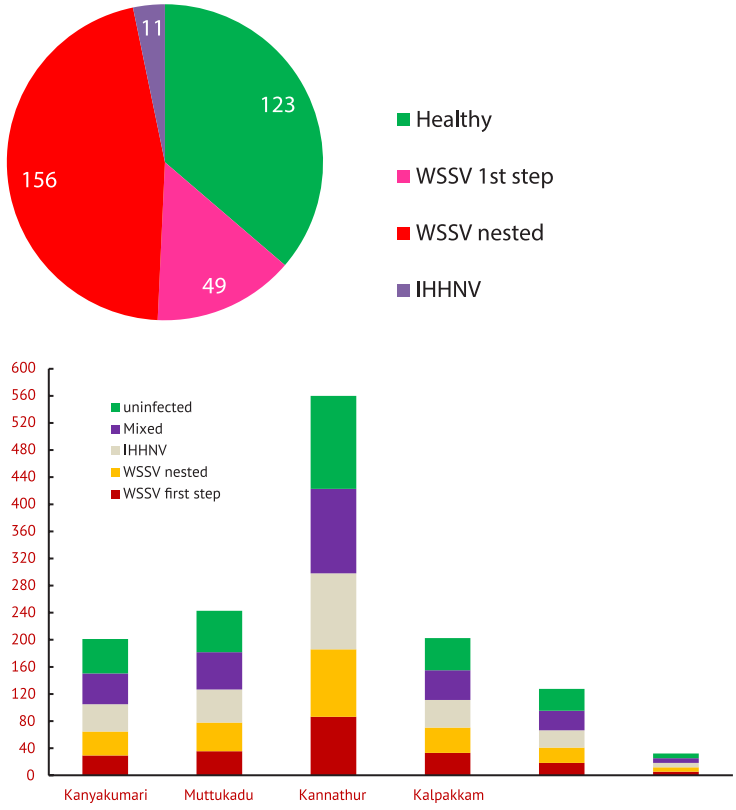
Enterocytozoon hepatopenaei (EHP) is continues to be the most important pathogens affecting shrimp aquaculture in India. Nearly 24% of farms out of 155 shrimp farms surveyed were affected by EHP. Interestingly, none of the mysis or post larval samples obtained from the 27 hatcheries surveyed were infected by EHP



A: Viral, bacterial and fungal diseases in AP and TN During 2015-16(120 farms), 2016-17 (155 farms) investigated,
B: occurrence of aquaculture system related diseases in AP and TN observed during 2015-17

Pathogen profiling of *Penaeus indicus* broodstock

As part of aquaculture diversification plan, CIBA has taken up a flagship program on indigenous white shrimp breeding and culture. *Penaeus indicus* broodstock sourced from five locations in Tamil Nadu (Kanyakumari, Muttukadu, Kanathur, Kalpakkam and Kasimedu) and one location in Odisha (Balasore) were screened for indigenous viral pathogens (WSSV and IHHNV) to ascertain the suitability for breeding programme in CIBA hatchery. The study was carried out during the year with 284 *P. indicus* broodstock using OIE protocols. It was found that as high as 72% of broodstock were affected with WSSV and 3.87% were affected by IHHNV.



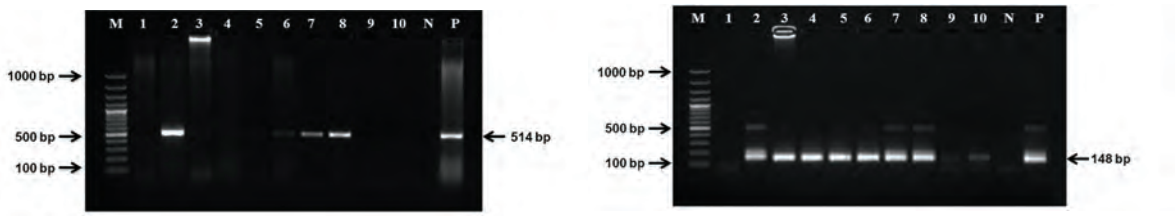
Prevalence of WSSV and IHHNV in Wild *Penaeus indicus* broodstock and in different locations on the East coast of India

Hepatopancreatic microsporidiosis of shrimp

Hepatopancreatic microsporidiosis (HPM) caused by *Enterocytozoon hepatopenaei* (EHP) has been causing serious concern in shrimp farming in India since 2015. Heavy infections may lead to retarded growth and finally the farm production. Earlier studies showed that natural infection of microsporidian parasite has been found in association with an array of clinical signs reported from grow-out farms.

Shrimp samples with known history of white faecal syndrome (WFS) and signs of growth retardation obtained from affected farms were confirmed to be naturally infected with EHP by PCR. These shrimp were separately reared under laboratory conditions and closely monitored for a month. Most of the shrimp in both groups showed signs of white gut and excretion of white faeces, which ultimately recovered under laboratory conditions. However, the feed intake was reduced with characteristic empty watery gut and pale yellow hepatopancreas. Reappearance of pale yellowish faecal threads were observed after 24th day, but the faecal strands did not float on the surface of water like 'white faecal thread' usually observed in grow-out ponds. White faeces sampled from live animals and hepatopancreas from dead animals also tested positive by PCR. The severity of EHP infection in these animals increased from 83% on day 15 to 100% on day 30 as indicated by

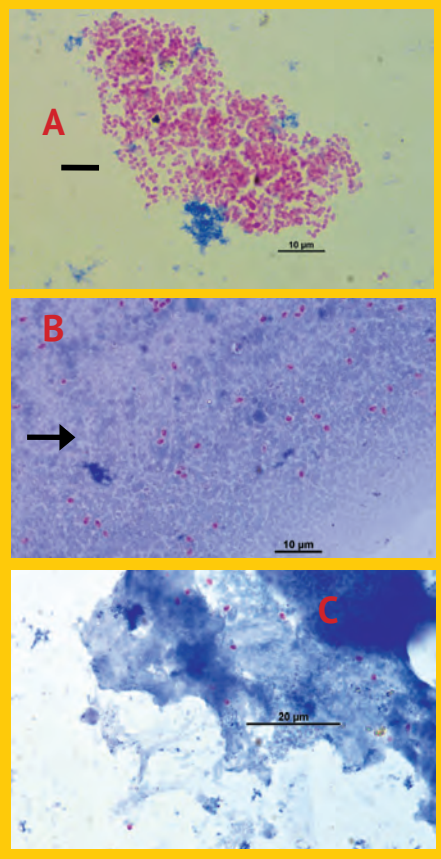
PCR tests. PCR negative animals on 1st and 15th day of maintenance were found PCR positive on 30th day. The EHP infected shrimp neither showed significant weight gain nor mortality even after 30 days of captivity, but most of the animals showed signs of loose shell syndrome. Persistence of EHP infection and release of microsporidian spore in faeces continued till the end of the monitoring period.



A representative samples (1-10) of shrimp tested for *Enterocytozoon hepatopenaei* using SWP PCR amplifying 514 bp and 148 bp amplicon.

Improved microscopic method for detection of EHP in shrimp

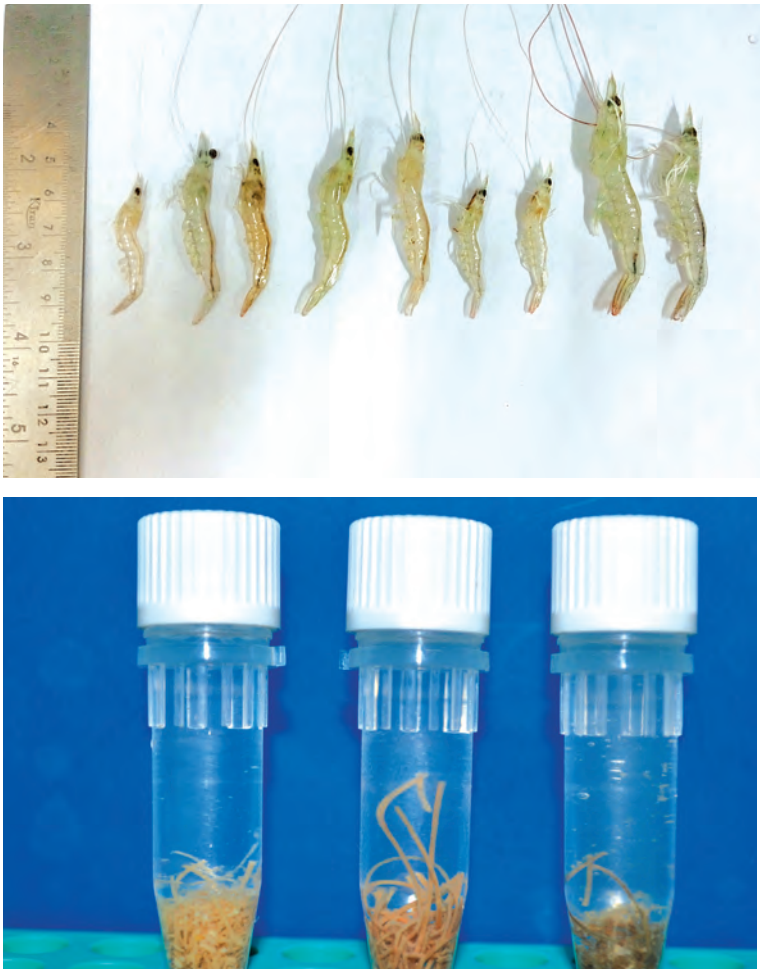
Light microscopic examination of the stained clinical smear is an inexpensive method for diagnosing microsporidian infections although it does not allow species level identification. EHP spores could be relatively easily detected by microscopic examination of modified Ryan-blue trichrome staining method. This improved selective staining protocol would be useful for the detection of microsporidian spores in faecal / hepatopancreatic smears and histological section of shrimp hepatopancreas. This method enables differential diagnosis of microsporidian spores by a characteristic staining pattern of pinkish-red which could be easily distinguished from similarly staining particles or debris.



Spores of *Enterocytozoon hepatopenaei* from shrimp faeces after formalin-ether sedimentation, stained by modified trichrome staining (A-heavy, B-moderate and C-light infections). Spores (arrow) are ellipsoidal staining pink-red with a small polar or central non-staining zone (inset: enlarged view).

Transmission of EHP in shrimps

Transmission of EHP from shrimp to shrimp is known to be by cannibalism and cohabitation, making difficulties for control in rearing ponds. Bioassay experiments were conducted to understand the mode of transmission of EHP. It was found that EHP could be transmitted to healthy SPF vannamei shrimp on two weeks of cohabitation with infected shrimp and after seven days of feeding with hepatopancreas from the EHP affected shrimp. Another interesting observation was that EHP could be transmitted through soil as confirmed by PCR upon 15 days of exposure of healthy shrimp to pond-soil. However, shrimp reared in pond water from EHP affected ponds were not found to be infected with EHP even after 30 days of rearing. It suggests that the spore count in the pond water may not be adequate to elicit infection. There was no weight gain in any of these experimental groups compared to control. These bioassay experiments confirmed transmission most likely by oral route and hence a direct life cycle for EHP. The earliest detection of spores by PCR in healthy shrimp by *per os* challenge with infected hepatopancreas was found to be five days post infection, with clinical signs of pale faeces, significant growth retardation in test group as compared to uninfected control group. All other methods of exposure to naive shrimp showed a delay probably due to low level of oral ingestion of spores originating from faeces and soil.



Growth retardation and white faeces upon per os experimental infection of *Enterocytozoon hepatopenaei* in *Penaeus vannamei* (A) and pale coloration of faeces (B) in affected shrimp 30 day post infection

Role of aquatic invertebrates as carriers for EHP

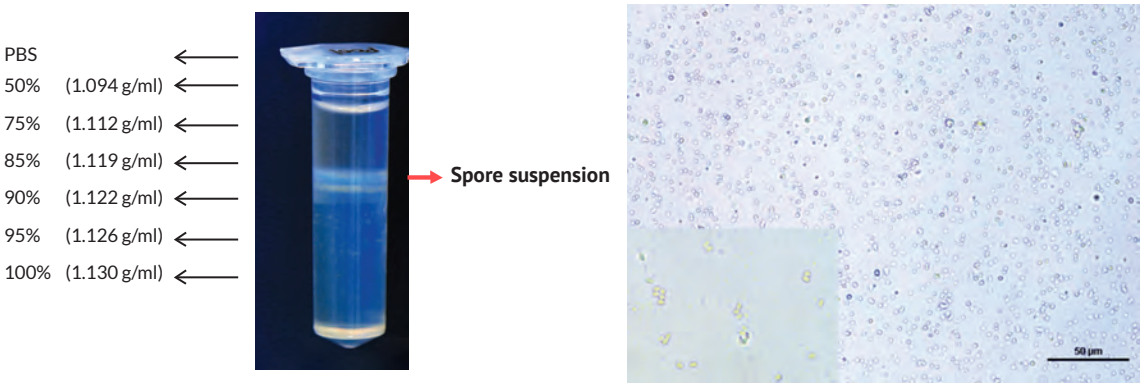
Live feeds (polychaetes and bivalve molluscs) used for broodstock maturation are considered as one of the likely sources of EHP in shrimp hatcheries. Hence a study was conducted to screen for the presence of EHP in the polychaete worms and clams from different locations. A total of 46 samples including polychaete worms, green mussel and clams were tested for EHP by nested PCR and all found negative, suggesting that these organisms may not be involved as secondary host or in the transmission of EHP to shrimp.

Fish	No of samples	Location	Positive	Negative
Polychaete	26	Muttukkadu, Kovalam, Marakkanom	0	26
Green mussel	12	Kannur	0	12
Clam	8	Pazhaverkkadu	0	8

Purification of EHP spores

A variety of filtration and concentration approaches were evaluated for purification and recovery of EHP spores from infected shrimp samples. The spores were partially purified from cell debris of fecal or hepatopancreas samples first by filtering through 40 micron nylon mesh to remove larger particles followed by a sedimentation technique using diethyl ether. This semi-purified sediment was further subjected to density based centrifugal separation (12,000 rpm) for 30 min using discontinuous Percoll gradient ranging from 50-100% in 1.5M NaCl. A prominent band between 75 and 85% with specific gravity ranging from 1.112 to 1.119 was consistent in having high density of spores as revealed by microscopy and was harvested for further studies.

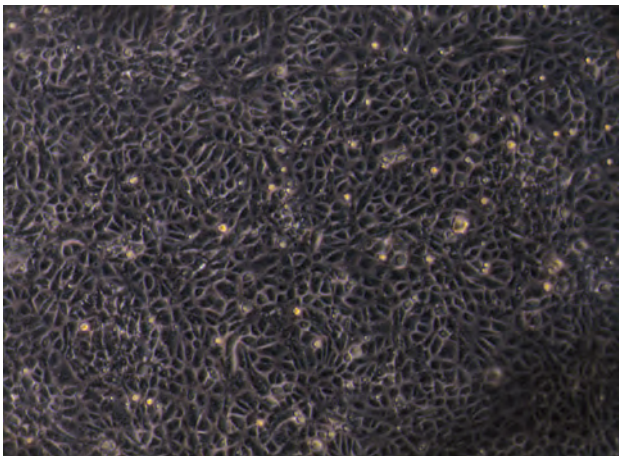
Fresh feeds, polychaete and bivalve, used for the penaeid broodstock maturation was found to be EHP negative suggesting that these live animals are not involved in the transmission of EHP



Purification of *Enterocytozoon hepatopenaei* spores using Percoll gradient centrifugation

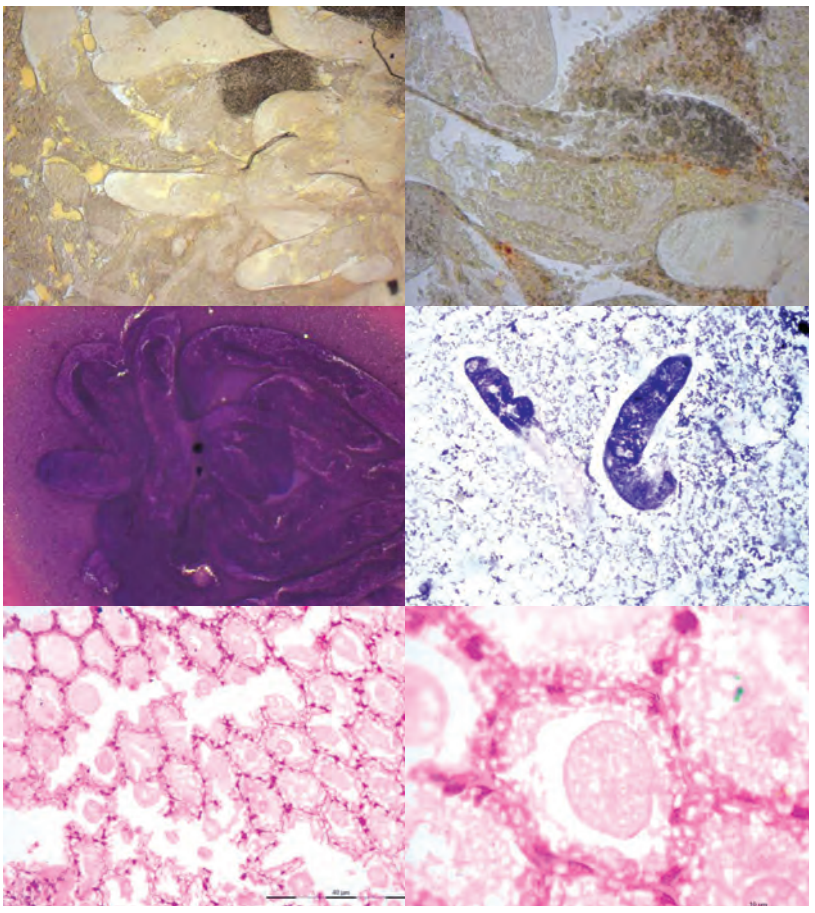
EHP could not be cultured *in vitro* in Vero cell lines

An effort was made to culture EHPin mammalian Vero cell line. Purified EHP spores were inoculated to Vero cell monolayers in L-15 medium and incubated at 37° C for ten days. No cytopathic effect was observed in the Vero cell monolayer. The infected cell suspension was collected in all passage levels and tested for EHP by PCR. EHP could be detected in the first passage only, and subsequent passages were found to be negative for EHP spores indicating that there was no propagation of EHP spore in Vero cells.



Monolayer of Vero cells inoculated with EHP spores at third passage (no cytopathic effect was noticed)

White faeces syndrome of *P. vannamei* in shrimp farms

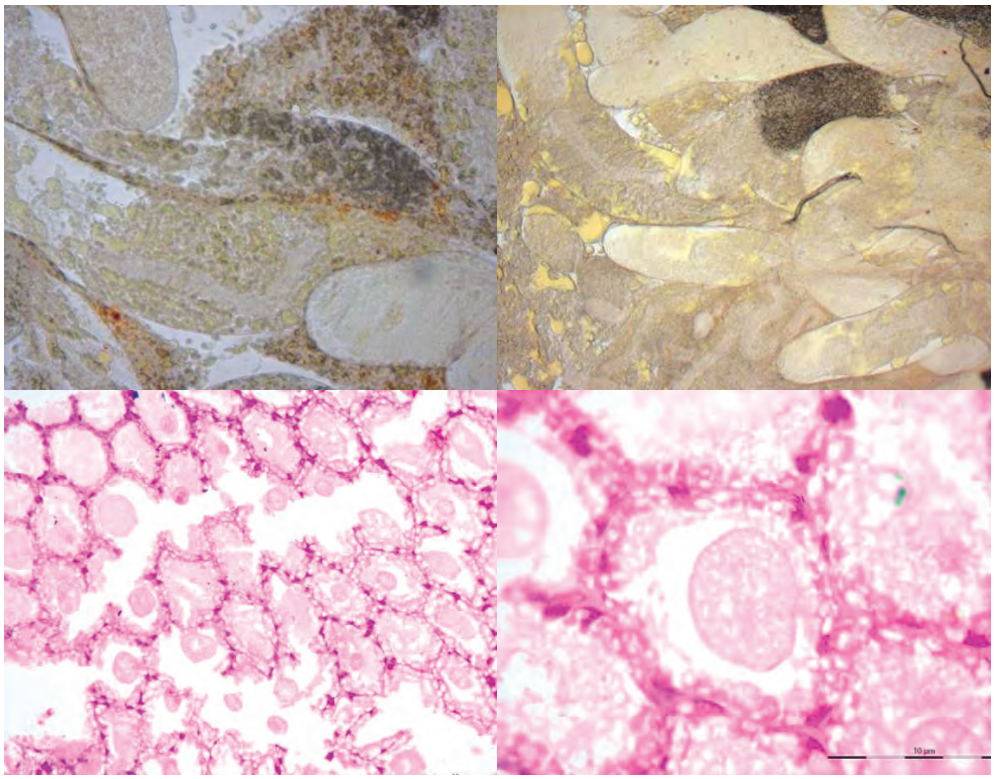


White faeces syndrome (WFS), Chronic / running mortality syndrome (CMS/ RMS), and white muscle syndrome (WMS) have been prevalent in vannamei farms since 2011, especially after intensification of culture practices. Microscopic studies of hepatopancreas of WFS affected shrimp revealed aggregated transformed microvilli (ATM) like structures. Histological studies revealed severe necrosis in the hepatopancreatic epithelial cells and cross section of ATM like structures inside the lumen

Squash preparation of WFS affected animals hepatopancreatic tubules showing ATM (aggregated transformed microvilli like structures); C: ATM like structures stained with Giemsa stain. D – ATM like structures stained with Haematoxylin stain. E and F- WFS affected animal HP observed with severe necrosis and ATM like structures (arrow)

To understand the nature of WFS, twenty five shrimps from WFS affected ponds were brought and reared in the laboratory conditions and were closely monitored. It was observed that the white faecal threads reduced and t cured without any treatment after seven to ten days of rearing in good quality water. Light microscopic and histological studies revealed disappearance of ATM like structures in the hepatopancreas of WFS-recovered shrimp. Histological studies unveiled the regeneration of hepatopancreatic epithelial cells surrounded by degenerative epithelial cells, suggesting that ATM like structures were causing white faeces.

Normal shrimp and shrimp affected with white faeces syndrome (WFS); hepatopancreas and gut of normal and WFS affected hepatopancreas; WFS affected shrimp reared in the laboratory recovering in good quality water



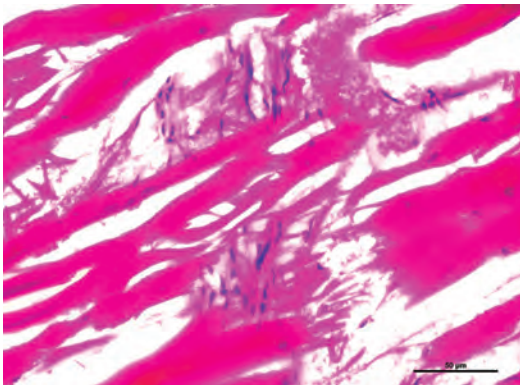
WFS recovered animal observed with normal HP tubules without any ATM like Structures. C and D: WFS recovered HP noticed with regeneration of epithelial cells (arrow) among the degenerative cells (arrow head).

Infectious myonecrosis (IMN) detected in farmed shrimp

An investigation on shrimp disease outbreaks was carried out (Vemuladeevi, West Godhavari district, AP) with the history of mortalities in *P.vannamei* shrimp farm in March 2017 (DOC: 24-120). The salinity ranged 5- 6 ppt in freshwater area and 15 – 50 ppt in coastal farming areas. The pH of pond water was 7.8 – 8.2 and the temperature was 28 – 30°C. Affected shrimp had white necrotic areas in the distal abdominal segments, extensive whitish necrotic areas in the striated muscle, loose shells and in some cases, black gills. Affected shrimp were floating near pond bunds as white cooked shrimp. The mortalities reached 70 -90% in five days. Emergency harvest was done in many areas (>40 - 70%). Affected shrimp samples were found to be positive for an OIE listed pathogen, infectious myonecrosis virus (IMNV) by reverse transcriptase RT-PCR. IMNV was also detected in a couple of shrimp ponds (11 g; DOC-53) in Nagapattinam with symptoms of redness in tail and pale hepatopancreas as co-infection with EHP. Histopathological studies showed shredding of muscle fibers, coagulative to liquefactive necrosis with haemocytic infiltration in striated muscle ,hypertrophy of lymphoid organ (LO) and ectopic lymphoid organ spheroids (LOS) in myocardial trabeculae. This pathogen has so far not been reported in Indian aquaculture, and in depth investigations would be required to understand its prevalence and impact on Indian shrimp farming.

When shrimps from the ponds affected by white faeces syndrome (WFS) were reared in laboratory conditions found to be cured from WFS. It suggests that good water quality conditions and better husbandry cures WFS

Shrimp showing necrotic areas in the distal abdominal segments

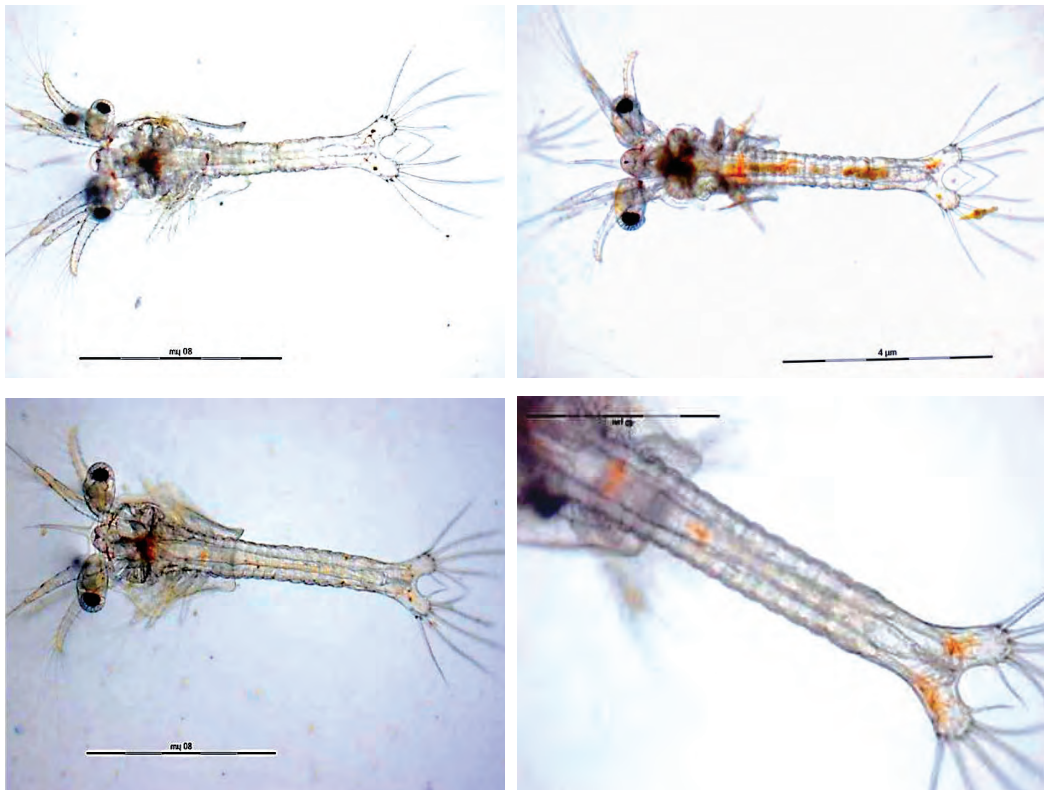


Histopathology of infectious myonecrosis of shrimp

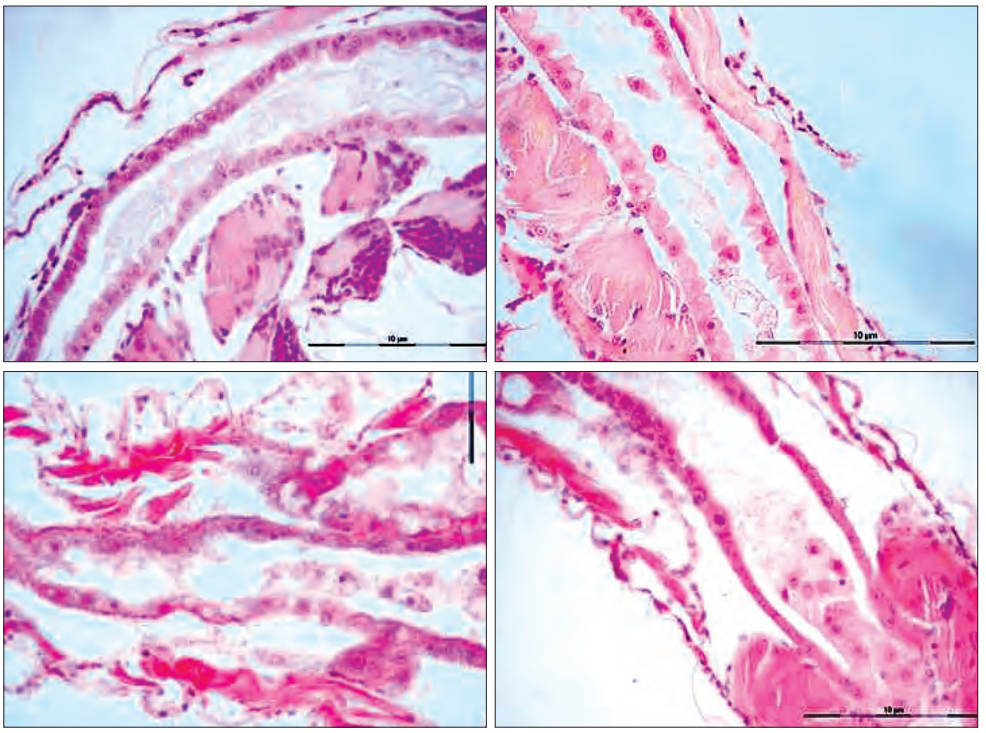
Detection of infectious myonecrosis virus (IMNV) by RT-PCR. Lane M: Ladder; Lane 1: *Penaeus vannamei* muscle; Lane 2: *Penaeus vannamei* pleopod; Lane 2: *Penaeus vannamei* pleopod; Lane 3: *Penaeus vannamei* gill; Lane 4-6: *Penaeus vannamei* haemolymph, copepods and algae; Lane 7: Freshwater finfish; Lane 8: negative control; Lane 9: positive control.

Enigma of Zoea II syndrome in *P. vannamei* shrimp hatcheries

Recent years, in India, mass mortalities at zoea II stage was widely experienced in shrimp hatcheries after the introduction of *Penaeus vannamei*. Zoea II syndrome has been reported since 1993 from Latin America as delayed molting or impairment of metamorphosis into larval stages, followed by mass mortality at zoea II stage. An investigation was conducted to understand the aetiology for zoea II syndrome. Two larval production cycles in five hatcheries in TN and AP were subjected to light microscopy, histology and transmission electron microscopy (TEM) besides screening for known viral and bacterial aetiologies. It was observed that the mortality of zoea progressively increased. Water quality parameters were found to be optimal in most hatcheries and did not seem to play any role on zoea-2 syndrome. Light microscopic observations indicated inflammation of the gut epithelium from 6th day of stocking and appearance of round ball like structures on the 7th day of stocking nauplii. Histological examination revealed the necrosis, sloughing of hepatopancreatic tubule epithelial cells and disintegration of peritrophic membrane, hypertrophied cells, vacuolization, sloughing/ desquamation and detachment of epithelial cell in to the lumen in middle and posterior intestine. *Vibrio alginolyticus* was found predominant during the larval production cycles. Systemic abnormalities such as anorexia, arrested peristaltic movement of gut, inflammation of intestinal epithelium, empty gut with no fecal strands and white balls or white spheres like structures were perceived in infected zoea with light microscopy. None of the larval samples tested positive for any known viral pathogens. The study has revealed that zoea-2 syndrome in *P. vannamei* hatcheries is not caused by known infectious agents.



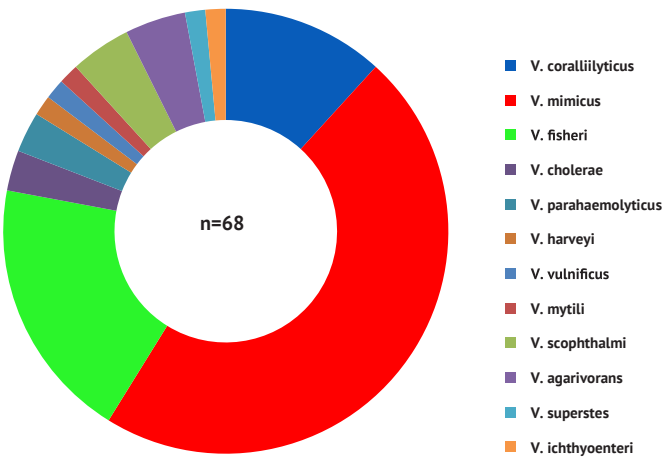
A: 2nd day - Normal Zoea with fullgut; B: 4th day– Affected zoea with emty gut; C: 6th day - inflammation in the gut epithelium; D: 7th day – white ball like structures observed in the gut epithelium.



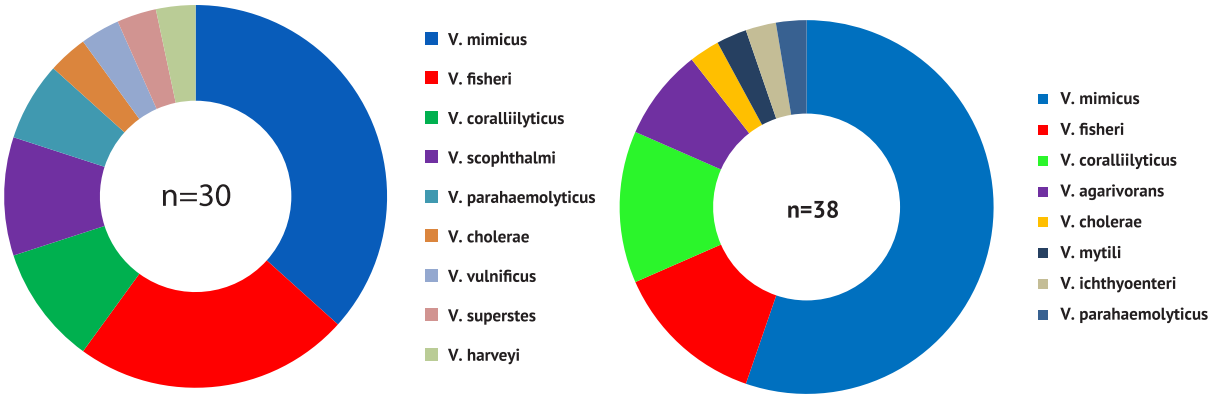
A: 2nd day – norma gut epithlium; B: 4th day – sloughing of epithelial cells form epithelium; C: 6th day – sloughed off epithelial cells accumulated in the gut; D:7th day – vacuolation and disintegration of peritrophic membrane.

Microbial profiling of mud crab hatchery

Larval rearing of mud crab and seed production is a major challenge in the aquaculture industry as the percentage of conversion of zoea into crab is at an average of 2-4% globally. An attempt was made to study the role of microbial community in crab larval rearing system. Water and animal samples were collected from crab larval rearing facility of CIBA during culture operation starting from Zoea 1 to Zoea 5 stages. A total of 126 bacterial colonies were isolated, out of which, 68 colonies were found to be *Vibrios*, belonging to 12 Vibrio species, comprising *Vibrio mimicus, V. fisheri, V. coralliilyticus, V. cholera, V. parahaemolyticus, V. harveyi, V. vulnificus, V. mytili, V. scophthalmi, V. agarivorans, V. superstes*and *V. ichthyoenteri*. It was observed that *V. mimicus*was the dominating species (47%) followed by *V. fisheri* (19%), *V. coralliilyticus*(12%). *V. mimicus, V. fisheri,V. coralliilyticus,V. parahaemolyticus* and *V. cholera,* were common in both water and larvae and *V. mytili,V. agarivorans* and *V. ichthyoenteri* were present only in larvae and *V. scophthalmi, V. harveyi, V. vulnificus* and *V. harveyi* were found in water only.



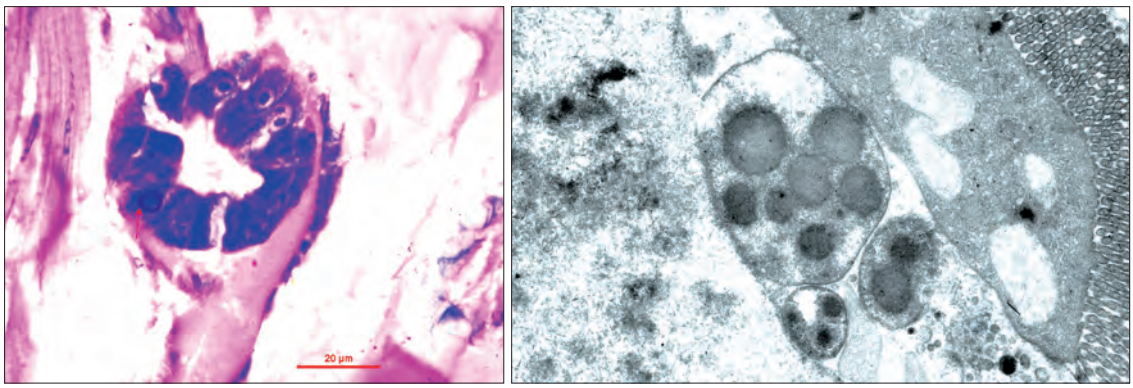
Culture dependent diversity of Vibrio species in *Scylla seratta* zoea rearing system



Composition of Vibrio species in zoea of S. serattaand rearing water

A case study on mortality in Indian white shrimp hatchery

Recurrent *P. indicus* larval mortalities were observed in the experimental hatchery at Muttukkadu Experimental Station (MES). Cumulative mortality up to 70% was observed in mysis to post larval stages during May to September 2016. Larvae were collected and investigated by light microscopy and analysed histologically and examined through Transmission electron microscopy for ultrastructural changes. Bacteriological studies revealed *Vibrio campbelli*, *Vibrio alginolyticus*, *V. vulnificus* in larval stages. Melanised areas were present on the body surface as revealed by light microscopic observation and intracellular inclusion bodies were detected in hepatopancreas by histology and transmission electron microscopy (TEM).



Inclusion bodies in hepatopancreas under 40 X objective and ultramicrograph showing intracellular parasitic stages (red arrows), microvilli (black arrows) in hepatopancreatic cells.

Diseases in finfish farming

Finfish Diseases

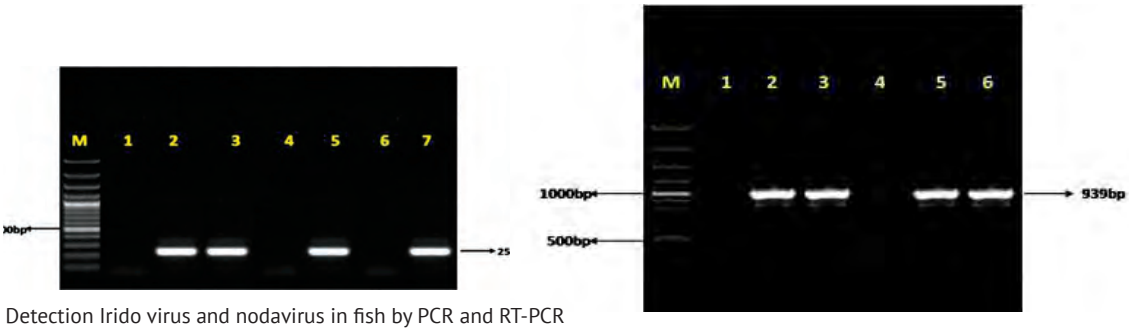
Culture of brackishwater finfish is an alternate option for aquafarming, as shrimp farming is distraught by diseases.

Farming of brackishwater finfishes for example: Asian seabass (*Lates calcarifer*), milkfish (*Chanos chanos*), pearlspot (*Etroplus suratensis*) and Cobia (*Rachycentron canadum*) are gaining impetus. However multitude of factors such as intensified aquaculture practices, movements of live animals and carrier fish spread pathogens into aquaculture systems. Finfish viral diseases, especially the viral nervous necrosis (VNN) and irido viral diseases are economically

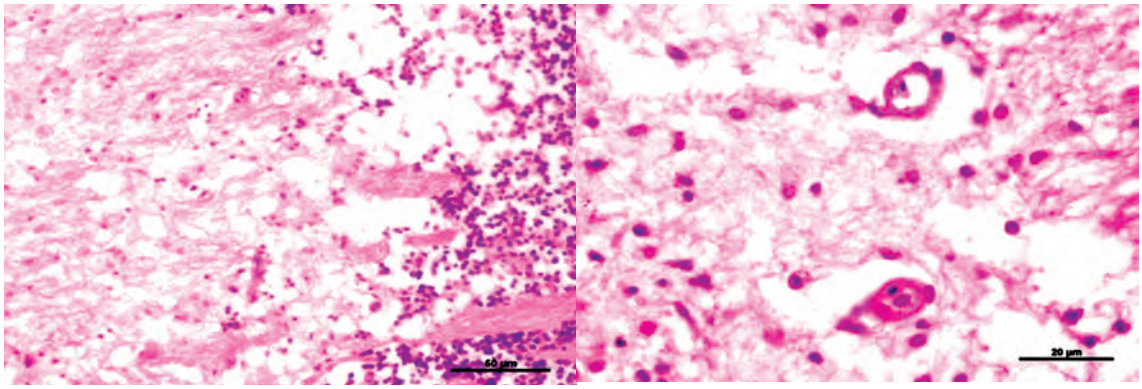
important diseases worldwide. While VNN is a major disease problem in larval and juvenile stages of fish, irido viruses are emerging disease in important fish species.Samples of seabass (*L. calcarifer*), wild mullet (*M. cephalus*), wild red snapper (*Lutjanus argentimaculatus*), tilapia,cobia and pompano from various locations in AP and TN, cultured in nurseries, culture ponds, cages and wild sources with history of swirling movement, haemorrhages and mortalities were investigated for diseases. Dual infection of iridovirus and VNN virus was found to be common in seabass, mullet and Tilapia as revealed by PCR and RT-PCR tests. VNN was recorded in red snapper for first time in India. These findings have been substantiated with histopathological studies and transmission electron microscopic studies and experimental challenge studies. Further, VNN and irido virus have been adapted in seabass spleen cell line (SISS), which was evident by characteristic cytopathic effect. The prevalence of iridovirus and VNN in finfish aquaculture was 40 and 20 percent respectively. While actual economic loss due to these finfish viral diseases needs to be quantified, vaccine development and biosecurity measures such as screening of brooders, regulation of commercial movement of live fish / seed are important strategies in management of diseases in finfish aquaculture.

Cage culture of tilapia and seabass in AP with mortalities due to dual viral infection

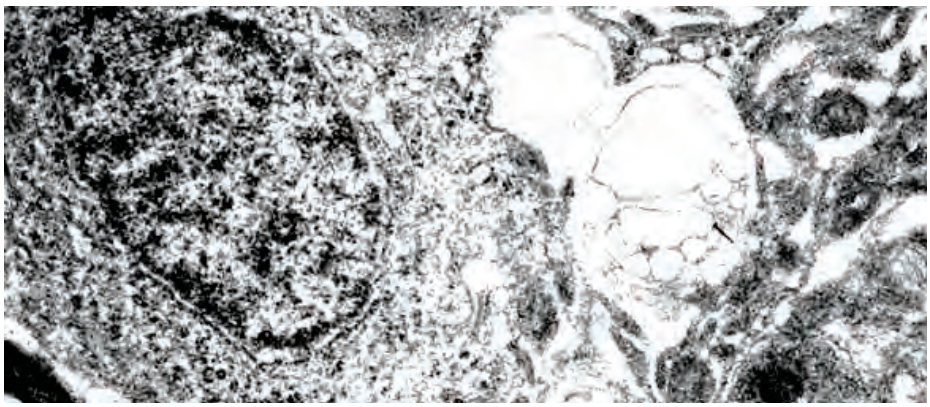
Cage cultured seabass and tilapia, wild mullet and red snapper affected with iridoand VNN viruses



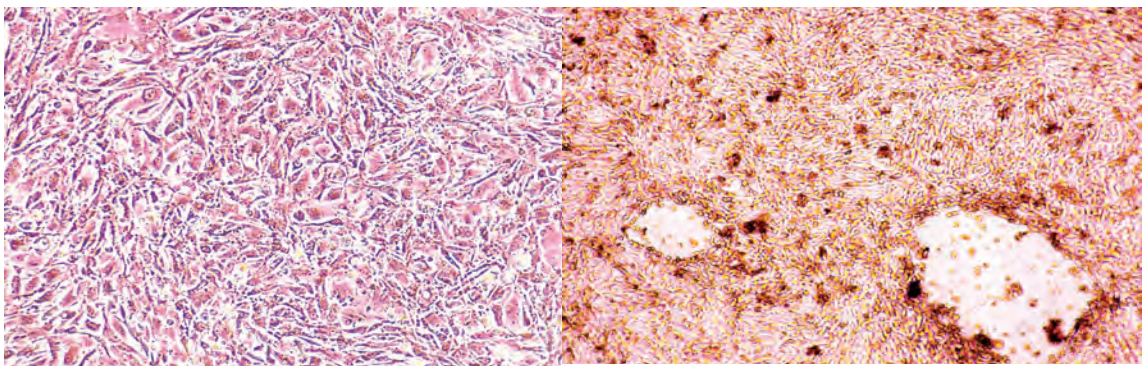
Detection Irido virus and nodavirus in fish by PCR and RT-PCR



Histopathology of brain of seabass section showingvacuolation due to VNN virus infection and nodule formation adue to irido virus infection



Transmission electron micrographs showing vacuolation in brain due to VNN infection and Irido virus like particles seen in brain

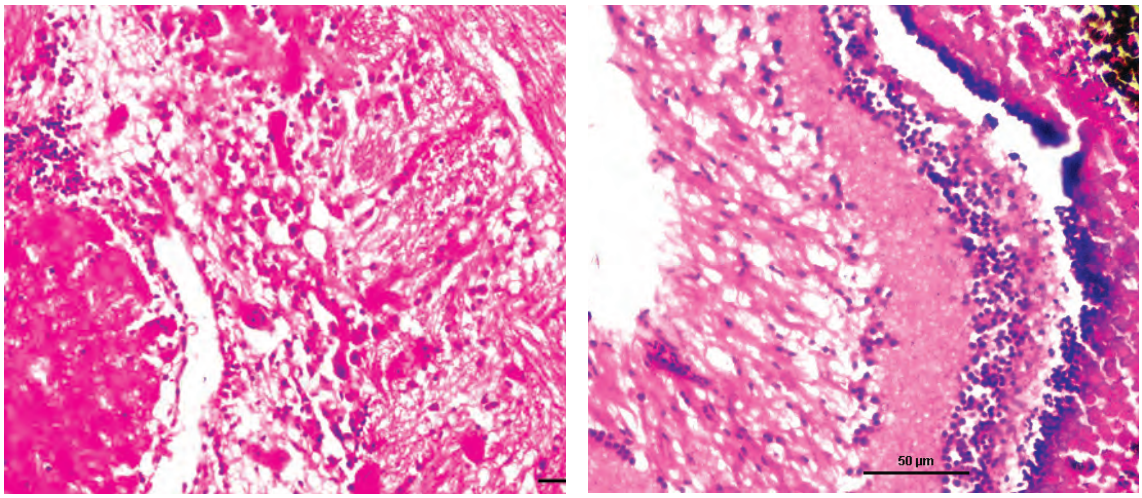


Cytopathology due to iridovirus in seabass spleen cell line (SISS) (normal cell line and plate showing cytopathic effect)

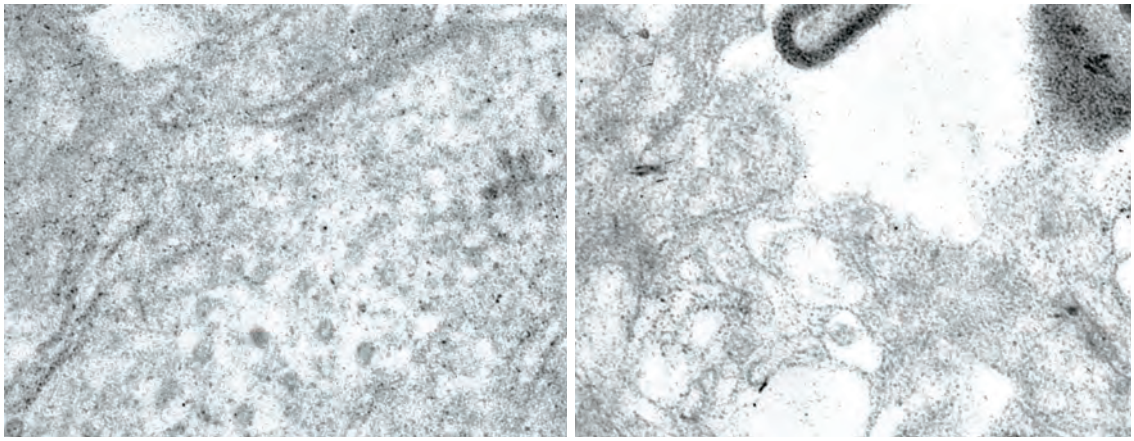
Experimental infection of Betanodavirus in freshwater fish *Gambusia affinis* and *Etroplus maculatus*

This study was aimed to demonstrate experimental infection of an isolate of betanodavirus (RGNNV genotype) in freshwater fishes, *Gambusia affinis* and *Etroplus maculatus* for elucidation of transmission mechanism and potential use as a laboratory model. Morbidity and mortality rate was significantly higher by injection route of infection as compared to immersion by bath and the symptoms resembled the natural infection of juvenile marine fish. The disease affected fishes showed severe neurological disorders accompanied by extensive vacuolar degeneration and mild to moderate neuronal necrosis of the brain in comparison to control. Amplification of ~427 bp product in the variable region of the coat protein gene of betanodavirus was achieved by RT-PCR with 100% sequence homology to RGNNV genotype (NCBI Acc No. KY040104).

Betanodavirus infected *Gambusia affinis* showing pigmentation, descaling and cork screw swimming pattern



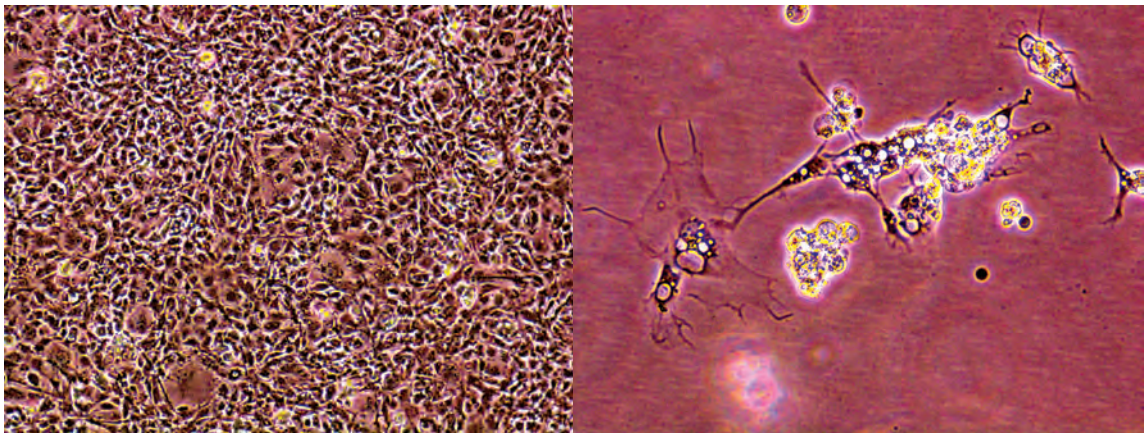
Histological section (brain) of the experimental fish *Gambusia affinis* showing vacuolations in the brain and eye tissue of different groups n 4 dpi; A- immersion (Gr. 1) and B- injection (Gr. 2).



Transmission electron photomicrograph of the brain of the experimental fish Gambusiaaffinis showing beta noda virus virion particle (arrow) affecting the neuron (A) and brain cells with large vacuoles (arrow) in the cytoplasm (B); Lead citrate and Uranyl acetate stain.

Isolation and characterization of VNN in striped snake head (SSN-1) cell line

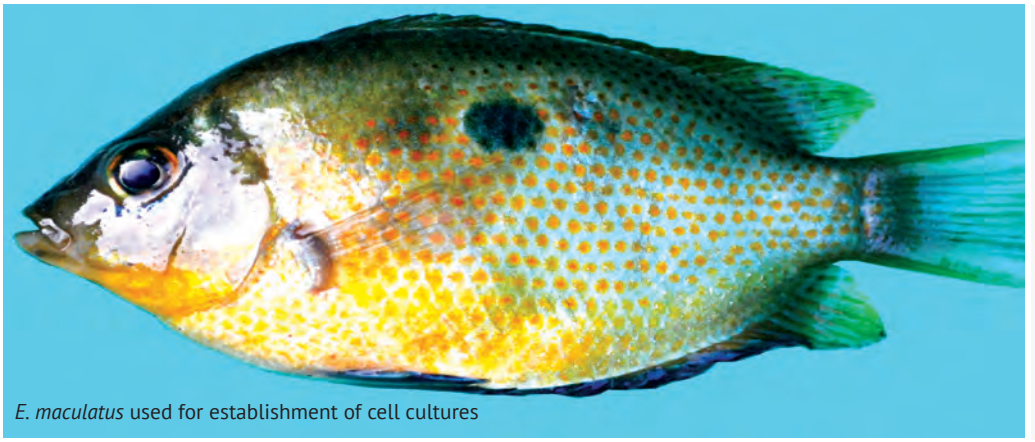
The VNN virus, a bi-segmented single stranded RNA virus was isolated from infected adult Asian seabass ovarian tissue in cell culture of striped snake head (SSN-1) cell line. The virus produced characteristic cytopathic effect including vacuolation, granulation and cell detachment within 72 hours post infection. The virus was plaque purified and the virus titer ($TCID_{50}$) was estimated to be $10^{8.8}$ in SSN-1 cells. The pathogenicity of the virus was confirmed in seabass fry in which it produced 100% mortality. Viral growth kinetics was studied by estimating the virus titer at different time points post infection. The peak virus titer was achieved at about 72 h post-infection. The whole genome of the virus was cloned and sequenced, which indicated that the virus belonged to the red-spotted grouper nervous necrosis virus (RGNNV) genotype.



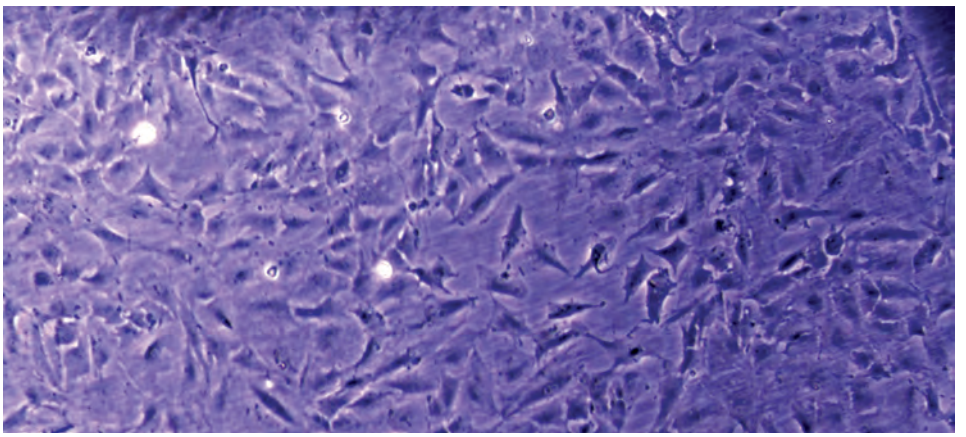
Uninfected striped snake head cells line and cells infected with VNN virus showing cytopathic effect

Propagation of VNN in cell culture system

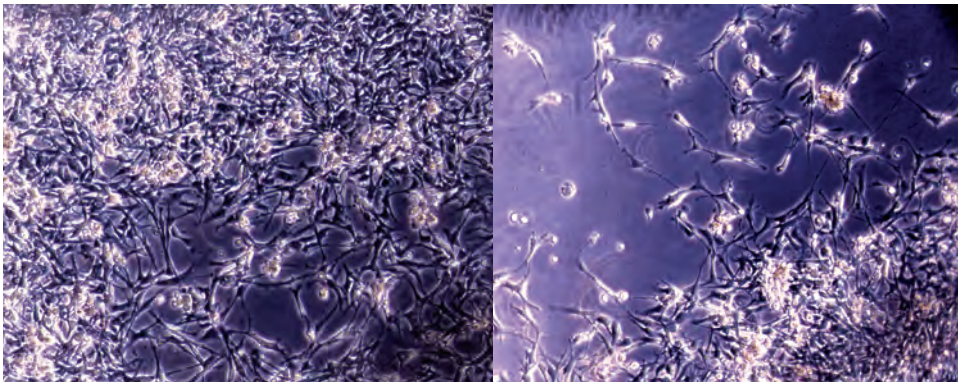
Cell cultures are useful tools as an *in vitro* model for carrying out various studies like viral infection, gene expression, toxicological studies and an alternative to live animals for many experiments. In order to adapt fish viral pathogens, explant cultures of primary caudal fin, spleen, heart and brain of orange chromide (*E. maculatus*) were attempted. Cell cultures of primary caudal fin and brain were established and evaluated for adaptation of VNN virus isolates. After three blind passages, CPE was observed as rounding and sloughing of monolayer within 10 days and after five passages cell cultures were found to be positive for VNN by RT-PCR, suggesting multiplication of the virus in the cell culture system.



E. maculatus used for establishment of cell cultures



Primary monolayer cultures from caudal fin of *E.maculatus*

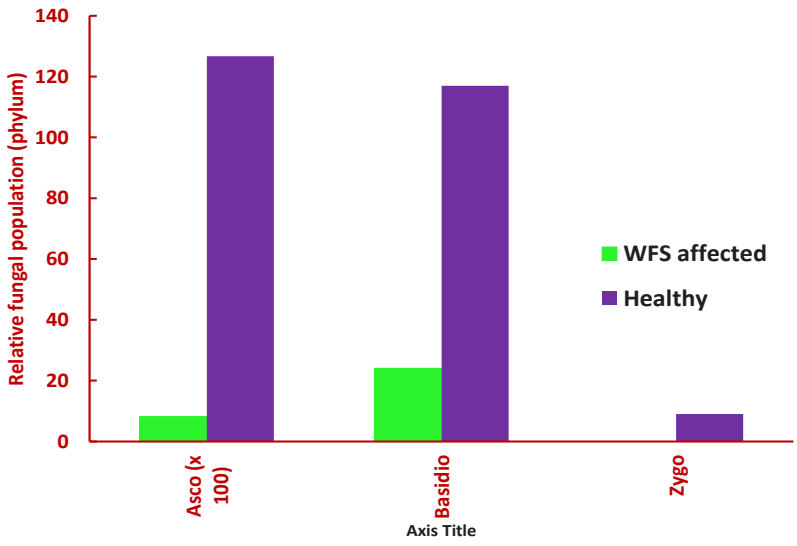


Cytopathic effect due to VNN adapted in primary caudal fin and brain cultures of *E.maculatus*

Microbes in aquaculture ecosystems

Mycoflora in aquaculture pond

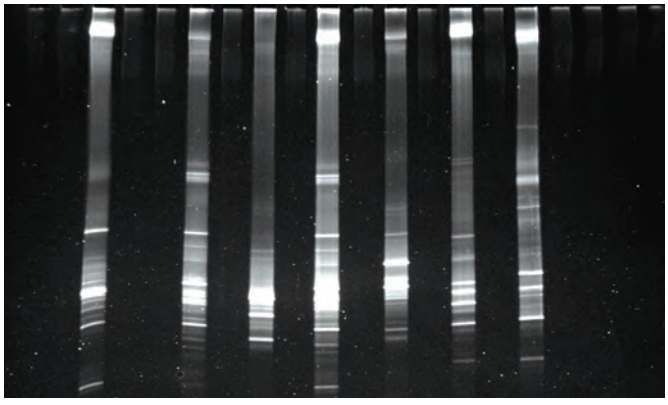
Microbes constitute largest biomass on the planet and play an extremely important role on the outcome of shrimp crops. Considering increasing incidences of aquaculture management related issues such as CMS, stunted growth, WFS, WMS etc, a study was undertaken to understand the microbial diversity of WFS affected shrimp pond using next generation sequencing (NGS). Pond water samples (20 L) processed using TFF system from a healthy and a WFS affected pond. Bacterial diversity of WFS affected pond was described during 2015-16. In the current year, NGS analysis was done for understanding the fungal diversity based on the ribosomal internal transcribed spacer (ITS) region for 5.8S rRNA using Illumina MiSeq platform. The fungal community sequence data analysis carried out using the QIIME pipeline. Results showed a significant difference in the fungal diversity of healthy and WFS ponds. While the Ascomycota were the dominant phyla in both healthy and WFS affected ponds, the fungi of group Zygomycota were present only in healthy pond. The number of Ascomycota was 10,000 times higher and Basidiomycota was six times higher in healthy pond compared to WFS affected pond . These results indicate that major metabolic processes of fungi are hampered in WFS affected pond. Further, looking at the genus level, the results indicated significant variation in the fungal diversity in the WFS affected pond compared to healthy pond. Fungal genera such as *Malassezia*, *Ganoderma* were present only in WFS affected pond. *Malassezia* is known to cause skin infection (dermatitis) in human and animals. *Candida* species was predominant genera in WFS affected pond. Many of its species are pathogenic in nature. The study has revealed the diversity of fungi in healthy and WFS affected ponds, however, it has thrown up important questions on how to promote the proliferation of Ascomycota and Basidiomycota in ponds to maintain healthy balance of mycoflora.



Fungal population in WSSV infected and no infected shrimp pond

General observation on *P. vannamei* hatcheries and list of presumptive marine vibrios isolated

Hatchery code	Facility	Observa-tions On the larval cycle	Inputs	Water sample	*Vibrio*spp
HAT-A	Naupli rearing Centre (NRC)	Healthy	Probiotics	Zoea-1 H2Z2	*V. metschnikovii* *V. orientalis*
HAT-A				Post larvae H2PL2	*V. orientalis* *V. metschnikovii* *V. alginolyticus*
HAT-B	Brood stock facil-ity and NRC	Healthy	Probiotics	Zoea-1 H3Z3	*V. calviensis* *V. mediterranei*
HAT-B				Post larvae H3PL3	*V. orientalis* *V. calviensis*
HAT-B				Brood stock BS3	*V. orientalis,* *V. metchnikovii*
HAT-C	Naupli rearing Centre (NRC)	Luminescent bacterial disease Zoea 2 syndrome Moult delays Lethargy	Probiotics and antibiotics	Zoea-1 HIZ1	*V. fisheri* *V. alginolyticus* *V. mimicus*
HAT-C				Post larvae H1PL1	*V. alginolyticus* *V. fisheri* *V. vulnificus* *V. mimicus* *V.campbelli*



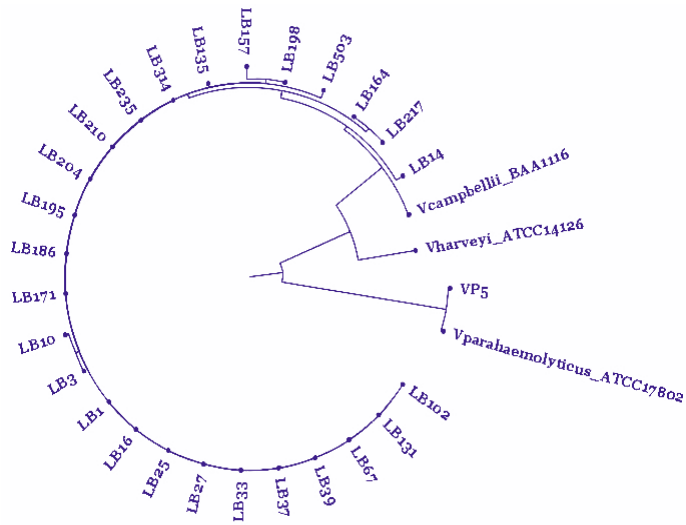
PCR-DGGE profiling of microbial DNA from penaeid shrimp larval rearing systems

Virulence of *Vibrios*

So far more than 131 species have been described under the genus *Vibrio*. The virulence mechanism of vibrios in aquatic animals has been enigmatic. The *Vibrio* species under the *Vibrio* Harveyi clade include *V. harveyi, V. campbellii, V. owensii, V. jasicida*, and *V. rotiferianus*. They are well recognized aquatic animal pathogens. Although efforts have been made by several investigators to understand the virulence mechanism of these microbes, its understanding has been eluding scientific community. Hence an investigation was undertaken to examine the identity and virulence of the isolates of vibrios obtained during previous years from various sources in the aquaculture ecosystems.

Vibrio campbellii is widely prevalent in Indian shrimp hatchery

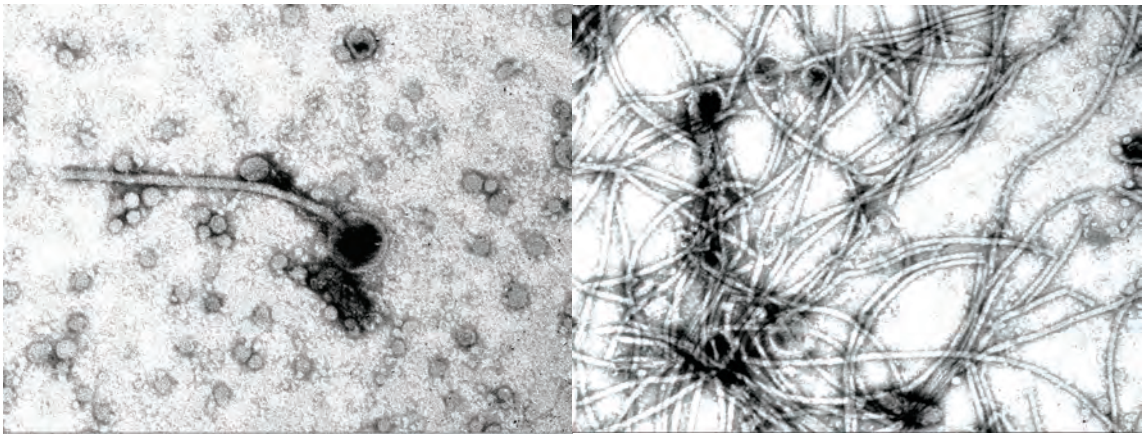
The *Vibrio* species under the *Vibrio* Harveyiclade, have been often mis-classified due to similarities in their rDNA sequences and phenotypes. *Vibrio campbellii* affects mysis and early post-larval stages of penaeid shrimps. It closely resembles the marine pathogen *V. harveyi* and is almost indistinguishable based on phenotypic characteristics, 16S rRNA gene sequence and DNA-DNA homology. Recent studies taking multi-locus sequence typing (MLST) using house-keeping genes and whole genome sequencing indicated that a large number of isolates have been mis-classified as *V. harveyi*. This included type strain, *V. harveyi* BAA1116, a model strain widely used for quorum sensing work. This was later found to be *V. campbellii* and has been renamed as *V. campbellii*, BAA 1116. ICAR-CIBA over the years has isolated large no. of luminescent *Vibrios* (more than 400) from hatcheries affected with luminescent vibriosis. These isolates were phenotypically characterized and classified as *V. harveyi*. Based upon isolates' history (disease / healthy), luminescence, phenotypic characters and challenge study results, a group of 30 isolates were selected for detailed characterization. These isolates were subjected to 16S rRNA sequencing and 28 isolates were classified as *V. harveyi* and two isolates as *V. parahaemolyticus*. All these isolates were further evaluated by sequence analysis of house-keeping *RpoD* gene, synthesise sigma factor (σ70). Analysis of *RpoD* gene sequence indicated that 28 isolates belonged to *V. campbellii* and the two isolates (LB5 and LB7) belonged to *V. parahaemolyticus*. The CIBA study indicated the wide prevalence of *V. campbellii* in shrimp hatchery ecosystems.



Phylogenetic analysis of luminescent bacteria

Novel lysogenic phages identified in virulent strains of *V. campbellii* LB1

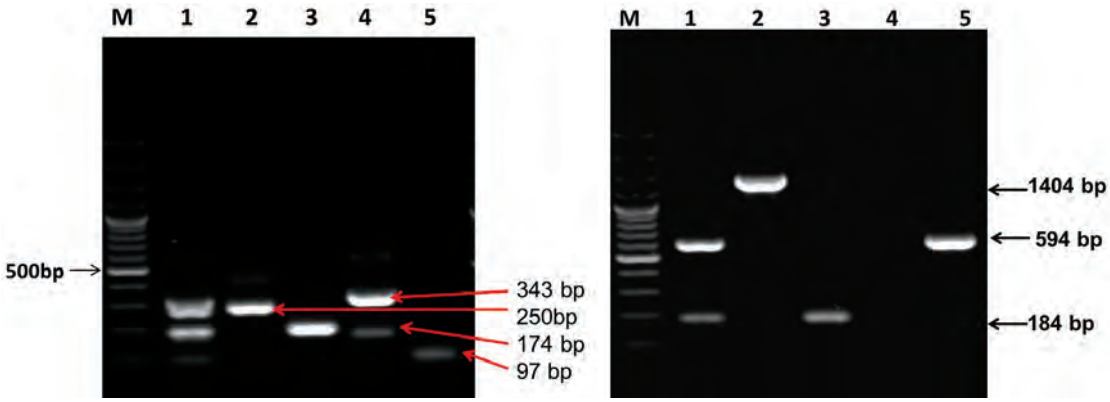
Lysogenic phages have been implicated in the virulence of many pathogenic bacteria including, *V. cholerae* and pandemic strains of *V. parahaemolyticus*. To characterise lysogenic phages, *V. campbellii* LB 1 was subjected to mitomycin induction, phage particle purification by ultracentrifugation followed by transmission electron microscopy. The results indicated that the strain possess two different types of phages namely siphovirus and filamentous phages .Molecular characterisation of these phages and its possible role in virulence is being investigated.



Lysogenic siphovirus and filamentous phages in pathogenic strains of luminescent bacteria

Virulence of *V. parahaemolyticus*

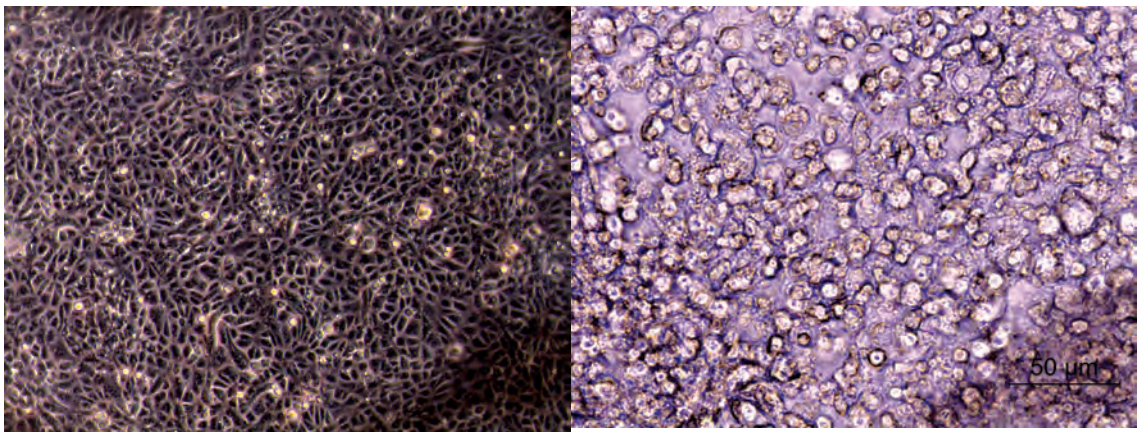
Forty five numbers of *V. parahaemolyticus* bacterial strains were isolated and characterized from 240 samples comprising water samples from shrimp ponds, brackishwater lagoons and shrimp samples with various clinical signs such as white spot, white faeces syndrome, size variation and slow growth. All isolates of *V. parahaemolyticus*were screened for early mortality syndrome (EMS) or acute hepatopancreatic necrosis disease (AHPND) using AP4 primers,and were found to be negative. All the isolates were also screened for virulence genes such as haemolysin genes, thermo-stable direct haemolysin (TDH) and thermo-stable direct haemolysin related haemolysin (TRH) genes related with pathogenicity. All isolates were found positive for type-3 secretion system (T3SS1) genes. Multiplex PCR for T3SS2α and T3SS2α genes were standardized using reference *V. parahaemolyticus* strain ATCC 17802 and forty five isolates were tested using multiplex PCR protocol and were found to be negative for T3SS2α and T3SS2α genes. Crude extra cellular products from culture supernatant of eight *V. parahaemolyticus* isolates were assayed for cytotoxicity on Vero cell monolayer. All the eight isolates capable of producing cell rounding within 24 h of incubation. The *in-vivo* immersion challenge experiment was conducted for eight isolates of *V. parahaemolyticus* and LD_{50} of strains ranged from 10^6 cfu ml^{-1} to 10^9 cfu ml^{-1}.



Detection of T3SS2α and T3SS2β by mutiplex PCR

In-vivo immersion challenge of *V. parahaemolyticus* isolates to *P. vannamei* post larvae

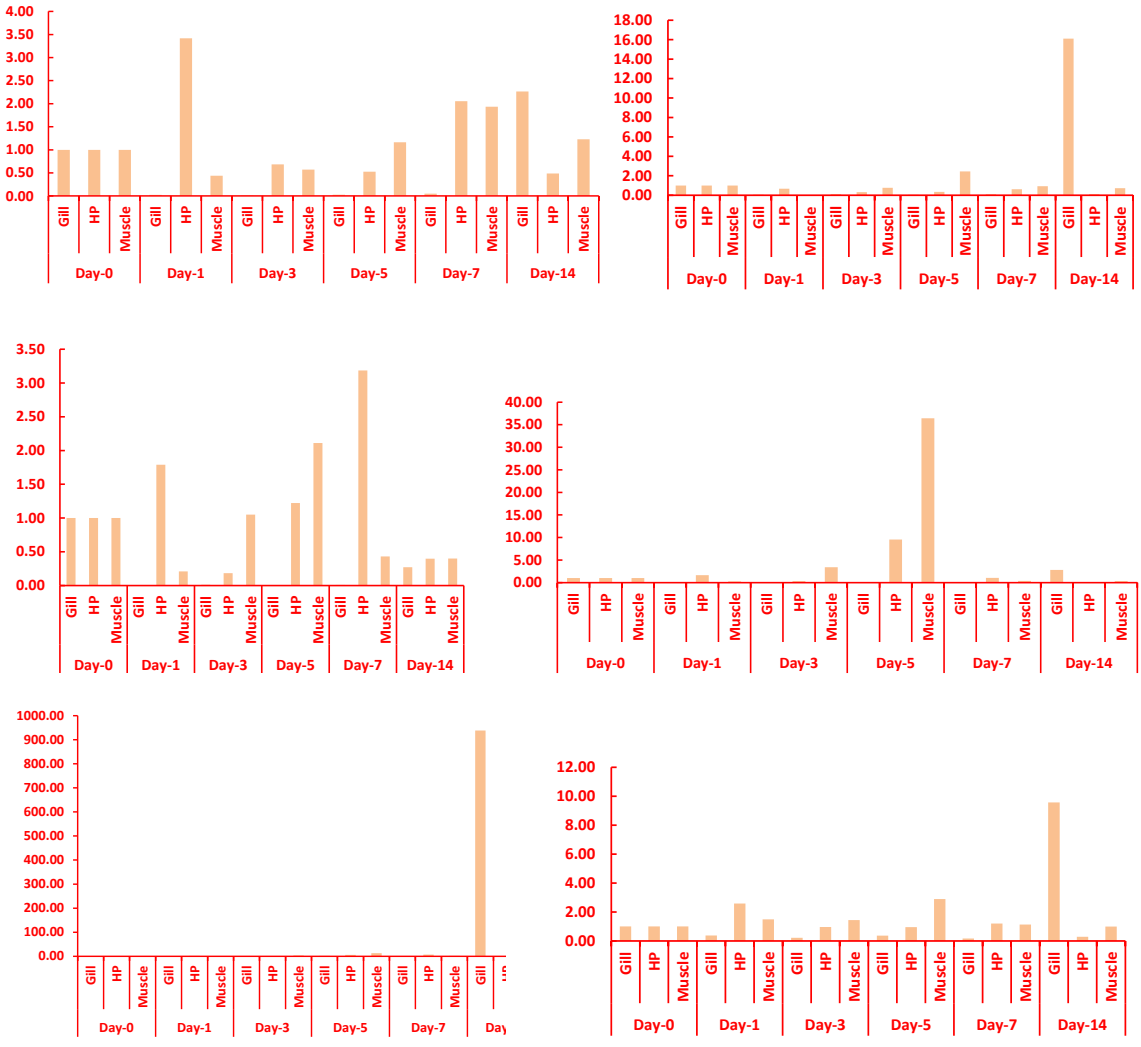
S.No	Isolate No	Source of sample	LD_{50} at 96 h
1	AHVP 38 (KL)	Green mussel	$1.02x10^{6}$
2	AHVP 40 (KL)	Green mussel	$4.01x10^{8}$
3	AHVP 90 (NE)	Shrimp gut	no mortality
4	AHVP 91 (NE)	Shrimp gut	no mortality
5	AHVP 96 (NE)	Shrimp gut	no mortality
6	AHVP 97 (NG)	Shrimp Hepatopancreas	no mortality
7	AHVP 98 (NG)	Shrimp Hepatopancreas	$2.00x10^{8}$
8	AHVP 99 (NG)	Shrimp gut	$1.10x10^{9}$



Normal Vero cell line and the one infected with *V. parahaemolyticus* strain (right) showing cytopathic effect

Host response to IHHNV infection in shrimp

The enzymatic profiling of hepatopancreas, gills and muscles during IHHNV infection was studied using Real time PCR. The level of various enzymes like super oxide dismutase (SOD), lysozyme, glutathione S-transferase (GST), and antimicrobial peptides, heat shock protein (HSP) 60, HSP 70, penaedin, crustin, were analyzed at various time intervals during IHHNV infection in shrimp. It was observed that only penaedin was up regulated on 14th day in the muscle and gill tissues. Similarly the enzymes like lysozymes, SOD, GST, HSP and crustin were found to be more in the muscle tissue on day 5 and day 7 of the infection. While on these days HSP 60 was found to be more in the hepatopancreas. It was evident that an antimicrobial peptide, penaedin was possibly involved in the defense mechanism of the shrimp upon IHHNV infection. Higher level of enzymes like lysozymes, SOD, penaedin, GST, HSP and crustin in the muscle tissue on day 5 and day 7 of the infection indicates the higher protection mechanism by the animal to evade the disease.



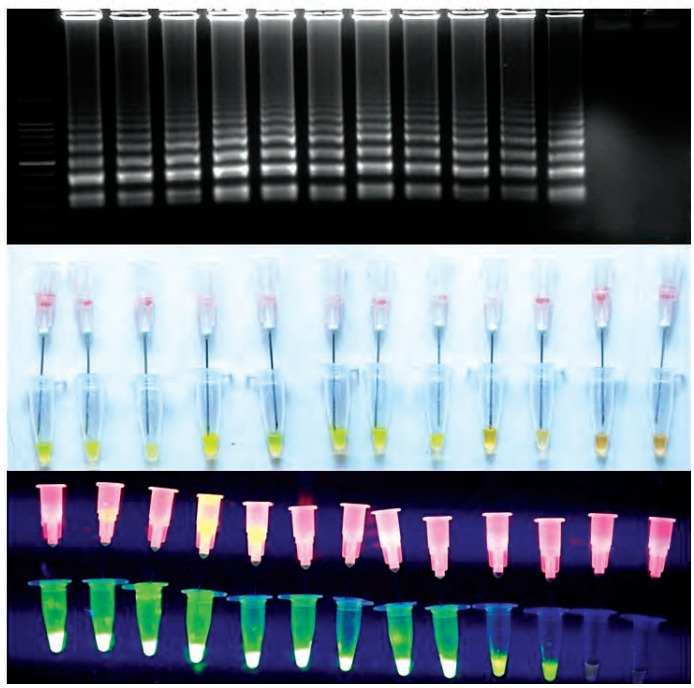
Regulation of antimicrobial peptides and enzymes in response to IHHNV infection in shrimp on different days of infection in different tissues

Development of Diagnostics

Development of visual loop mediated isothermal amplification (LAMP) assay for specific and rapid diagnosis of EHP

Enterocytozoon hepatopenaei infection in shrimp cannot be detected by visual inspection and there are no specific distinctive gross clinical signs except that it is suspected to be associated with growth retardation and WFS. EHP infection can be detected by demonstrating spores in light microscopy of stained hepatopancreas tissue smears, hepatopancreas (HP) tissue sections and faecal samples. A polymerase chain reaction (PCR) based diagnostic test targeting 18 s small subunit (SSU) rRNA gene (SSU-PCR) or spore wall protein gene (SWP-PCR), using extracted DNA from hepatopancreas tissue, faeces and whole post larvae have been described. In this study a rapid sensitive and specific, loop mediated isothermal amplification (LAMP) protocol was developed for diagnosis of EHP. LAMP primers were designed based on the 18s (SSU) rRNA gene of EHP. The target sequence of EHP was amplified at constant temperature of 65°C for 45 min and amplified LAMP products were visually detected in a closed tube system by using SYBR green dye.

The sensitivity of this LAMP protocol was found to be 10 copies. Field and clinical applicability of this assay was demonstrated with 152 field samples including 96 HP tissue samples, 56 faecal samples, from which EHP could be detected in 55 samples (46 HP samples and 9 faecal samples). This LAMP assay could be completed in an hour, specific and more sensitive diagnostic procedure than SSU-PCR and equivalent to nested SWP-PCR.



Detection of LAMP products in agarose gel electrophoresis, with SYBR green under visible and UV light of serially diluted plasmid DNA

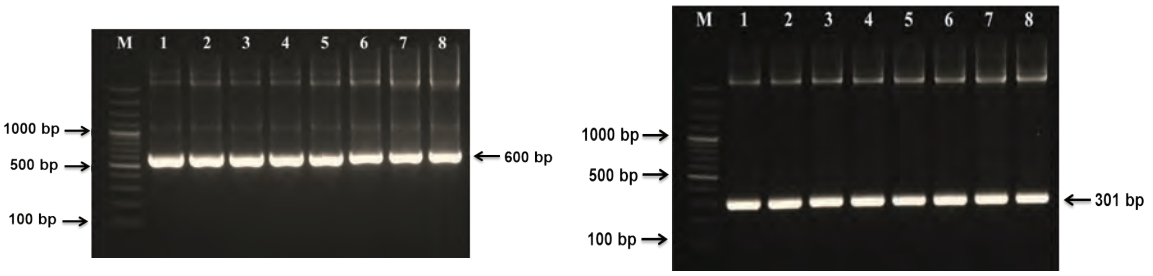
Evaluation of LAMP Protocol with clinical samples

Clinical samples	No of samples	Spore wall PCR protocol		LAMP
		First step	Nested	
DNA from Hepatopancreas	96	32	44	40
DNA from faecal samples (*)	56	10	15	15
Total	152	42	59	55

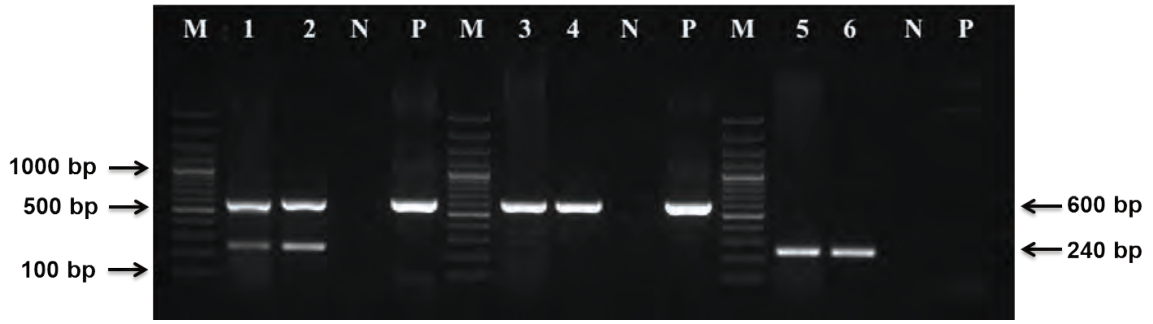
* Includes 15 white faeces samples

Development of nested PCR protocol for detection of EHP

Two sets of primers were designed based on sequence of 18s small subunit rRNA gene of the parasite based on sequences generated from EHP isolates in India. The PCR reaction was optimised initially using SSU rRNA plasmid (1.2kb) containing target sequences along with ß-actin gene as control. The detection of EHP was accurate in experimentally infected *P. vannamei* with no false positives.The sensitivity and specificity of these two primers sets for detection of EHP is being tested using naturally infected samples.



Optimization of PCR detection of EHP (amplicon of 600 bp by 1st step PCR and 301 bp by nested PCR).

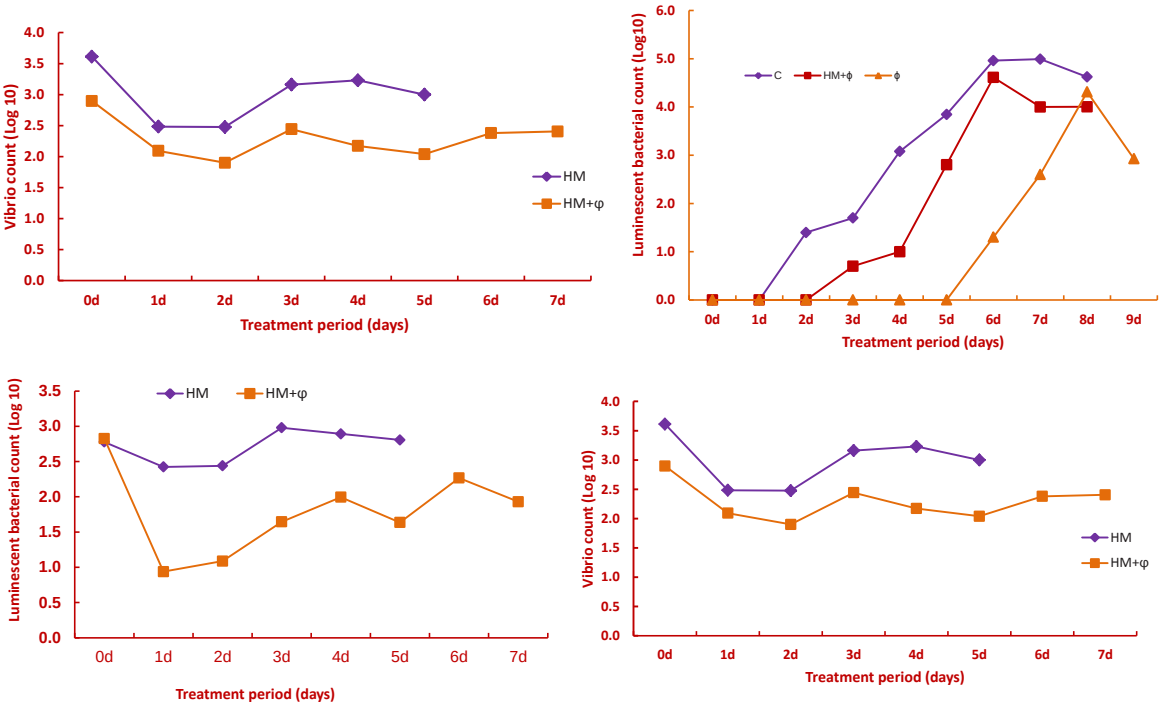


Detection of EHP in shrimp using hepatopancreas and faecal samples amplifying 600 bp PCR product by first step reaction along with the amplification of 240 bp product of b-actin gene as internal control.

Development of prophylactics and therapeutics

Biocontrol of *vibrios* in shrimp hatcheries using bacteriophages

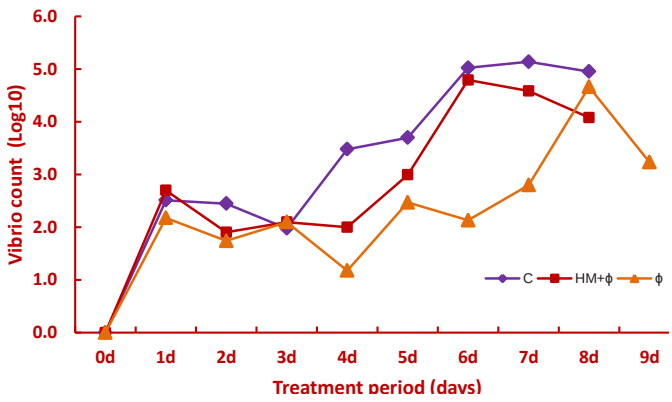
Luminescent bacterial disease is one of the biggest threats to shrimp hatchery operation and it attracts large quantum of antibiotic application. Bacteriophage therapy can be an effective biocontrol measure to manage bacterial diseases. CIBA has a stock of well characterised bacteriophages. For conducting hatchery trials, large amount of bacteriophage stock is required, and therefore, protocols for the mass production of bacteriophages were standardised. Growth conditions of host bacteria and bacteriophages were optimised in fermenters with regard to multiplicity of infection (MOI) of 0.1 and 0.01 and bacteriophage yield of 10^{10}pfu $ml^{-1}$and 10^{12}pfu ml^{-1} respectively were obtained. Encouraging results were obtained in the hatchery trials, with the application of a consortium of four phages as a prophylactic. The total vibrio count was reduced by 3 longs while the luminescent bacterial (LB) counts came down by 2 logs during subsequent days up to Mysis stages. In therapeutic treatment, the phage treatment gave 40% larval survival against 0% survival in the control tanks with one log reduction in the LB count.



Effect of bacteriophage on biocontrol of vibriosis in shrimp hatchery Note: HM-Hatchery management, Φ- Bacteriophage treatment

Development of microencapsulated probiotics

Gut probiotics have been known to improve the digestibility, growth, FCR and immunity. In order to develop an effective probiotic product for use in shrimp aquaculture beneficial microbes were isolated from brackishwater environments. A microbial consortium was developed containing four bacteria, *Bacillus amyloliquefaciens*, *B. subtilis* and two strains of *B. pumilus* and two yeasts, *Saccharomyces cerevisiae* and *S. boulardii*. Media and growth conditions required were standardized and yield was



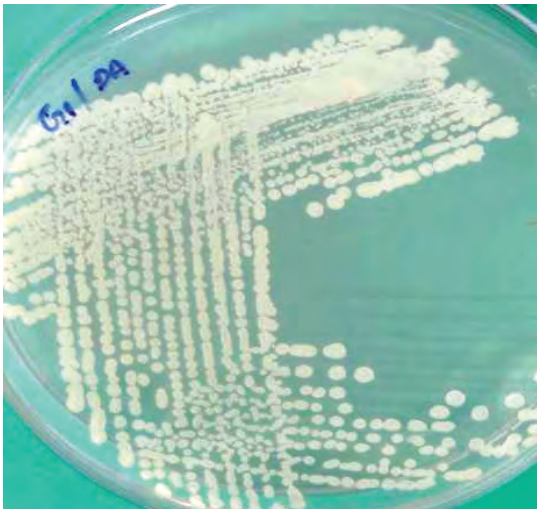
Growth of probiotics in the fermentor and formulation

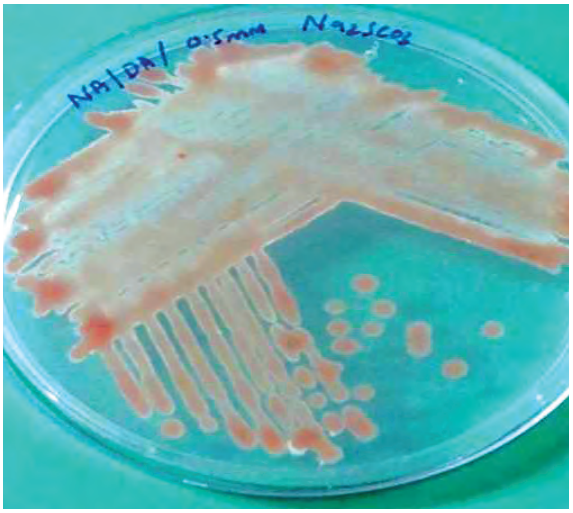
optimized in pilot scale fermenter with an yield of 10^9cfu ml^{-1}. Biosafety of the microbial consortium was confirmed in both larval and juvenile stages of *P. vannamei* shrimp. To improve the shelf life, the product was microencapsulated using suitable combination of starch and maltodextrin in different combinations and it was observed that a combination of 1% Starch + 10% maltodextrin provided recovery rate of 90% in tray dried probiotic formulation. The probiotic was administered as coat on the shrimp feed. Preliminary experiments indicated improvement of growth and survival of shrimp.

Development of selenium enriched *Bacillus* probiotic to enhance shrimp health

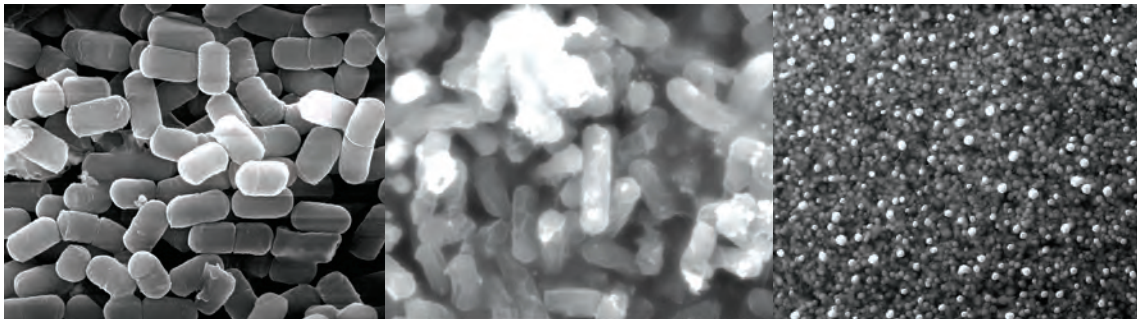
Selenium is a micronutrient required for basic metabolic activity. It is also known for its anti-microbial property. Biogenic nanoparticles (NPs) of selenium were produced by incorporating sodium selenite in *Bacillus subtilis* and *Pseudomonas aeruginosa*. In addition to increasing antimicrobial property, the selenium incorporation enhanced growth in some bacteria. The selenium incorporated bacteria change medium to reddish colour as indication of development of Se nanoparticles. Scanning electron microscopic images confirmed formation of SeNPs on the bacterial surface as well as in the medium Yard experiment was conducted by administering SeNP incorporated bacteria to shrimp larvae by immersion method. With 0.5 mM Se, bacteria (10^3cfu ml^{-1}) showed higher survival (95%) of shrimp PL against control (60%). Further studies need to be conducted to evaluate the benefits of Se incorporation in the probiotic bacteria.

Growth of probiotic bacteria after incorporation of different concentrations of sodium selenite in culture medium





The growth of isolate BS01 on Zobell marine agar medium (a) and 5mM sodium selenite supplemented medium, showed the selenium enrichment in the colonies.

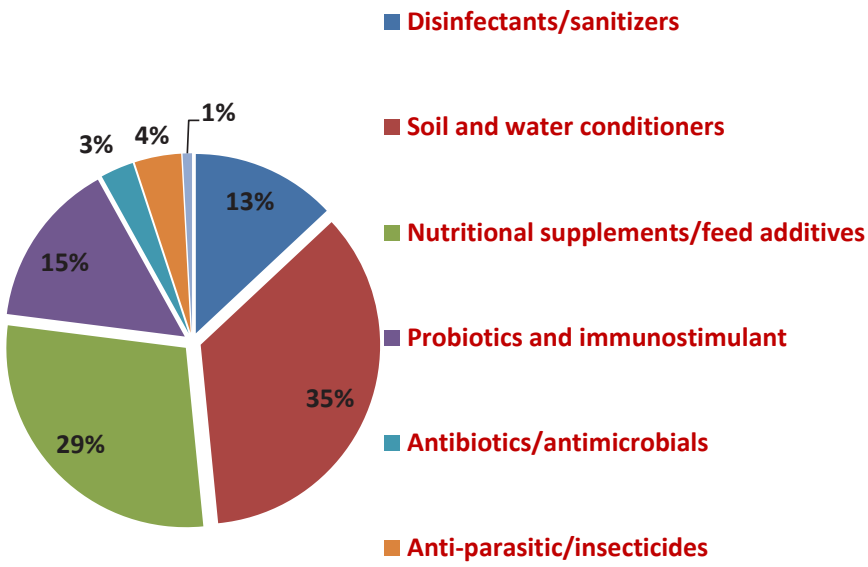


SEM Micrograph of probiotic bacteria *Bacillus subtilis* BS01 (a) and selenium enriched *Bacillus subtilis* BS01. Arrow indicating attached SeNPs on the surface of bacteria (b). Selenium nanoparticles isolated from bacterial medium (c).

Aquaculture Medicine

Drugs and chemicals used in aquaculture

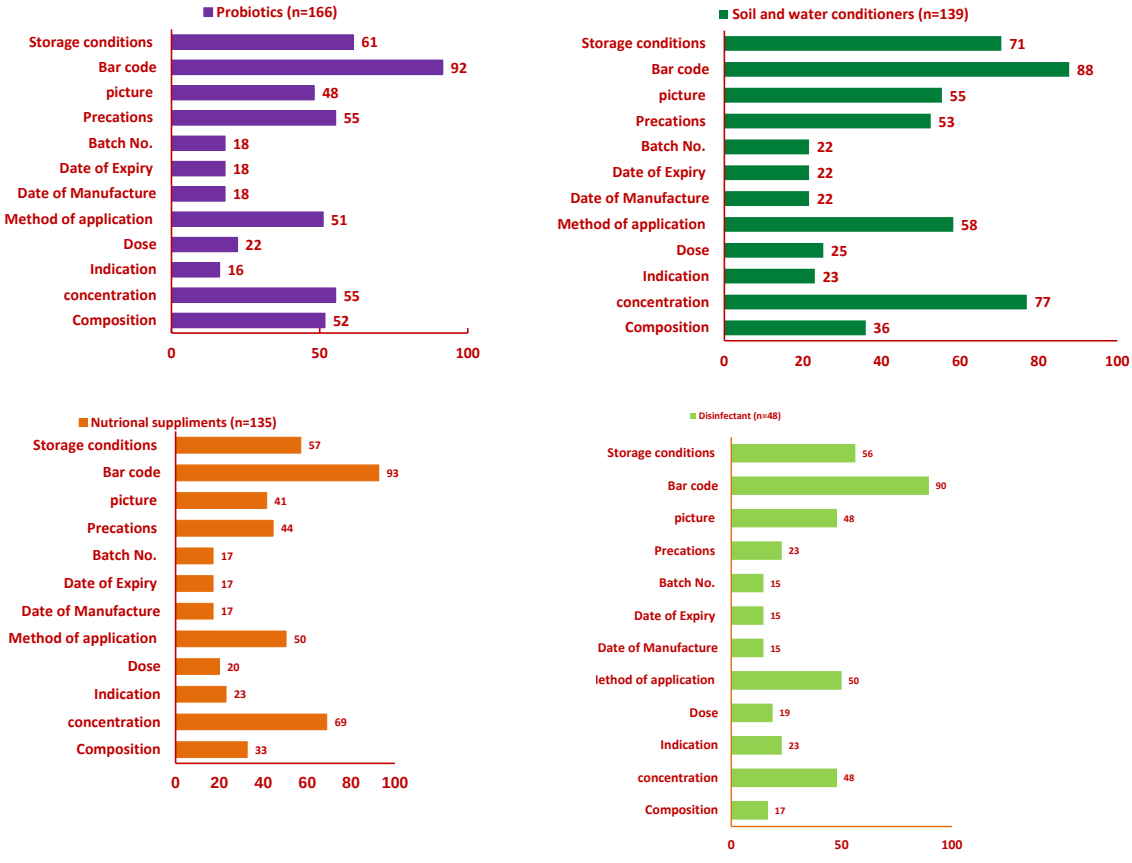
A number of commercial products are being used in Indian aquaculture and there is lack of information on nature of these products. To understand the types of drugs and chemicals used in Indian aquaculture, a survey was carried out covering different aquaculture systems such as freshwater, brackishwater, coldwater and cage farming. Information on 1300 drugs and chemicals was collected from aquaculture markets from throughout India and classified as probiotics, disinfectants/sanitizers, soil and water conditioners, nutritional supplements/ feed additives, antibiotics, anti-parasitic drugs and hormones/spawning aids.



Drugs and chemicals used in aquaculture

Labelling of drugs / chemicals used in Indian aquaculture

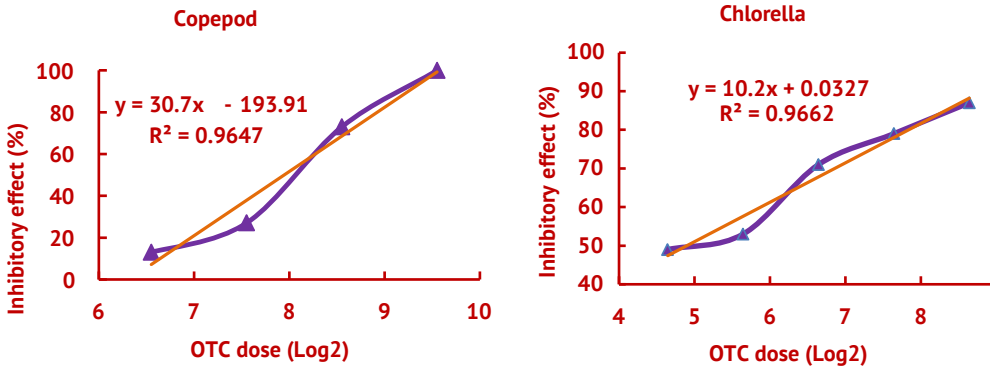
Labelling information is crucial for any commercial products, especially pharmaceutical substances intended for use in agriculture, animal husbandry and fisheries. There are mandatory guidelines regarding labelling information on medical and veterinary products in India. In the absence of any such guidelines it essential to understand the way practiced in the labelling drugs/chemicals used in aquaculture. A total of 497 products registered under Coastal Aquaculture Authority (CAA) for use in aquaculture were classified as probiotics, nutritional supplements, soil and water conditioners, disinfectants and antimicrobial drugs. Labelling information on the drugs/chemicals against the standards followed in Veterinary and Medical drugs was evaluated. Among the products studied 33.4% were found to be probiotics followed by soil and water conditioners (27.97%) and nutritional supplements(27.16%) while disinfectants constituted 9.66% and antimicrobial agents including herbal products were only 1.81%. Among the probiotics more than half of the products did not mention composition, concentration, method of application and precautions on their labels. Similarly concentration of the active ingredients and directions for use was not provided in more than half of the nutritional supplements, soil and water conditioning agents and the disinfectants. It was observed in the study that labelling information was incomplete in significant number of products surveyed. Results of the study suggest the need for strict mandatory guidelines for labelling information on aquaculture products marketed in India.



Labelling of drugs / chemicals used in Indian aquaculture

Biosafety of anti-parasitic drug, emamectin benzoate in candidate finfish species

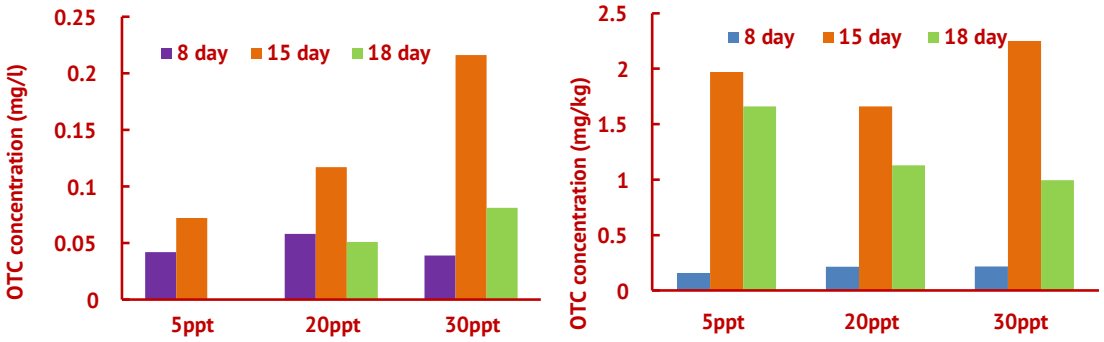
Medication using emamectin benzoate (EB) has been recommended by USFDA to control bacterial infections and parasitic infestations in marine and freshwater fishes. Establishing the biosafety is a primary requirement for adopting any treatment regimen to new species of target host. Hence, to evaluate the biosafety of Oxytetracycline (OTC) and EB in Asian seabass, a study was conducted by feeding ten times the standard dose (OTC: 80 mg kg^{-1} fish d^{-1} and EB: 50µg of EB kg^{-1} fish d^{-1} and three times the standard duration (OTC: 10 days and EB: 7 days) of treatment. At concentrations of 1x, 5x and 10x the OTC was administered for 30 days and EB for 21 days and fishes were monitored for general behavior, feeding, survival, growth in addition to monitoring the water quality parameters. Medicated feed was prepared by top-coating commercially available feed with EB. Asian seabass fingerlings (mean total length 8.92 cm; mean body weight 7.69 g) were stocked into 500 litres flow-through tanks at 30 fish/tank. Diets were randomly assigned to three replicate tanks per treatment. Throughout the trial, water quality was maintained within ranges suitable for Asian seabass. Fish were fed @ at 2 per cent BW/d divided equally between three feedings. Gross and histopathological changes and gene expression profiles were evaluated in liver, heart, spleen, eyes, skin, gill and kidney. Results of the study suggest that both OTC and EB are safe at the concentrations and the durations treated for Asian seabass. Lack of appetite which was noticed in the group fed with highest concentration of the drugs was regained by the end of the study period. The results indicate that there is an adequate margin of safety associated with administering EB-medicated feed to fingerling Asian seabass at the proposed therapeutic treatment regimen of 50µg of EB kg^{-1} fish BW d^{-1} for 7 d.



LC50 determination of OTC for indicator species of brackishwater aquaculture

Impact of oxytetracycline on the biota in aquaculture ecosystem

Environmental impact assessment of any substance used in aquaculture is a primary requirement for setting up regulatory guidelines. The study was designed to understand the impact of oxytetracycline (OTC) on indicator organisms, copepods, rotifers, *Chlorella* and *Spirulina*. The LC_{50} values for copepods, rotifers, *Chlorella* and *Spirulina* were 187.5 to 375 ppm, 400 ppm, 25 ppm and 100 ppm respectively. The results of the study indicate that at the therapeutic concentration of 4.5 g kg^{-1} feed the OTC is safe to the receiving environment.



Effect of salinity on OTC degradation in in seawater water and sandy clay loam pond soil

Effective dosages of chlorine as a disinfectant against shrimp WSSV

Disinfection of aquaculture tools and culture ponds/ tanks is one of the basic steps in biosecurity. An experiment was conducted to standardize the optimum dosage and the duration of chlorine application for effective inactivation of WSSV in simulated shrimp culture environment. The study used sodium hypochlorite as source of chlorine as disinfectant in inactivating WSSV (10^8 copies l^{-1}) following 3 hours of contact period on with / without soil base. Efficiency of WSSV inactivation was assessed by infection experiments following treatment under aeration. Reproduction of the disease was recorded by mortality and specific pathological changes and confirmed by PCR testing.

The study revealed that 5 ppm of chorine was sufficient to inactivate the WSSV filtrate while 10 ppm is required for inactivating the virus in the affected shrimp tissues in two days while similar viral loads needed 15 ppm and 20 ppm respectively in tank filled with soil in the tank bottom. It was interesting to note that exposure to sun light reduces the required chlorine concentration to 10 ppm to achieve the similar inactivation. The observations of the study suggest that 20 ppm is the minimum concentration of chlorine required for inactivation of WSSV in non-drainable ponds while drying reduces the chlorine requirement to half to achieve the same viral inactivation.

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 2016 to March 2017, a total of 41 samples including imported *Artemia* cyst samples, frozen frozen vannamei samples, fish and prawn pickle samples, live shrimp broodstock feed were tested for OIE listed shrimp and fish pathogens for the AQCS, Chennai. It was found that none of the samples tested were positive for any of the OIE listed pathogens.

Screening of samples for OIE listed shrimp pathogens

S. No.	Sample	No tested	Shrimp Pathogens							
			DNA Virus		RNA virus			Bacteria		Parasite
			WSSV	IHHNV	IMNV	YHV	TSV	APHND	NHPB	EHP
1	Frozen vannamei samples for import / export	6	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
2	Reimported Frozen vannamei samples	20	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
3	Imported Artemia cyst	10	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
4	Imported / Reimported broodstock feed	3	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
5	Reimported prawn pickle	1	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

Validation of IMNV detected by other laboratories

As per the guidelines of the DAHD&F, MoA, IMNV infected samples were submitted to NRLD by C. Abdul Hakeem College, Melvishram. The samples were tested using OIE protocols and all the three samples were found to be positive for IMNV by three independent PCR methods and therefore these samples were diagnosed as positive for shrimp IMNV. In the experimental challenge carried out by NRLD, ICAR-CIBA using the sample submitted revealed typical clinical signs and mortality through injection challenge experiments. Oral and immersion challenge failed to reproduce the symptoms or disease.

It was suggested that in the interest of the high value shrimp aquaculture industry and the country, reporting this disease should be made with extreme caution only after enough evidence and epidemiological study. Until then, it is desired to confine the present information under the surveillance team, till the prevalence of the said pathogen is increasing, and goes beyond the 2% level in the population level. Further targeted surveillance has to be carried out to check the presence and status of this pathogen from the area of report under the surveillance project.

Validation of IMNV detection by School of Aquaculture, Fisheries College and Research Institute (FCRI), Tamil Nadu Fisheries UniversityThoothukudi was also carried out. The samples were tested using OIE protocols and failed to amplify 328 bpproduct in the first step rt-PCR and also in the nested rt-PCR (139 bp product) and hence were regarded as tested negative for IMNV. Amplification of a housekeeping gene (b-actin) was performed as an internal control on the samples and it was insured that the integrity of the RNA was good and did not have any PCR inhibitors. Suggestions were given to the concerned with regard to proper collection of samples and sequencing of amplification products.

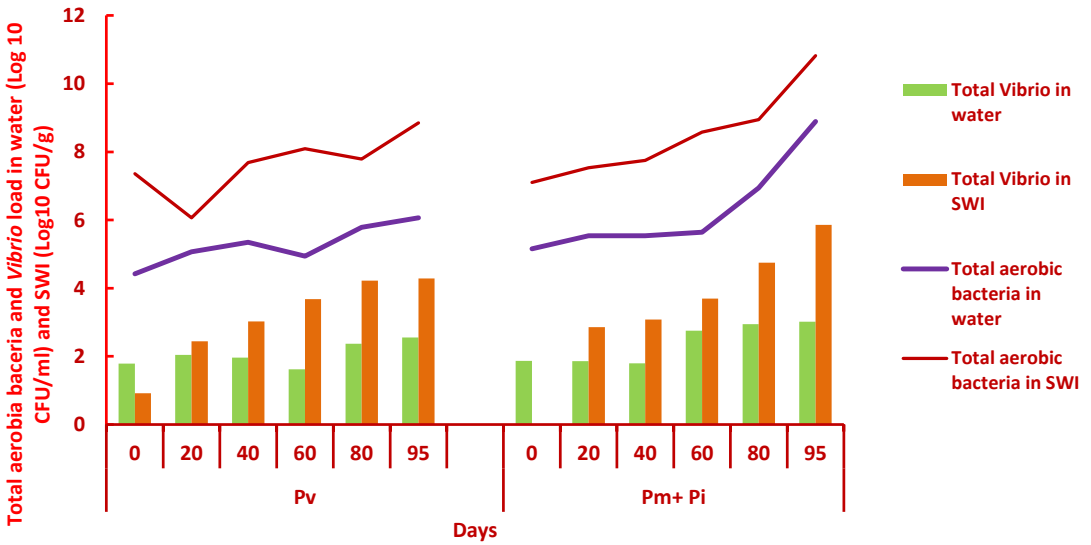
Aquaculture Environment and climate change

A farming site at Thanjavur, Tamil Nadu where shrimp farms and paddy fields are operational together without any problems

AQUACULTURE ENVIRONMENT AND CLIMATE CHANGE

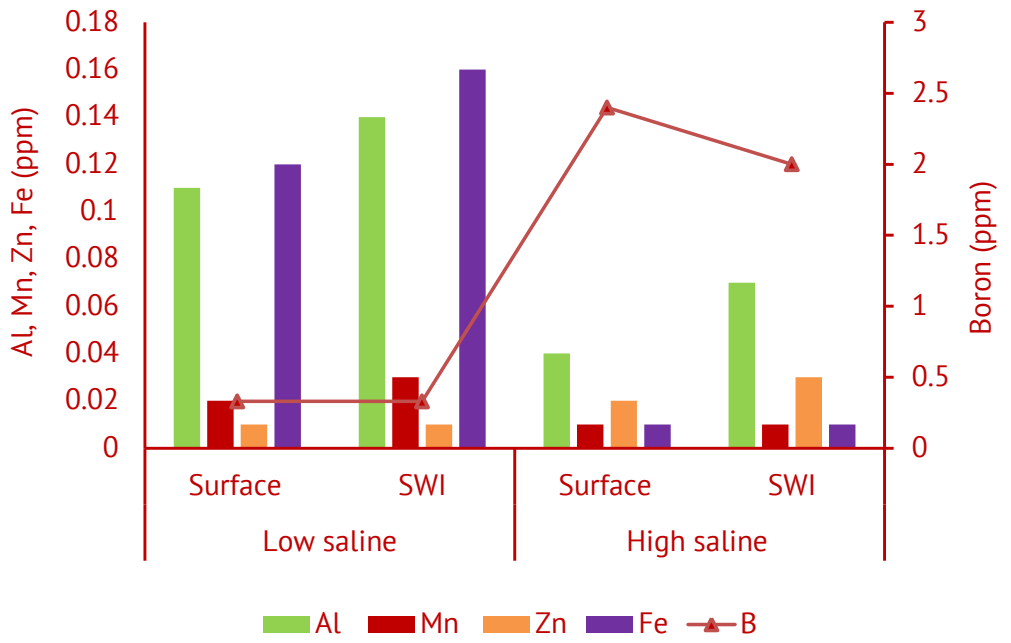
Metagenomic studies indicate predominance of sulphur bacteria in sediment water interface in the shrimp culture ponds

Samples from sediment-water-interface (SWI) is a significant indicator of aquaculture pond health. Microbiological and chemical quality of surface water and at SWI was studied in *P. vannamei*, and *P. monodon* and *P. indicus* mixed culture ponds with stocking densities of55 per m^2 and 35 per m^2 respectively of 95 days culture in South 24 Parganas, West Bengal. The total aerobic bacterial and total *Vibrio* counts were found be more in the *P. monodon* and *P. indicus* mixed culture ponds than that in the *P. vannamei* ponds in water as well as in the SWI. At the SWI, the total aerobic bacterial counts and total *Vibrio* counts were more compared to that in the surface water.



Total aerobic bacterial and Vibrio counts in sediment water interface (SWI) and surface water of shrimp culture ponds

The total carbon content at SWI and water was higher in ponds with high salinity compared to that in the low saline ponds. Composition of minerals indicated no significant difference with respect to sodium, potassium, calcium and magnesium between surface water and SWI. However iron, aluminium, manganese and zinc was comparatively higher at SWI under low saline culture ponds and boron was higher in high saline ponds compared to that in the low saline ponds at both surface and SWI. Further investigations would be required to understand the mineral cycles and microbial processes taking place at SWI which would throw more light on the pond productivity.



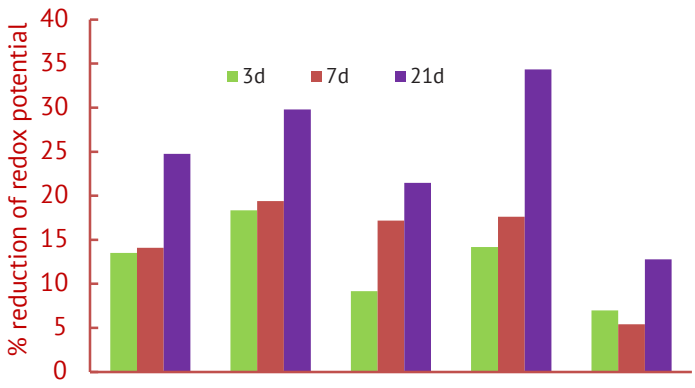
Trace minerals at the sediment water interface (SWI) and surface water of *P. vannamei* culture ponds with different salinities

Development of soil probiotic

Deteriorating pond bottom condition (reduced) can be mitigated by the supplementation of beneficial microbes that degrade the organic matter and improve the pond bottom conditions. In order to evaluate the efficiency of beneficial microbes, microcosm with deteriorated condition of pond bottom was simulated with redox potential (E_h) of -258 mV and treated with beneficial bacterial strains and consortia of all the strains. All the treatments showed reduction in the redox potential vis a vis the control after first and third week respectively. The organic carbon (OC) content and total vibrio

Microcosm of bad pond bottoma

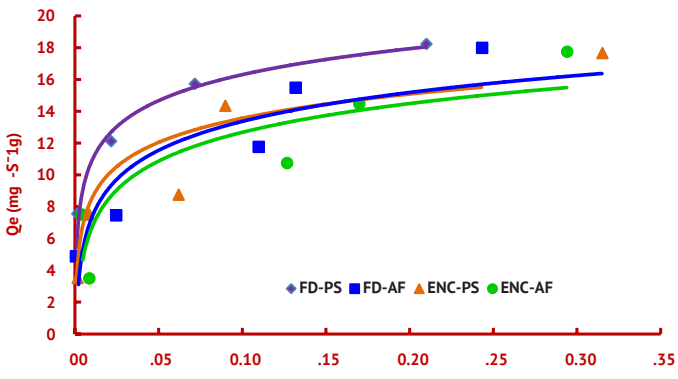
counts (TVC) were found to decrease upon probiotic treatments compared to untreated control. Since, consortium of probiotics showed comparatively better efficiency and also had denitrifying property, a soil probiotic was prepared and tested for its efficiency in decreasing the nitrogenous metabolites in water with spiking of total ammonia nitrogen (TAN) at different time intervals.
The probiotic treated group showed reduction of 79.12 - 93.5% and 95.15 - 97.28% TAN and NO_2 – N, respectively in 96 hours



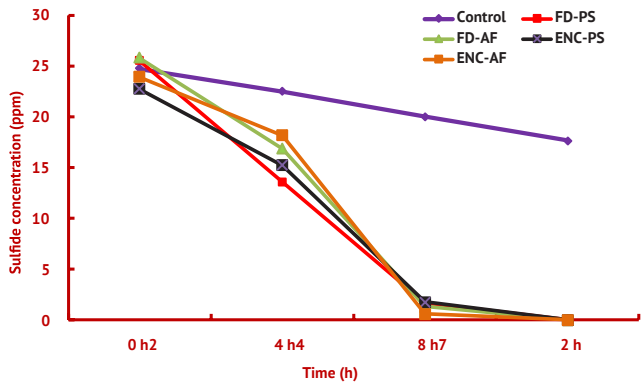
Effect of soil probiotic on reduction of redox potential

Sulfide removal efficiency of bacterial preparations

10% of the crop loss is reported due to sulfide. In this regard, capacity of two sulfur oxidizing bacteria, *Pseudomonas stuzuri* and *Alcaligens faecalis* was evaluated for their sulfide removal capacity from aqueous solution (1-5 ppm sulphide concentration) and enriched sediment by freeze drying and encapsulation techniques with cell concentration of 10^9cfu/ml. Bacterial preparations showed excellent adsorption capacity in aqueous conditions. Complete (100%) removal of sulfide was achieved with freeze dried and encapsulated bacterial preparations within 5 h and 7 h, respectively. Experimental data fitted well to pseudo first order kinetics with high correlation coefficient. Sulfide production was simulated in enriched sediments under laboratory conditions and once blackening of sediment was found, bacterial preparations were applied separately and sulfide concentration was monitored. Sulfide was below detectable limit within 72 hrs in all the treatments, whereas in control, sulfide was detected. Addition of these bacterial products in pond bottom may help in the aerobic decomposition of organic matter thereby preventing the build-up of toxic hydrogen sulfide in shrimp culture ponds.



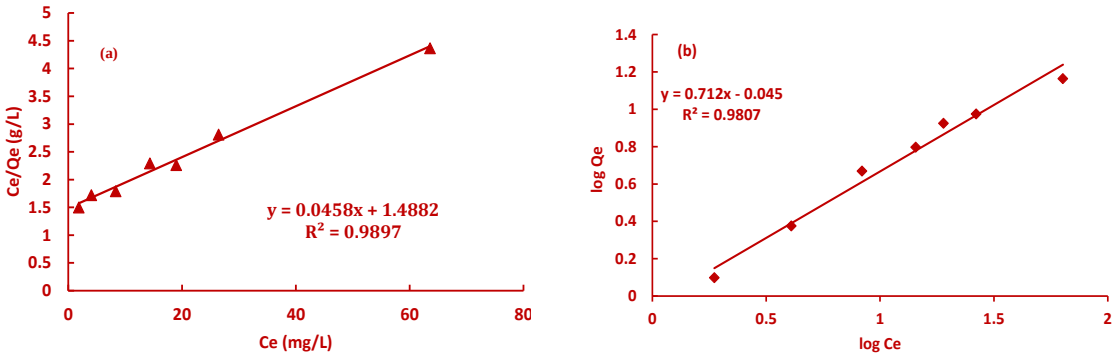
Pseudo first-order kinetics for sulphide adsorption by bacterial preparations.



Efficiency of bacterial preparations in sulphide removal from enriched sediment

Biopolymer clay composite for management of nitrogen metabolites in shrimp ponds

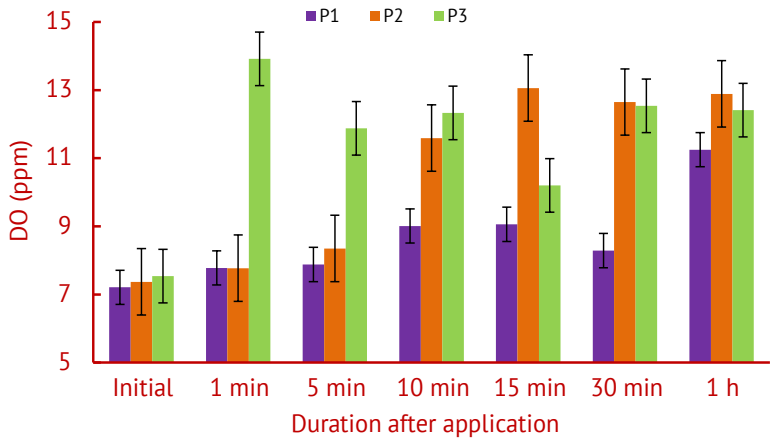
The total ammonia nitrogen (TAN) is toxic to shrimps especially with high stocking density. Application of zeolite is common practice by farmers to manage the metabolites, which is less effective in the brackishwater systems. In order to develop an adsorbent with enhanced ammonia removal capacity, biopolymer bentonite composite was synthesised by co-polymerisation method. The X-ray diffraction of the composite revealed the enhanced d-spacing of bentonite clay mineral by the intercalation of chitosan molecule resulted in higher surface area. The composite was evaluated for its efficiency in the removal of TAN from aqueous system. The removal capacity of the composite was 21.83 mg TAN g^{-1} composite at 0 ppt, which reduced to 10.17 mg TAN g^{-1} composite at 30 ppt salinity, much higher than the values reported for zeolite. Adsorption isotherms showed the efficiency of the composite in decreasing TAN. Treating the low saline shrimp pond water with the composite resulted in 77.9% reduction in TAN level within 15 min. The synthesised composite can be utilised as an adsorbent for total ammonia nitrogen in shrimp farming.



TAN Removal by bentonite composite as indicated by Langmuir (a) and Freundlich (b) isotherms

Sodium percarbonate based formulation effective in dissolved oxygen release

Dissolved oxygen releasing compounds were synthesised by active components, stabilizers and fillers, etc. Evaluation of the prototype DO releasing powders at three salinities (10, 20 and 30 ppt) showed effectiveness of sodium percarbonate (SPC) based product (P1) compared to calcium peroxide based product. DO level with SPC prototype product enhanced the DO level to 13.9 ppm at 10 ppt salinity

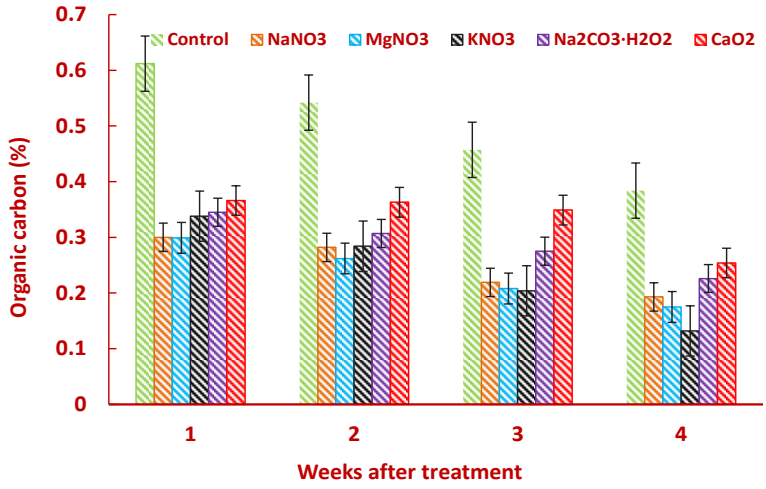


Dissolved oxygen release from different products at 10 ppt salinity.

immediately after application and sustained the level to 12.41 ppm after 1 hr of application. Similarly prototype product raised the DO to maximum of 12.37 and 11.17 ppm immediately after application at 20 and 30 ppt salinity, respectively. On comparison with commercial SPC based products in granular (P2) and tablet forms (P3), powder form (P1) was more efficient in enhancing the DO levels followed by granular and tablet forms. As DO release products are in need during emergency situations, the SPC based product can be effective during such conditions.

Nitrate salts effective in oxidising the pond bottom soil

Pond soil quality is one of the major factors that determines the success or failure of shrimp culture. Generally after the crop harvest, water draining is not uniform throughout the pond bottom in most of the farms and it takes more time for drying compared to the other portions on the pond bottom. In order to oxidise the soil with these water patches, sodium percarbonate, calcium peroxide, and nitrate salts of potassium, sodium and magnesium were applied @ 20% (w/w) to wet pond sediment. The results showed that nitrate salts were found to be more effective in reducing the organic carbon content than the formulations with SPC, calcium peroxide and control.



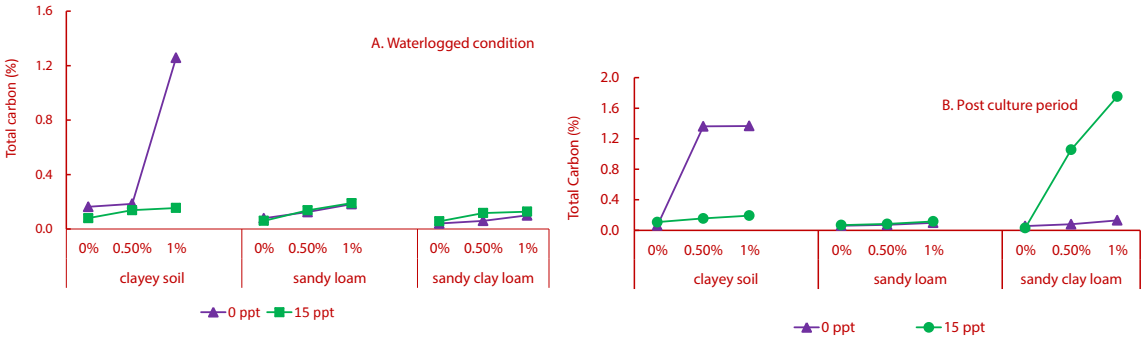
Effect of chemical treatments on oxidation of pond soil

Carbon saturation capacity and labile carbon in aquaculture pond soils

It is important to understand the variation in the carbon saturation of aquaculture pond soils, which varies with the input of carbon in the pond bottom soil from uneaten feed, faecal matter, bloom crash etc.The quantification of the easily available form of carbon (labile carbon) in culture pond sediment will give a clear insight into the state of carbon degradation. To determine the carbon saturation capacity of aquaculture pond soils, experiments were conducted mimicking the pond environment with three soils varying in texture (clayey, sandy loam and sandy clay loam) and carbon substrate in the form of cellulose at different concentrations for a period of 90 days at two salinities. One set of experiment was maintained in waterlogged condition representing the culture period and the other set was maintained at field capacity mimicking the post culture period. It was observed that, fine textured soil, clayey soil and sandy clay loam soil reached saturation at higher salinities faster than sandy loam soil in water logged and post culture conditions.

The addition of carbon substrate decreased the redox potential under higher salinity in sandy loam and clayey soils indicating differential pattern of organic matter degradation in different textured soils. Analysis of labile carbon fraction in the pond sediment from *P. vannamei* culture ponds varying in texture (sandy loam and sandy clay loam) showed

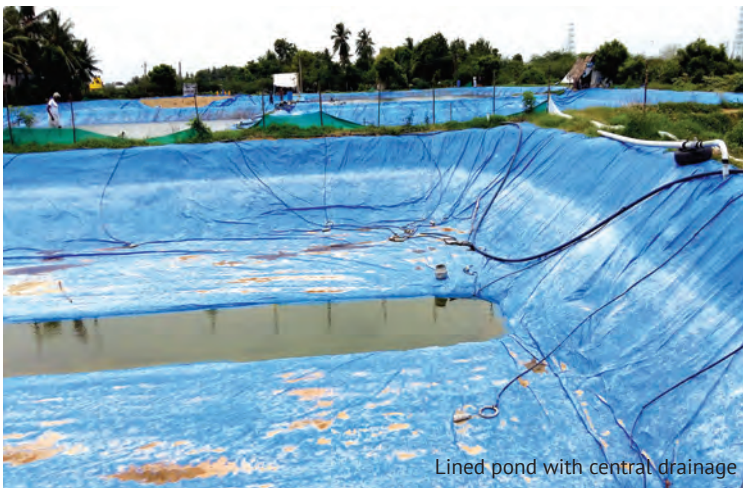
higher quantity in sandy loam soil and more reduced condition compared to sandy clay loam. The study indicated that though the total carbon saturation was faster in fine textured soils, it is the labile carbon fraction which is responsible for faster deteriorating pond bottom conditions.



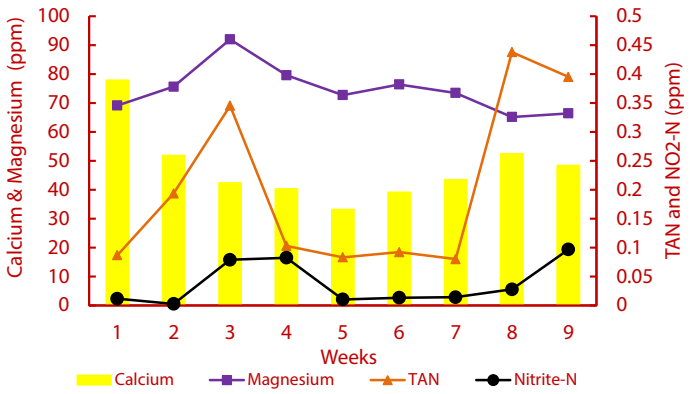
Total carbon content in different soils under A) water-logged and B) field condition

Performance of *P. vannamei* farming in plastic lined ponds

Recently, there is a growing trend to culture *P. vannamei* in plastic lined ponds in both low saline and brackishwater areas, even though the soil in the area is suitable for earthen pond culture due to certain advantages such as complete removal of sludge after culture and produce more crops per year. In order to assess the pond health in lined ponds with central drainage system,*P. vannamei* culture with 60 per m^2 stocking density, performance under low salinities was monitored for two crops in Walajabad, Kancheepuram District, Tamil Nadu. pH and salinity ranged from 7.3 to 9 and 1 to 2 ppt throughout the culture in both the crops. The concentration of metabolites was within the desirable limits. Average nitrate and phosphate concentrations were 0.14 and 0.12 ppm, and 0.07 and 0.04 ppm in 1 st and 2 nd crops, respectively. Though only 60% survival was obtained due to low salinity and minerals concentration, production of 6 t / ha was achieved with FCR of 0.8.



Lined pond with central drainage



Concentrations of minerals and metabolites in *P. vannamei* lined ponds

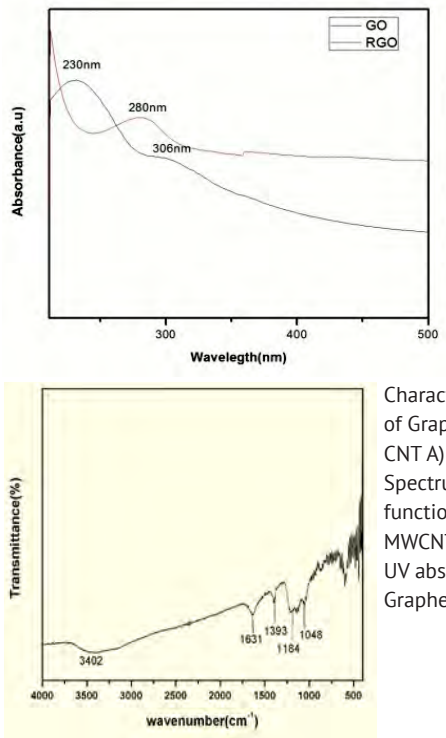
Environmental impact assessment of low saline *P. vanaanei* farming

Of late, farmers culturing *P. vannamei* in low saline or freshwaters in Tamil Nadu and Andhra Pradesh are being criticized for environmental issues. In order to assess the environmental impacts of low saline shrimp aquaculture, case studies were conducted in Orthanadu, Thanjavur District, Tamil Nadu. Most of the low saline (0 to 1 ppt) shrimp farms were surrounded by rice fields and the discharge water from these farms were used by the agriculture farmers for irrigating paddy crop. The sediment from the shrimp culture ponds was applied as manure for the tree crops within the farm. Paddy crop irrigated withshrimp farm discharge water with 0.795 ppm NO_3-N and 0.274 ppm phosphate-P resulted in production of 2700 to 3000 kg $acre^{-1}$ compared to yield of 2160 to 2400 kg $acre^{-1}$ obtained upon irrigation with normal water with 0.05 ppm NO_3-N and 0.068 ppm phosphate. Paddy farmers are saving approximately Rs.5000/- $acre^{-1}$ by minimising the use of fertilizers. Better growth of Teak trees with the use of harvested low saline shrimp pond sediment showed its potential as manure for horticultural crops.

Impact of low saline *P. vanamei* farming A) Shrimp farms and paddy fields B) Pumping shrimp farms discharge water to irrigate paddy fields

Carbon nanotube based sensor for ammonia detection in aquaculture ponds

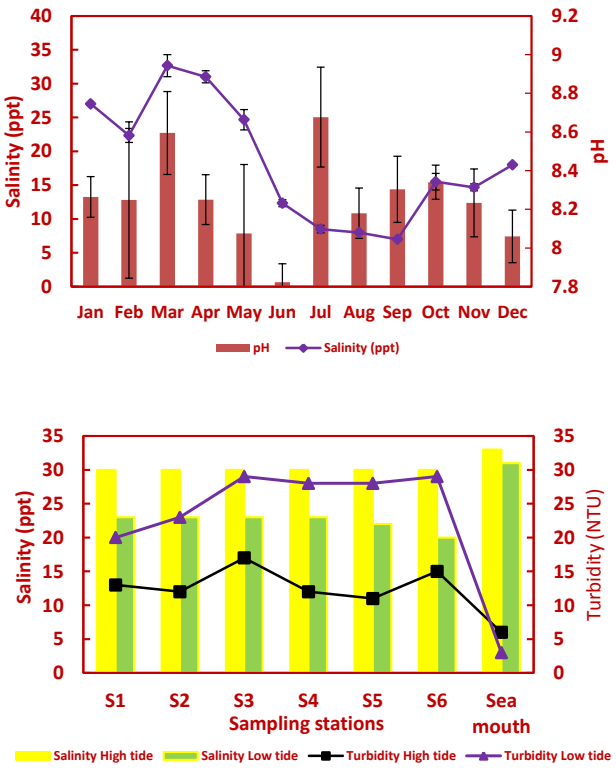
To detect ammonia concentration, Graphene-CNT-CuO nano-composites were synthesized and characterized to confirm their properties. The peak position and the relative peak intensities in the XRD of synthesized CuO matched with the JCPDS no. 48-1548. The FTIR spectra of CNT showed a broad band at 3400 cm^{-1} and a narrow band at 1631 cm^{-1} due to O-H and C=C stretch respectively, confirming that CNT is functionalized with OH groups. The UV absorption of reduced graphene oxide is slightly red shifted from 265 to 280 nm which lowers the band gap and the absorption in this range is due to the π-plasmon excitation of graphitic nanostructure. The prepared nano-composites were able to measure only high concentration of ammonia (> 5 ppm) in freshwater environment.



Characterisation of Graphene-CNT A) FTIR Spectrum of OH-functionalized MWCNT and B) UV absorption of Graphene

Environmental monitoring of Adyar creek and Muttukadu backwaters

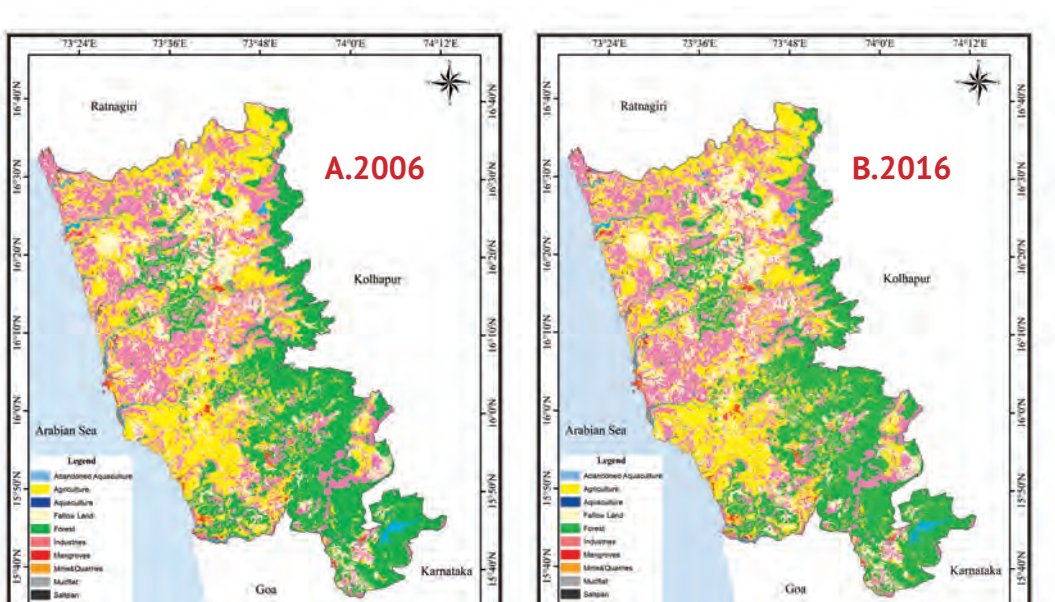
Adyar creek of 150 Ac with a length of 1.5 km out of a total water spread area of 300 Ac, and Muttukkadu backwaters were monitored at monthly interval with 6 and 9 fixed sampling stations, respectively in 2016. Adyar creek water pH and salinity ranged from 7.9 to 8.6 and 7 to 33 ppt, respectively pH and organic carbon content of the creek sediment varied from 7.5 to 8.9 and 0.23 to 2.8 % respectively. Salinity, turbidity, metabolites and nutrients content of Adyar creek were significantly influenced by tidal pattern. There was significant variation in water quality parameters between the seasons in Muttukkadu backwaters. Nitrate N and phosphate concentration were found to be high during April-June and low during July-August across the sites. Chlorophyll content was highly correlated with phosphate concentration of water.



Changes in water quality parameters of Adyar creek A) Month-wise variation in pH and salinity B) Tidal influence on salinity and turbidity

Environmental impact assessment of crab farming

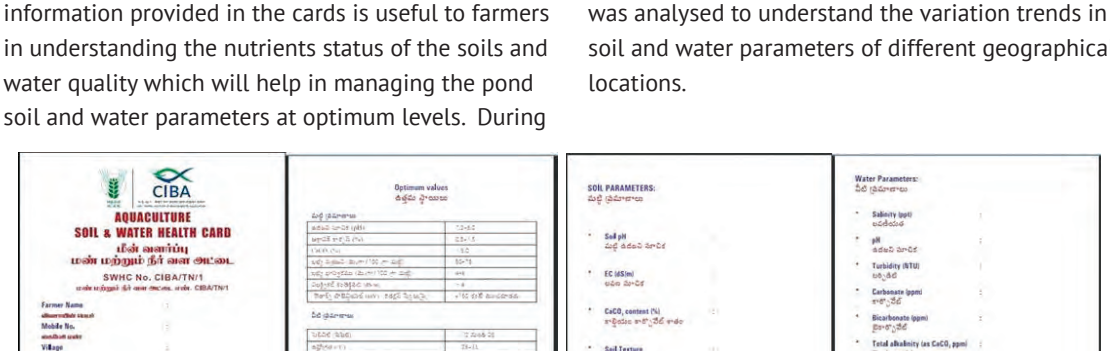
Environmental impact assessment(EIA) of crab culture project sites was carried out in three coastal Taluks viz., Malvan, Davgad and Vengurla in Sindhudurg District, Maharashtra. Land use changes through GIS studies over the years indicated that aquaculture area was 101 ha in 2006 and decreased to 67 ha in 2016. Environmental parameters of source water, inlet, culture pond and outlet were monitored and comparison with the baseline data indicated that crab farming did not have any negative environmental impacts on the receiving water bodies. Though few water parameters showed high values in discharge water, the values in the receiving water body were within the permissible limits due to good flushing capacity or rate of dilution in the water body. Carrying capacity assessment of source waters viz., Achara Creek in Malwan, Naringre Creek in Devgad and Mandavi Creek in Vengurula for crab farming indicated that water parameters at all the sampling points were within the permissible limits and there is a scope for increasing the crab farming area in the district.



Land use classification maps of Sindhudurg District A) 2006 and B) 2016

Soil and water health cards distributed to brackishwater aquaculture farmers

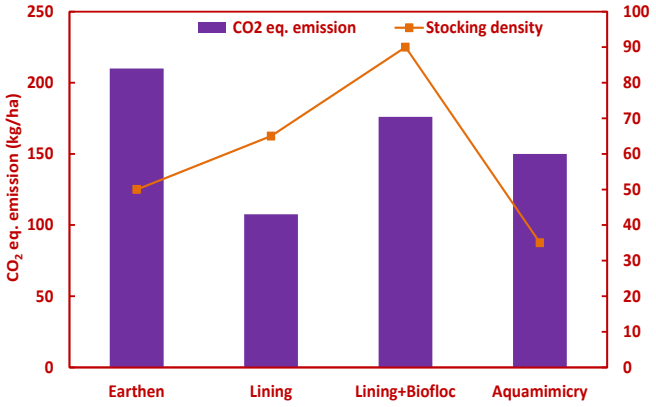
First time in the country, soil and water health cards (SWHC) were issued in fisheries sector by ICAR-CIBA to brackishwater aquaculture farmers. Maintenance of soil and water quality is essential for successful and long-term sustainability of aquaculture. The information provided in the cards is useful to farmers in understanding the nutrients status of the soils and water quality which will help in managing the pond soil and water parameters at optimum levels. During the year, 520 soil and water health cards for aqua farms in Nagapattinam and Ramnathpuram districts of Tamil Nadu, and Guntur and Prakasam districts of Andhra Pradesh, and distributed to farmers. The data obtained on the soil and water characteristics was analysed to understand the variation trends in soil and water parameters of different geographical locations.



Model Soil and Water Health Card

Greenhouse gas emission from different *P. vannamei* culture systems

Emission of greenhouse gases (GHGs) from *P. vannamei* culture ponds was compared with plastic lined, lined biofloc and aquamimicry culture systems. Emission of GHGs was measured every month from all the culture systems during the culture period. Molasses was added in the biofloc technology culture ponds as extra carbon source. Aquamimicry, a new technology of shrimp farming mimics the aquatic natural inhabitation of shrimps, which is believed to effectively provide zooplankton blooms, mainly copepods as supplemental nutrition to the cultured shrimp and beneficial bacteria to maintain water quality. Carbon sources such as rice bran and soyameal were fermented and applied to ponds along with *Bacillus* sp. probiotics. Compared to biofloc, the amount of carbon added was less in aquamimicry



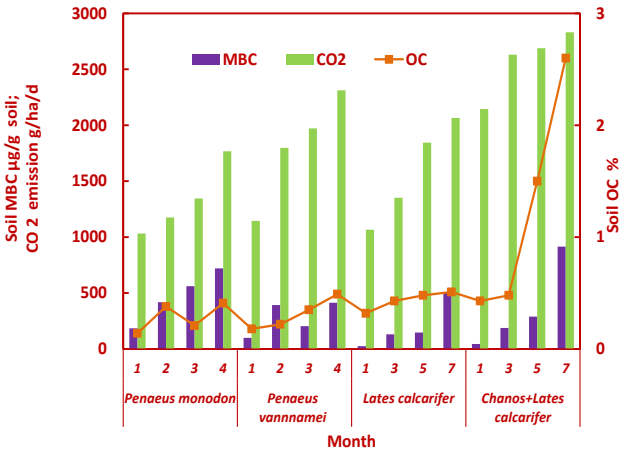
GHGs emitted (av. values) from *P. vannamei* culture systems

systems. Average emission of GHGs in terms of CO_2 eq. emission in kg ha-1 was less in lined ponds followed by lined biofloc ponds and aquamimicry culture systems compared to earthen ponds culture.

GHGs emission and microbial biomass carbon in aquaculture ponds

Soil microbial biomass carbon (MBC) helps to understand the nutrient cycling and organic matter turnover and also serves as an indicator for augmented atmospheric carbon dioxide. Pond soil samples were collected at monthly intervals from *P. monodon*, *P. vannamei* and fish farming systems (*Lates calcarifer, Catla catla* and *Labeo rohita*) from Tamil Nadu and Andhra Pradesh, respectively. MBC, soil organic carbon (OC) and CO_2 emission from aquaculture ponds were estimated and correlated.

The values of MBC and OC were significantly correlated with days of culture and had high correlation during summer crop compared to the winter crop. The MBC was positively correlated with CO_2 emissions in *P. monodon, Lates calcarifer, Catla catla* and *Labeo rohita* ponds where as OC was positively correlated with CO_2 emissions in *P. vannamei* ponds. The study showed the significance of MBC as an indicator of CO_2 emission in aquaculture ponds.



MBC, OC and CO2 emission from shrimp and fish culture systems

Influence of organic matter on methane production

In anaerobic sediments methanogenesis is an important mineralization pathway carried out by methanogenic archaea. As the culture progresses, considerable amount of organic matter accumulates in pond bottom which provides ideal condition for these bacteria to flourish. In order to study the effect of organic matter on methane production, laboratory scale microcosm was maintained with the sediment from shrimp culture pond for a period of 20 days using two formulated feeds varying in carbon content at two doses and two salinity levels. To create complete anaerobic condition, oxygen free nitrogen gas was bubbled and the microcosm was kept undisturbed for 3 days. Changes in redox potential and pH were monitored every 24 h and methane production was measured at every four days interval. Overall, high methane production was achieved under high organic matter treatment, in both the salinities. In low saline water (5 ppt), methane production was high, compared to high saline (30 ppt).

Setup of experiment with microcosm

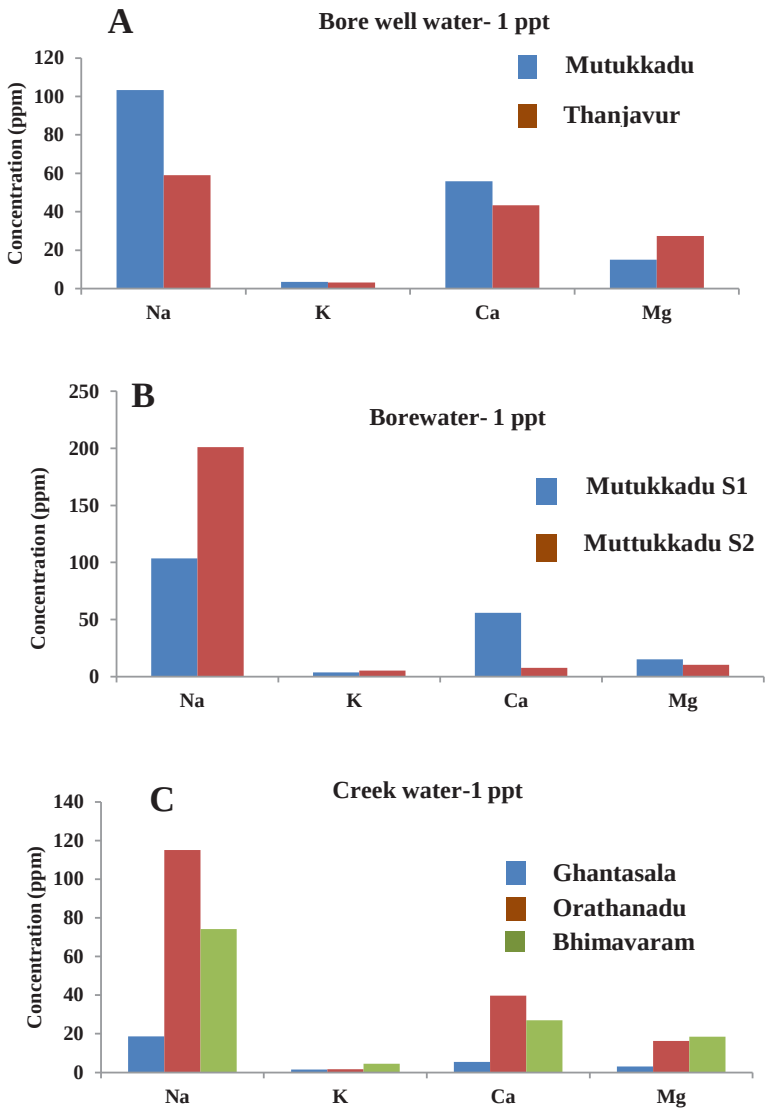
Impact of extreme weather events on shrimp aquaculture

The damage to shrimp aquaculture due to heavy rains induced flood in July, 2016 in Valsad District, Gujarat was estimated. About 1000 tons of feed was lost. Flood from Oranga and Kothar Rivers inundated 259 and 125 ha belonging to 75 and 49 farmers, respectively and resulted in huge loss to infrastructure and stock amounting to Rs. 267 million. Accumulation of silt was observed up to 15 cm on pond bottom.

Inundation of ponds and infrastructure damage due to flood in Valsad dist., Gujarat

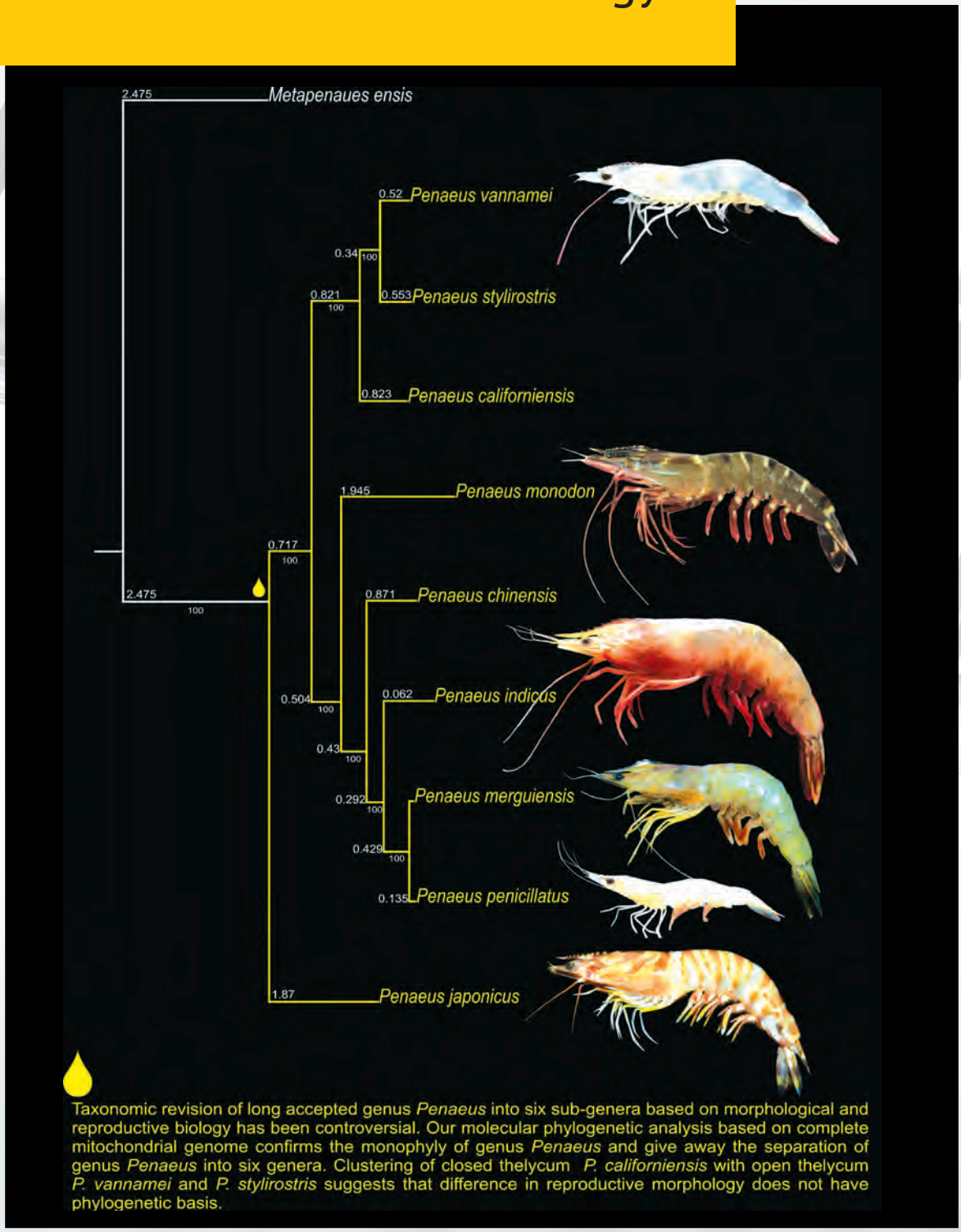
Mineral and ionic composition of shrimp farm source waters

Mineral composition of the source waters used for shrimp farming in coastal states of Andhra Pradesh, Gujarat and Tamil Nadu was examined. Composition of minerals (Na, K, Ca and Mg) varied in the bore waters of different salinity. With regard to the ionic ratios (Na/K, Mg/Ca and Ca/K) in bore water with that of seawater, the ratios these minerals were dissimilar to seawater with salinity of 0 to 10 ppt, whereas, the ratios of minerals in waters with salinities ranging from 15 to 20 ppt was almost similar to that of seawater. In creek waters of 1 to 7 ppt and above 40 ppt, the ionic ratios were not similar to seawater ratios, whereas they are similar in 20 to 28 ppt waters. Comparison of mineral composition of bore and creek waters of similar salinity from different geographical locations indicated that values of K were similar between the sampling places in bore waters whereas, other ions differed in composition. In case of creek waters, all the ions differed with sampling places. The observations suggest that mineral balance is comparable in water of salinity ranging from 15-20 ppt in bore and seawater.



Variation in minerals concentration of bore and creek waters of similar salinity

Genetics and Biotechnology



Taxonomic revision of long accepted genus *Penaeus* into six sub-genera based on morphological and reproductive biology has been controversial. Our molecular phylogenetic analysis based on complete mitochondrial genome confirms the monophyly of genus *Penaeus* and give away the separation of genus *Penaeus* into six genera. Clustering of closed thelycum *P. californiensis* with open thelycum *P. vannamei* and *P. stylirostris* suggests that difference in reproductive morphology does not have phylogenetic basis.

GENETICS AND BIOTECHNOLOGY

Population genetic analysis among the stocks of candidate species

The genetic characterization of species of interest along the natural habitat is of paramount importance as it delineates the divergent genetic stocks existing in a species. The information so generated would be extremely useful in initiating genetic improvement programmes for economic traits. Presently, genetic characterization is being carried out for species viz. Pearlspot and Indian White Shrimp.

Pearlspot

Pearlspot belongs to the Cichlid family and has commercial significanceas food as well as ornamental fish. Realizing its growth potential, the instiute has initiated a genetic characterization program to comprehend the divergence among the stocks. So far, specimens have been collected from four locations, Kollam (Ashtamudi lake), Thiruvananthapuram (Vellayani lake), Cochin (Vembanad lake) and Pulicat (Pulicat lake). Consensus sequences of three mtDNA genes namely ATPase6/8 (674 bp), Cytochrome b (281 bp) and 12S rRNA (382 bp) were used to unravel the divergence between stocks. The 12S rRNA and Cytochrome b genes were not able to detect any divergence between stocks. However, the ATPase6/8 gene demonstrated ~54% of variation between stocks,and indicates the divergence existing among stocks. The specimens of Pulicat were observed to be completely divergent from the rest. The Vellayani and Vembanad stocks also showed significant divergence

AT Pase6/8 gene demonstrated thatt~54% of variation between stocks of pearlspot, and indicates the divergence existing among stocks. The specimens of Pulicat were observed to be completely divergent from the rest.

F_{ST} values (below-diagonal) and their significance values (above-diagonal) between stocks of Pearlspot based on ATPase6/8 gene.

Stocks	Vellayani	Vembanad	Ashtamudi	Pulicat
Vellayani	-	0.000	0.207	0.000
Vembanad	0.139	-	0.351	0.000
Ashtamudi	0.074	0.010	-	0.000
Pulicat	0.634	0.756	0.941	-

Indian White Shrimp

Microsatellites

The penaeid shrimp, *Penaeus (Fenneropenaeus) indicus*, a native species of India and several Asian countries was the subject of intensive research investigation in late 1970s and 80s. However, its potential importance for commercial aquaculture lost to *P. monodon* and *P. vannamei*. Development of native speceis for aquaculture has been well acknowledged as a strategy for sustainable develoopment of aquculture sector. As *P. indicus* offers several commercial and aquaculture advantages, the Institue has been made this species as priority species for domestication and genetic improvement. Thus, geneticcharacterisation studies have been initiated to study the population structure of various stocks along the Indian coast. Unravelling the genetic diversity levels and population differentiation of Indian white shrimps are imperative for planning and initiating genetic improvement programs. Microsatellite markers were used for genetic characterisation of different stocks of Indian white shrimp. Samples from Kollam (38), Chennai (26), Puri (20) and Kanyakumari (9) were utilised for the study of nine microsatellite loci. The samples were genotyped by fragment analysis method using ABI3730 DNA analyser (Applied Biosystems) and subsequently the analysis was carried out using the Genepop (version 4.2) tool. The Hardy-Weinberg equilibrium test differs significantly among the populations indicating non-random union of gametes in the populations. The loci JF715227; JF715265 (P=0.004) and JN787957; JQ866319 (P=0.01) were found to be under linkage disequilibrium. The fixation index $F_{ST,}$(the most widely used parameter to examine overall genetic divergence among the subpopulations) was estimated by a weighted analysis of variance (Weir and Cockerham, 1984). The R_{ST} is the analogous measure of correlation in allele size (Rousset, 1996). The differentiation is negligible if F_{ST} and R_{ST} are as small as 0.05 or even less. It could therefore be inferred from the F_{ST} and R_{ST} estimates that very little genetic differentiation exists among the populations of Indian White shrim

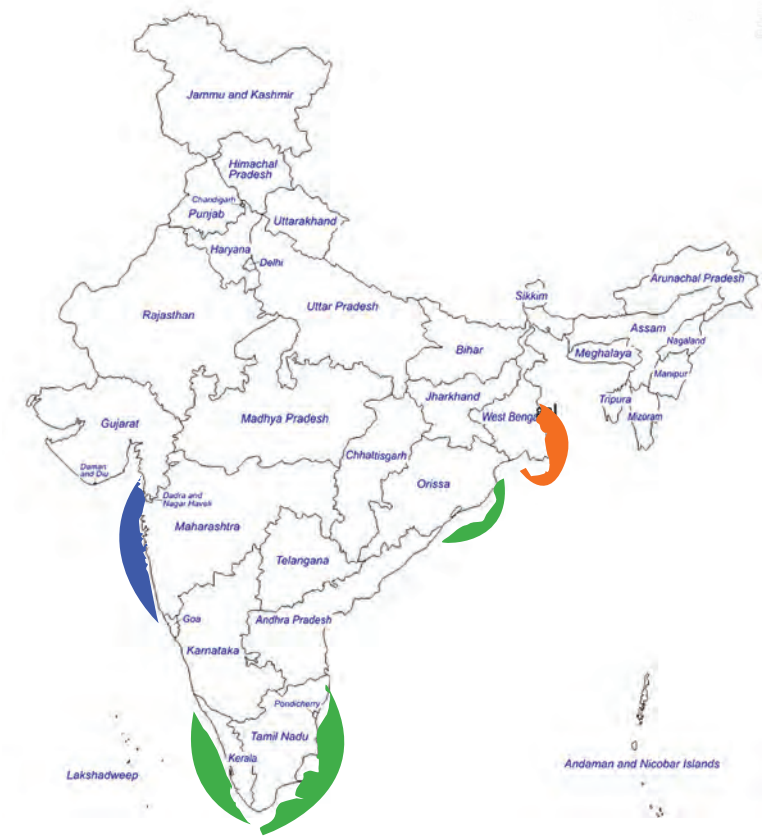
F_{ST} estimates among the stocks of Indian white shrimp

F_{ST} R_{ST}	Chennai	Kanyakumari	Puri	Kollam
Chennai	*	0.0634	0.0339	-0.0015
Kanyakumari	-0.0226	*	0.0086	0.0577
Puri	0.0111	-0.0339	*	0.0364
Kollam	-0.0085	-0.0202	0.0047	*

Penaeus indicus

Genetic stocks of Indian white shrimps as delineated by the mitochondrial DNA

In continuation of the population genetics study among India White Shrimp (IWS) stocks, specimens from Chennai, Kanyakumari, Mumbai, Puri, Kollam and Kakdwip have been analyzed based on partial fragment of mitochondrial DNA gene, 16S rRNA. A consensus fragment of 467 bp was considered for haplotype-based population genetic analysis in Arlequin software. Out of 94 sequences considered for analysis (Chennai: 14, Kanyakumari: 12, Mumbai: 10, Puri: 21, Kollam: 17 and Kakdwip: 20), 16 haplotypes were observed. About 84 % of total variation in the population was attributed to the differences among the stocks. The analysis did point out the existence of three genetic stocks for IWS as indicated in the figure.



Genetic stocks of *P. indicus* as delineated by the mtDNA gene, 16S rRNA.

Based on the mitochondrial DNA gene, 16SrRNA, three different stocks of *Penaeus indicus* in Indian water were obserevved

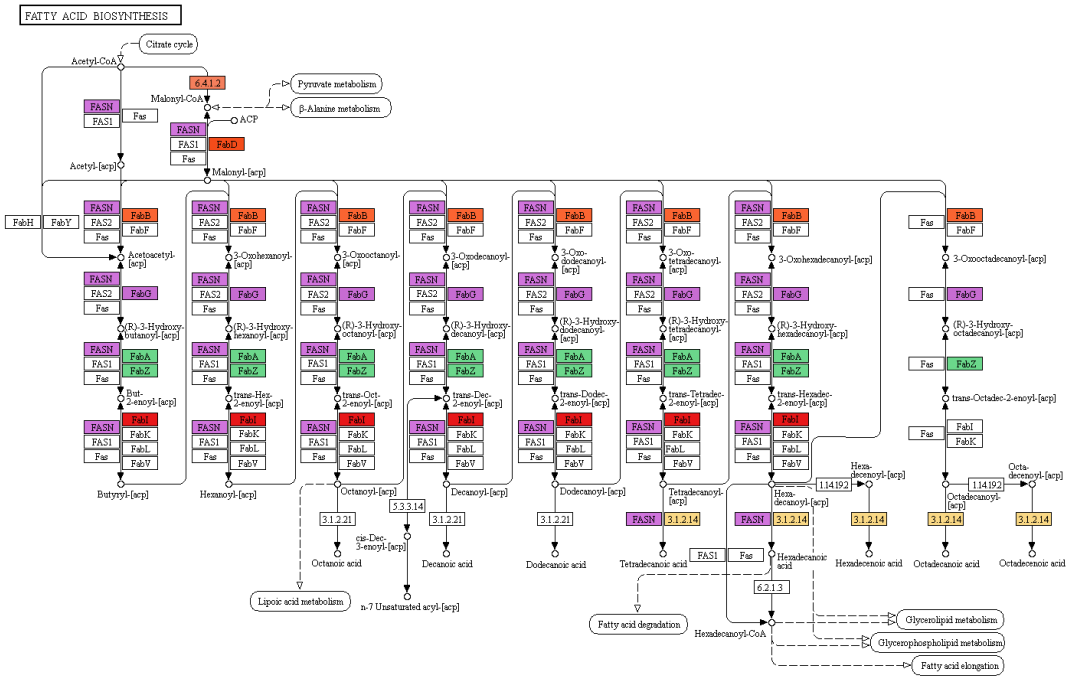
Grey Mullet

Mitochondrial DNA genes

The ATPase 6/8 gene was sequenced for 30 mullet samples collected from Kerala (Kochi), Tamil Nadu (Pulicat) and Navsari (Gujarat). Analysis of molecular variance (AMOVA) of mitochondrial DNA data revealed no significant genetic differentiation among Kerala and Tamil Nadu. A total of 5 haplotypes were identified among samples of Tamil Nadu and Kerala populations. Phylogenetic analysis based on partial ATPase 6/8 gene revealed that Gujarat stock is divergent from Kerala and Tamil Nadu stocks. Work is in progress with additional samples collected from Gujarat and barcoding of the same.

Effect of temperature stress on growth and transcriptome profile of *P. vannamei*

The juveniles of *P. vannamei* reared in thermostatic re-circulatory aquaculture system (RAS) system at varying temperatures, 29, 31,33and35°C showed better survival and growth between 31 and 33°C. The hepatopancreas of three shrimps per group were collected and used for of RNA extraction and transcriptomics. About 64 million good quality paired-reads were used to construct a *de novo* assembly in Trinity software. The assembly generated 1,63,198 transcripts. The enzymes were mapped on to KEGG pathways. Based on the differentially expressed transcripts for which enzyme codes are available, it may be inferred that the shrimp exposed to high temperature (31 and 33°C) displayed higher expression of transcripts involved in fatty acid biosynthesis compared to control (29°C), but not at 35°C. Other functional annotation tools like DAVID are being exploited to analyze all the differentially expressed genes (including those without enzyme codes also) before drawing final inferences.



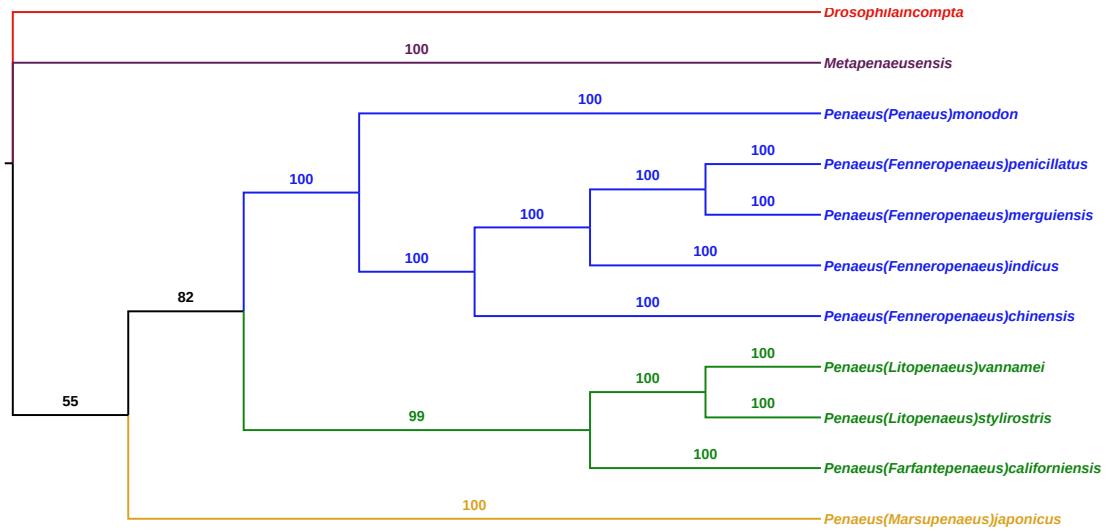
KEGG map depicting the up-regulated transcripts related to fatty acid biosynthesis in *P. vannamei* reared at 33°C.

Phylogenomic analysis among the penaeid shrimps

The split of genus *Penaeus* into six genera has been controversial ever since the revision. Researchers and commercial aquculturists has been opposing the split of the genus claim as the revision criteria were more of morphological nature rather than a combination of morphological and molecular data. The controversial re-classification was re-visited based on the phylogenetic analysis utilizing the complete mitochondrial genome sequence. Nine complete mitochondrial genome sequences already available for penaeid shrimps and the genome sequence generated for *P. indicus* by CIBA recently along with the sequence of *D. incompta* as outgroup were used for phylogenomic analysis. The maximum likelihood, maximum

parsimony and Bayesian approaches were employed to generate and understand the phylogenetic relations among the shrimps. A partitioned Bremer support analysis was also performed to document the contribution of individual genes to the nodal support of branches in the tree. The results did indicate that the true phylogenetic relation among shrimp species is more of geographical rather than morphological in nature. The CO1, ND1, 16s rRNA, ND4, CYTB and ND5 are the better genes over other protein-coding and rRNA genes of mtDNA for undertaking phylogeny studies in shrimps. The whole mitogenome study dismisses the six-genus/subgenera classification and suggests restoring the old genus *Penaeus*.

True phylogenetic relation among shrimp species is more of geographical rather than morphological in nature. The whole mitogenome study dismisses the six-genus/ subgenera classification and suggests restoring the old genus *Penaeus*



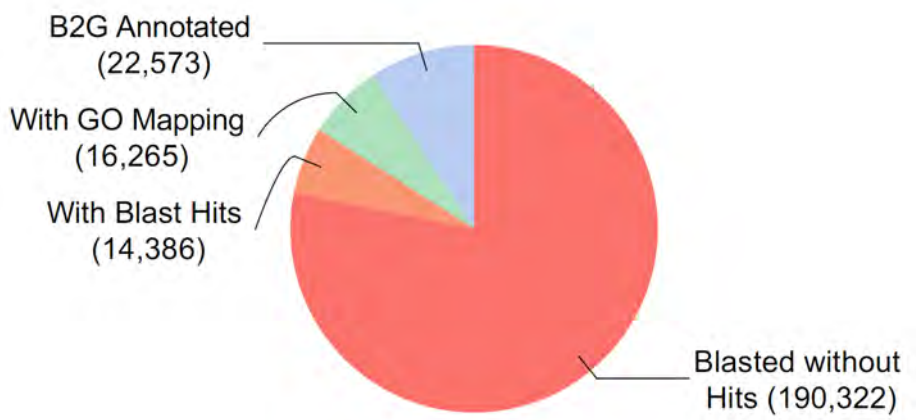
Phylogenetic tree of penaeid shrimps

Whole genome sequencing of *Penaeus indicus*

Penaeus indicus, an important species of commercial significance to Indian shrimp aquaculture, needs to be characterized for which the institute has taken up the programme of sequencing its whole genome. As part of the programme, it is important to build the total transcriptome of the species to characterize the expressed transcripts. The polymorphic positions in the transcripts are also of significance to understand gene variants. The transcripts and the polymorphisms may further help in validating the whole genome when generated. To build the actual genome itself, several long, medium and short reads of *P. indicus* DNA has been obtained which would be used for building the whole genome.

Transcriptome of *P. indicus*

A *de novo* transcriptome was assembled with Illumina paired-end reads generated using gills, heart, muscle, pleopod and hepatopancreas tissues of *P. indicus* in Trinity software. About 63 million good quality reads were used for making the assembly that consisted of 2,43,546 transcripts with a GC content of 41.97% and N50 value of 962 bp.A blast-search was performed for the transcripts against non-redundant protein database of NCBI followed by mapping and annotation in blast2go software. Only 9 % of the transcripts could be annotated and a majority of the transcripts (~ 78%) did not return any blast hits. More data from other tissues as well as from other life-stages are being appended for expansion of coverage.



Blast statistics for de novo assembled transcripts of *P. indicus*

Coding SNPs database in *P. indicus*

In order to document polymorphisms in transcripts of *P. indicus*, RNA-seq was performed on pooled samples collected from diverse geographic locations. Three runs were performed on Illumina platform for gills, muscle and hepatopancreas samples. After quality control of raw data, about 28 million good quality reads were utilized for assembling in Trinity software. The assembly consisted of 1,46,419 transcripts with a GC content of 43.35 %. A reference-based alignment was performed using bowtie tool to align reads to transcripts. Several intermittent files have been generated using various tools before generating the file containing information on Single Nucleotide Polymorphism (SNP) variations. A total of 2,41,327 high quality SNPs have been obtained.

Characterization of differentially expressed shrimp immune genes

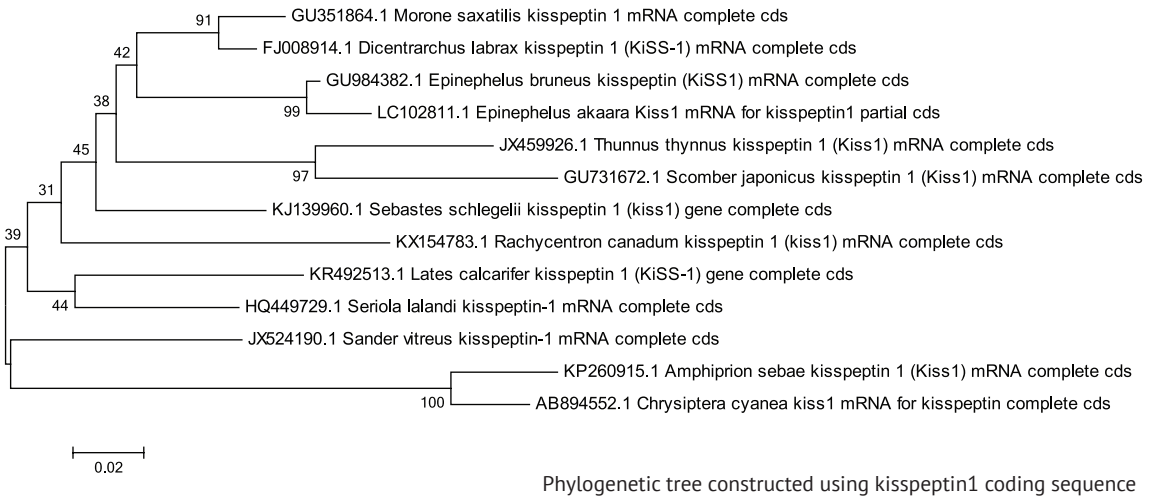
White spot syndrome virus, continues to cause huge economic losses to the aquaculture industry. In the absence of effective therapeutics to control WSSV, it is important to understand the host pathogen interaction at the molecular level. Suppression subtractive hybridization (SSH) cDNA library was constructed which led to identification of several differentially expressed genes in response to WSSV infection in *Penaeus monodon*. The genes expressed in SSH cDNA library of shrimpgill and gut tissues had a wide range of biological functions. The three differentially expressed genes, Single von Willebrand factor type C domain protein (*pm*SVC), P53 protein gene(*pm*P53) and ADP ribosylation factor (*pm*Arf) were up-regulated on WSSV infection. The *pm*SVCsequence showed homology with single VWC domain protein 1 of *P. vannamei* (*Lv*SVC1) having 168 amino acids. The sequence of P53 cDNA (1353 bp) showed high similarity to the P53 gene sequence isolated from *P. vannamei*. RNAi studies are in progress to evaluate the role of *pm*SVC, *pm*P53 and *pm*Arf genes in the shrimp defense against WSSV infection.

Functional genes in teleost reproduction

Characterisation of Asian seabass Kisspeptin1 gene

Kisspeptin stimulates gonadotrophin releasing hormone, and regulate puberty and spawning in fishes. It is considered as a novel potential therapeutic target/agent for artificial induction of breeding in fish. To understand the kisspeptin gene (Kiss1) at the molecular level, the complete coding

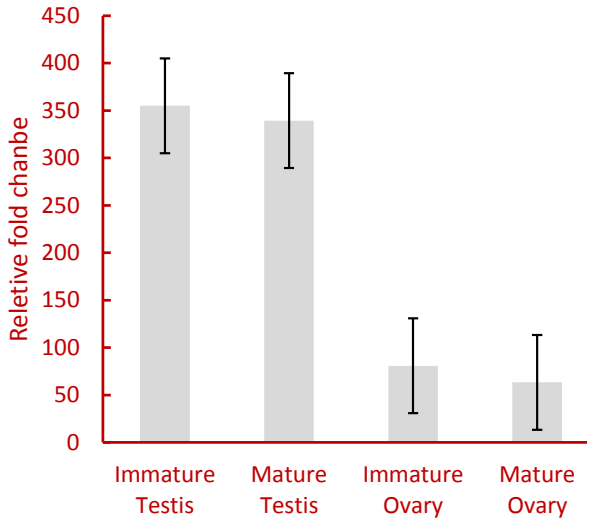
sequence of Asian seabass Kiss1 in pGEMTeasy vector was cloned and sequenced. The sequence comprised of 312 nucleotides and presumably encodes for a 103-aa protein. The encoded protein had an estimated molecular mass of 11.5 kDa. The sequence exhibited highest identity (87.4%) with European seabass (*Dicentrarchuslabrax*) and Yellowtail amberjack (*Seriolalalandi*) whereas it had least identity (56.5%) with Hong Kong grouper (*Epinephelusakaara*) at the nucleotide level. The transition/transversion ratio of 1.6 indicates the presence of transitional bias among the species studied. Phylogenetic tree reveals that Yellowtail amberjack is more closely related to Asian seabass compared to other fish species.



Phylogenetic tree constructed using kisspeptin1 coding sequence

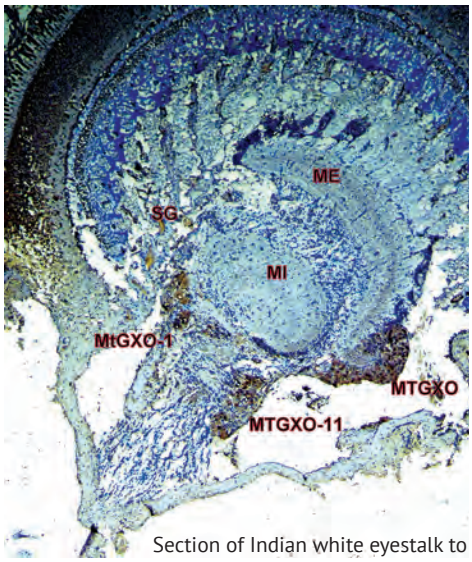
Dmrt1 expression in grey mullet

In an effort to find out male specific genes, differential expression of *dmrt1* mRNA transcript levels in the immature and mature male and female Grey mulletwas examined. The results revealed higher levels in males compared to females.



Quantitative RT PCR of dmrt1 in the testis and ovaries of *M. cephalus*

Immunolocalization of gonad inhibiting hormone in the eyestalk of Indian white shrimp *Penaeus indicus*

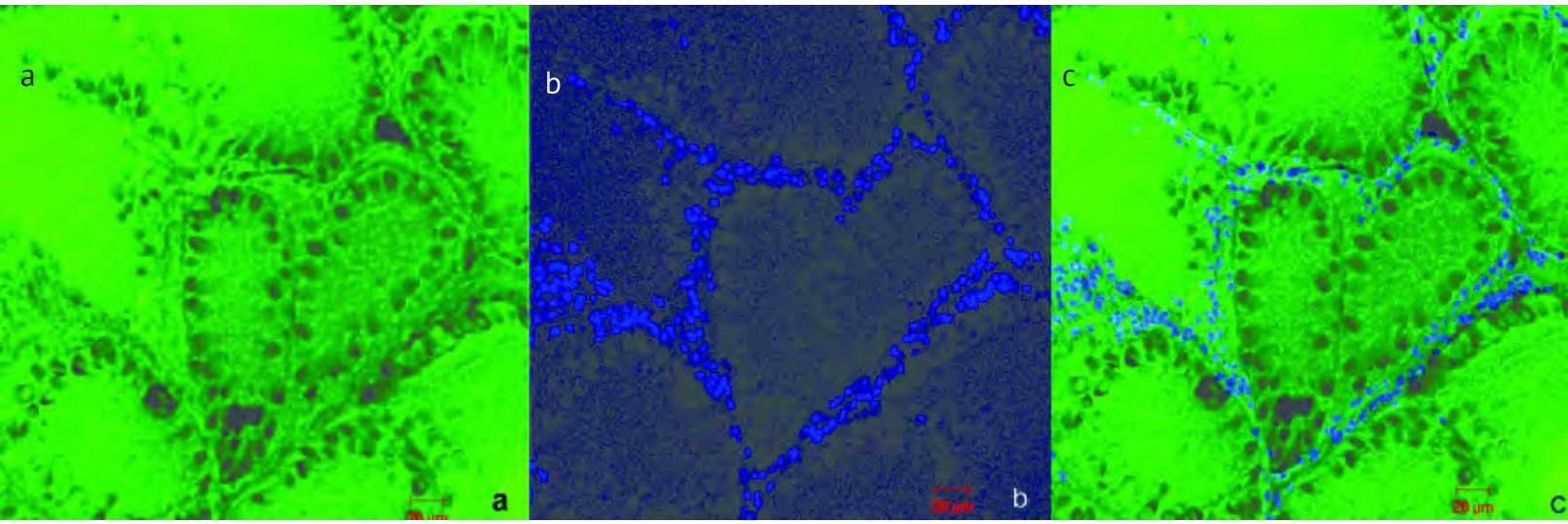


Section of Indian white eyestalk to show the GIH Immunoreactive signals

Gonad/vitellogenesis inhibiting hormone, neuropeptide hormone, synthesized by X-organ sinus gland complex of the eyestalk of crustaceans plays a pivotal role in the reproductive maturation of crustaceans. Bacterial expression systemwas adopted to express the recombinant form of gonad inhibiting hormone (GIH) from *P. indicus* as a soluble fusion protein. The purified protein was used to produce GIH specific antibody. IHC detection of GIH Immunoreactive signals were detected in the neuronal cell bodies within the eyestalk mainly in the medulla externa ganglionic X-organ (MEG XO), medulla terminalis ganglionic X-organ I and II (MTG XO-I, MTG XO –II) and sinus gland (SG

Vitellogenin in *P. indicus* ovary: an in situ hybridization, immunohistochemical and immunofluorescence study.

Vitellogenin gene, (Vg), important marker gene for reproductive maturation in the oviparous animals, was characterized at the cellular level and its expression pattern in the ovary of *P. indicus* was analysed. Strong Vg hybridization signals were obtained in the follicle cells surrounding the oocytes. The cellular localization of vitellogenin was examined by immuno-histochemical (IHC) andimmunofluorescence (IF) using specific anti-Vg antibody (*P. monodon* anti-Vg; 1; 1000 dilution). IHC staining confirmed that Vg/Vn protein was localized in ooplasm of pre-vitellogenic and vitellogenic oocytes. The staining was weak in immature oocytes, indicating the commencement of Vg protein secretion from pre-vitellogenic stage with highest expression in mature vitellogenic oocytes. IF staining wasalso indicated strong Vg signals in the ooplasm of vitellogenic oocytes. Comparing the signals of mRNA and protein, it is evident that Vg mRNA gets synthesized in follicle cells of oocytes and enter the oocytes as vitellin protein.



Immunolocalization of vitellogenin in *P. indicus* ovary: Immunoflurosense imaging. a. Vitellogenin - FITC (green) b. Counter strained with DAH (blue) c. Merged

Social Sciences and Development

"Cage aquaculture is an appropriate rearing model for judiciously utilize the open brackishwater resources. It requires location specific cage systems, inputs and capacity building."

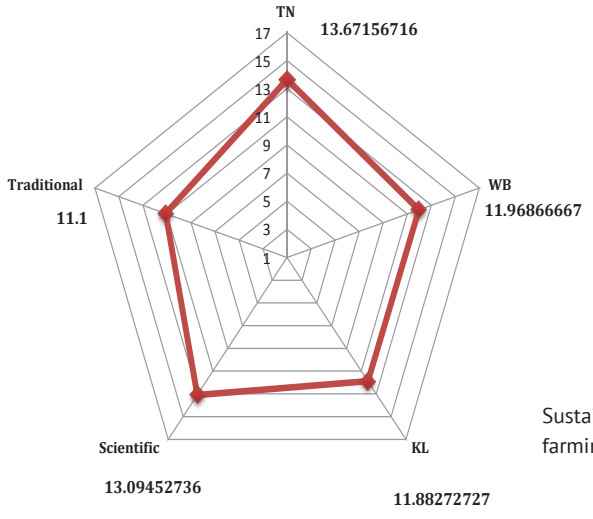
Photo: Fishers crafting the floating cages with expertise of ICAR-CIBA in Vennangupattu coastal village, Kanchipuram district, Tamil Nadu. Fishers crafting the floating cages with expertise of ICAR-CIBA in Vennangupattu coastal village, Kanchipuram district, Tamil Nadu.

SOCIAL SCIENCES AND DEVELOPMENT

Aquaculture research is inherently framed in a social context. Any research endeavour should ultimately serve society one way or other. Therefore, social science has been an integral part of the aquaculture research. Socials science research focuses on the peoples' aspiration, and, therefore, aquaculture science can continuously remaining relevant and contribute to the social welfare.

Investigations on the sustainability of shrimp farming systems

Sustainability of shrimp farming was operationalized as 'a function of productivity (technology), profitability (economic viability), in-tune with carrying capacity of the ecosystem (environment-friendly), harmony with other production systems and people, employment for the local people (socially acceptable) and support (institutional). A total of 28 indicators were identified based on a detailed methodology to measure the sustainability of shrimp farming systems. The findings of the study indicated that the mean sustainability index of shrimp farming was 0.74. Further, the semi-intensive and traditional shrimp farming had a sustainability index of 0.79 and 0.65 respectively. The results indicate that both the systems are sustainable but the semi-intensive system is relatively more sustainable as the non-parametric statistic Mann-Whitney test indicated that there is a significant difference in the sustainability showing an edge to the semi-intensive system. The semi-intensive system had an edge in case of technical, social and institutional indicators vis-à-vis traditional systems. However, returns to investment seem to be equal in both the systems and the economic sustainability score indicated that both the systems are sustainable on their own merits. As a whole, the radar chart indicates that semi-intensive shrimp farming systems exhibit better sustainability mainly due to their technical, social and institutional functions than the traditional shrimp farming systems. However, traditional systems need to be improved with technical interventions in stocking density and better management in feeding, water quality and health of the shrimps.



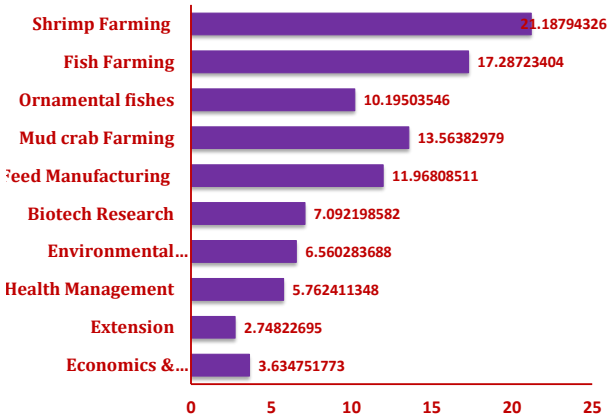
Sustainability of shrimp farming systems

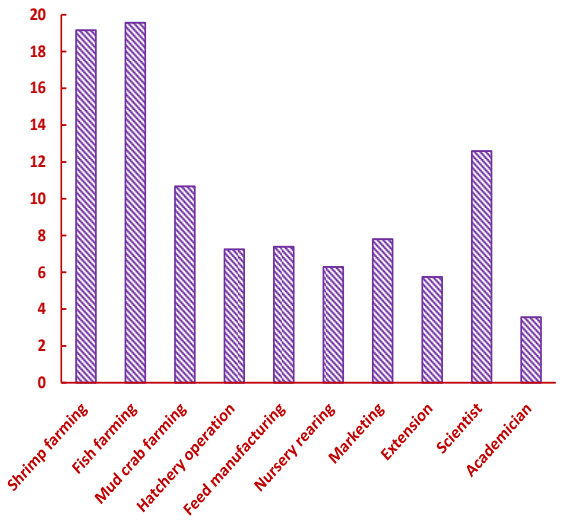
The study revealed that 40% and 52% of farms in TN were sustainable at high and moderate levels respectively. In WB 50% of the farms were rated as moderately sustainable. In the case of KL majority of the farms (59%) were rated as low sustainable and 36% were rated as moderately sustainable. The study indicates that TN farms were technically advanced, economically better performing, environmentally friendly, socially acceptable and institutional support in terms of access to technology and advisory services was better than KL and WB states. In the case of traditional systems majority of the farms (88%) were low sustainable due to their poor productivity and lack of scientific management. Alternative models like Integrated Multi-Trophic Aquaculture (IMTA) and scientific management may be advocated for enhancing the productivity of traditional aquaculture systems.

Awareness creation and entrepreneurship motivation among youth in brackishwater aquaculture

Attracting and Retaining Youth in Agriculture (ARYA) is a unique program to attract educated youth into aquaculture and its related facets. In order to create awareness on brackishwater aquaculture among school and college youth an "open day" was organized at ICAR-CIBA muttukadu experimental station, wherein all the hatchery and rearing facilities were opened up for learning and interest generation. A total of 429 students from 14 Universities/colleges and 37 students from 2 schools were exposed to different aspects of brackishwater aquaculture.

The feedback from the visiting students was collected in order to know the areas of interest for the youth in the field of brackishwater aquaculture. The youth were impressed in shrimp farming > fish farming > mud crab farming > feed formulations/ manufacturing > ornamental fish farming > biotechnology research > Environmental research> Health management> economics > extension, in order. Their career aspiration ranked top in fish farming followed by shrimp farming and then to serve as a scientist.





Subjects Matter attracted youth and their career preferences

Aquaculture in Adyar creek

For mainstreaming the aquaculture at the broader context of social development, landless and under employed fishers should be brought to the brackishwater aquaculture. Lack of culture area is the major constraint that precludes land less rural people from the benefits of aquaculture. Cage and pen culture in the communal water bodies may be the only option for these marginalized communities for beginning aquaculture. However, many water bodies, particularly in the metro cities, are ecologically deteriorated due to the various anthropogenic activities. Recently, Tamil Nadu Government has taken steps towards rejuvenating the Adyar estuarine ecosystem. In this ecosystem, the ICAR-CIBA has taken demonstration culture project with the participation of fisher families. Demonstration trials were carried out for rearing brackishwater finfishes in cages to understand the suitability of different species in the Adyar estuarine ecosystem. A total of 5 pre-grow out cages (2x1x1 m) were fabricated and installed in a 100 m^2 pen structure. Hundred seabass fry (size 2 g/5.1 cm); 80 milkfish fry (size – 8.5 g/9 cm); 10 red snapper fry (size - 6.2 g/6.3 cm) and 250 pearlspot fry (Size - 2.5 g /5.5 cm) were stocked in to five different cages separately. Fishes were fed on formulated diets made by ICAR-CIBA @ 5% body weight twice a day. After 40 days rearing, milkfish attained a size of 50.2 g and performed better than other species indicating the suitability of the species in murky waters of Adyar estuary. Additionally, the pen installed in the creek has been stocked using a combination of *Megalops cyprinoides* and *tilapia*. Fishes were fed on a formulated feed prepared by ICAR-CIBA @ 3-4% body weight twice a day apart from the natural feed available in the pen. The fisher folks (5 families; 2 nos. from each family) were trained in different aspects of cage installation, cage maintenance, feeding, and sampling etc.

Cages and Pen rearing systems installed in Adyar creek

Aquastat^{plus} - A complete database for Indian brackishwater aquaculture scenario

State wise fish and shrimp production, area and productivity data since 1991 to 2016 were compiled in a database. Additional information such as list of CAA registered farmers, *Penaeus vannamei* brooder imports, commodity wise and port wise export earnings from seafood and cumulative seed production details also formed a part of the database. Available market rates for major brackishwater species along with the state wise fish consumption data were also included. The database is named **Aquastat^{plus}** and will be hosted on CIBA website after cross-validating with the various data sources.

Economic impact analysis of CIBA technologies and policy interventions

The Economic impact of three selected aquaculture technologies: WSSV kit (2002-2009), the introduction of *Penaeus vannamei* (2009-2016) and the product CIBASTIM (2012-2016) were evaluated 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 estimated at Rs. 3.4 million, from three select technologies/policy support interventions attributable to the work of present and erstwhile scientists of ICAR-CIBA. The returns to the investment made in brackishwater aquaculture research have been so huge even with an analysis making use of only three of the institute's technologies.

Impact of select technologies and policy intervention support of ICAR-CIBA during 2002-2016

S.No	Technology/ policy Intervention & period	Incremental/ saved Shrimp production –cumulative (Qty.in lakh tons)	Employment generation in farms (lakh man days)	Employment generation in related enterprises (lakh man days)	Value of Incremental Shrimp production (Rs. Lakhs)	Reduction in cost of production (Rs. Lakhs)	Value of total employment (Rs.Lakhs)	Total Economic gain (Rs.lakhs)
1	WSSV kit (2002-2009),	8.50	61	1,113	2550	63	3.33,900	3,33,963
2	Introduction of *Penaeus vannamei* (2009-2016)	12.52	511	9,373	3756	0	28,11,900	28,11,900
3	CIBASTIM (2012-2016)	8.95	5	985	2685	0	2,95,500	2,95,500
	Total	29.97	577	11,471	8991	63	34,41,300	34,41,363

Livelihood support to tribal populations through brackishwater aquaculture

Polyculture of milkfish, white shrimp and pearlspot: Under the CIBA-TSP sub-plan, several programs were initiated to enhance livelihood options for tribal settlements in Tamilnadu belonging to the Irular community. Polyculture of milkfish, Indian white shrimp andpearlspotwastaken up in an Irular tribe community pond (0.1 ha) at Senjiammannagar, Tirupalaivanam, Tiruvalur district, Tamil Nadu using CIBA hatchery produced pearlspot fry (200 nos.), *E. maculatus* fry (250 nos.), *P. indicus*(PL18) (2000 nos.) and milkfish fry collected from wild (2000 nos.). Feeding was done @ 5% body weight twice in a day. After 120 days of culture 92 Kg of milkfish was harvested.

Harvesting of fish by tribals at Senjiamman Nagar

Polyculture of milkfish, mud crab and white shrimp: Polyculture of milkfish, mud crab, and white shrimp was also taken up in another tribal community pond (1 ha) at Kanvanthurai, Tiruvallur district, Tamil Nadu wherein milkfish (2000 nos) *P. indicus* (8000 nos) and crab were stocked into the community pond. An amount of Rs. 45,000/-was realized at the end of the trial. The tribal beneficiaries have also been trained in various aspects of brackishwater aquaculture as a new livelihood option.

Farming activities of by tribals at Kanvanthurai, Tiruvallur district, Tamil Nadu

Ornamental fish rearing as livelihood activity for tribal women

Nursery rearing of Pearlspot as brackishwater ornamental fish was evaluated as a model for the livelihood development of tribal communities. A total of 1400 early fry of pearlspot were provided to the Irular Women Self Help Group at Thiruvidanthai village with feed, water quality testing and technical support. The group reared the fry to fingerlings size in the fish rearing system established in the village. These are then sold to the farmers/ customers, enabling the self-help group to earn a substantial profit within a short period. This model is promoted by ICAR-CIBA as an additional livelihood activity. The project involved initial awareness meeting, hands-on training in brackishwater ornamental larval rearing and demonstration of larval rearing. In the initial phase 1400 seeds were sold in the market.

Onsite training for pearlspot nursery rearing to Irular Women Self Help Group at Thiruvidanthai Village, Tamil Nadu

Information dissemination through mobile phones

Short Message Services (SMS) were sent to 638 small scale fish farmers from Kanchipuram, Thiruvallur, Cuddalore and Nagapattinam districts of Tamil Nadu to help them in receiving timely and accurate information on seed availability and training. About 1329 SMS (31.37% on cost of seabass seeds; 24% on availability of seabass seeds; on availability of milkfish seeds, pearlspot, crab culture and fattening and CIBA training programmes) were sent during this year. An evaluation study indicated that 50.31% of the farmers reported

Shri V. Parivel a shrimp farmer, Nagapattinam receiving voice message related to farming from CIBA

that SMS was highly understandable. The messages sent were needful and timely for 81.34 percent of the respondents.The study indicated that SMS services are one of the most useful tools for dissemination of information. A WhatsApp group was also created using 96 aqua farmers from Tamil Nadu.

Comparative evaluation of production parameters of vannamei farming in three states

A comparative assessment of the mean production parameters of Pacific white shrimp (*Penaeus vannamei*) in Tamil Nadu, Kerala and West Bengal were studied through surveying. It was observed that farmers in all the three states had used optimum sized PL for stocking. Farmers in all three states have adhered to the CAA regulations on stocking density. In Kerala (KL) the farmers stocked lesser due to their limited infrastructure and aimed for bigger sized shrimps compared to Tamil Nadu (TN) and West Bengal (WB). The seed cost was higher in WB because they bought their seeds from Chennai or Kakinada and sometimes middlemen were involved in the seed procurement. The seed survival was higher in TN followed by WB and KL. The quantity of feed required to produce one kilogram of shrimp is lesser in KL followed by WB and TN. Removal of sludge after harvesting is important to reduce metabolite load in the pond however 85% of the farmers did not adopt it. The duration of culture was more in the case of KL compared to TN and WB because they preferred to harvest bigger size shrimp which fetched a better price.

Production parameters of semi-intensive vannamei farming

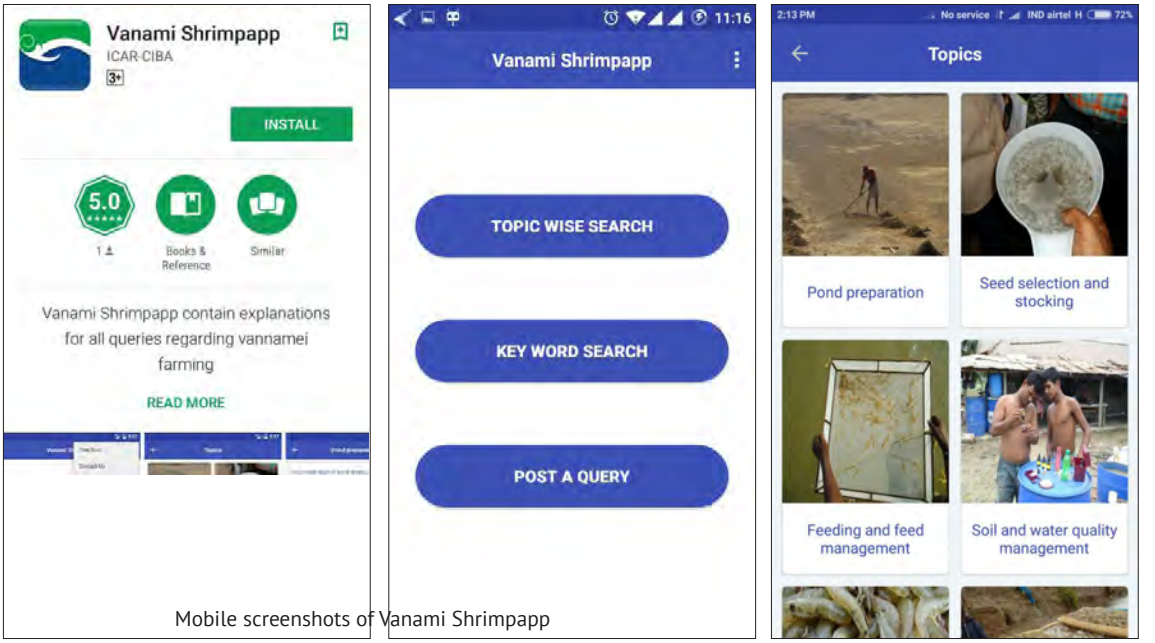
Sl. No	Production parameter	Tamil Nadu (n1= 134)	West Bengal (n2=45)	Kerala (n3=22)
1	Seed PL size	10.86±1.88	9.82 ± 1.56	13.81 ± 2.25
2	Stocking density in PL/m2	34.68±11.20	49.11 ± 7.69	9.81 ± 6.98
3	Seed cost (paisa)	40.75±8.86	70.22 ± 10.69	38.33 ± 6.23
4	Survival in %	76.97 ± 9.03	67.88 ± 7.92	60.71 ± 16.71
5	Feed Conversion Ratio	1.47 ± 0.22	1.39 ± 0.15	1.23 ± 0.54
6	Duration of culture	117±18.8	106±8.50	144±10.10
7	Productivity	5.51±3. 13	7.31 ±2.65	1.55±1.03
8	ABW (g) @ harvest	14.90±3.81	15.27 ± 3.16	15.29 ± 9.77
9	Cost of Production	266.00± 53.71	224.77 ± 36.05	186.59±60.47
10	Market Price	351.12 ± 59.94	342.22 ±49.39	425.91±80.77

Livelihood support for tribal farmers at Gujarat through seabass nursery rearing

Nursery rearing of Asian seabass juveniles in hapaswas demonstrated at farmer's pond at PalsanaVillage, Valsad district, Gujarat. Ten hapa with a size of 2x1x1m (2m2) was erected in 0.3 ha pond using bamboo poles. A total of 10,500 nos. of seabass fry were stocked in 10 hapas @ nearly 1100/ hapa (@ 550 no/m2). Feeding was done with fish meal balls three times a day in check trays. Seabass fingerlings were harvested at the end of nursery rearing and sold to Aqua farmers at approximately Rs.15/piece depending on the size. At the end of 45 days, a total of 5490 fingerlings (Avg. size 2.5-4.0 cm) were sold realizing an amount of Rs.81900/- which was highly profitable.

Launching of Vanami Shrimpapp by ICAR-CIBA

CIBA launched an Android based mobile app – "Vanami Shrimpapp" for the dissemination of technical information to stakeholders of shrimp farming sector. 'Vanami Shrimpapp' was conceived to provide all the relevant information related to technologies, products, markets, and policies, on the farming of crustaceans, not just vannamei. Presently the app provides information on better management practices of Pacific white shrimp (*Penaeus vannamei)* farming in the format of "Frequently Asked Questions (FAQs), targeting shrimp farmers and field level extension workers of coastal states. The mobile app can be downloaded from the Google play store free of cost and it works off-line enabling users to access information at their preferred timings. The mobile app content is organized in six major heads viz., shrimp pond preparation, seed selection and stocking, feeding and feed management, soil and water quality management, health management, regulation, food safety and record keeping. This app works as a two-way interactive tool containing both static and dynamic modules. The user can view the content either topic-wise or through key word search. The search tool looks for the keyword in the whole content, lists the relevant questions and displays the requisite information upon selecting the question. In the dynamic module, the users can post their queries through 'post a query' option and the questions are answered within two working days after consultation with a subject matter specialist. Since its release, Vanami Shrimpapp has been extensively used by the farmers and extension workers across the countries (India, Indonesia, Vietnam, Brazil, Peru, Mexico, Ecuador, and USA) and appraised with a Google performance



Mobile screenshots of Vanami Shrimpapp

rating of 4.7 out of 5.0. The majority of the queries received are related to shrimp health, soil and water quality management and feed management. The app will be updated at regular intervals based on the technological developments and the queries and suggestions received from responsible farmers

e-Knowledge center in brackishwater aquaculture

e-Knowledge centre was developed usingdrupal content management software (CMS) and My SQL 2.0 for disseminating need-based brackishwater aquaculture information and knowledge to different stakeholders *viz* farmers, researchers, students and policy makers etc. Based on the need assessment survey of 110 stakeholders, contents were processed and the following web pages were developed; (1) Overview of brackishwater aquaculture in India (2) Shrimp biology and identification; candidate species; soil and water quality; minerals in shrimp farming; diseases and their management; probiotics; and nutritional requirements (3) Crab farming and diseases (4) Details of fishes such as species like Seabass, milkfish, pearlsopt, mullet, grouper; and fish health and management. The opening screen of e-knowledge center gives a brief introduction of the center. The 'ENTER' button prompts the user to navigate into the center. There are eight modules supported in this center, named as Overview, Shrimp, Crab, Finfish, ICT tools, Statistics, Institutes and Important links. All the modules are linked in a Drupal CMS environment. Each module is linked with many sub-modules for highlighting the information about the topic.

Human Resource Development (HRD) - trainings, capacity building and skill development

Trainings attended by individuals

National

Shri Aritra Bera, Scientist attended a short-term training programme on Fish Cell Culture Techniques at ICAR-NBFGR, Kochi from 1-7th April, 2016.

Shri R. Kandamani, Smt. R. Vetrichelvi and Smt. B. Prasanna Devi attended training programme on Implementation of NIC`s e-procurement solution through CPP portal for ICAR Institutes at ICAR-NAARM, Hyderabad from 25-26th April, 2016.

Dr. S. K. Otta, Senior Scientist attended a training programme on Preparation, Appraisal, Monitoring & Evaluation of Fisheries Projects at NFDB, Hyderabad from 25-29th April, 2016.

Smt. V. Usharani, Assistant Administrative Officer attended a training programme on Reservation in Service including Reservation roster and Reservation Register at ICAR-NAARM, Hyderabad from 27-29th April, 2016.

Shri N. Ramesh, Senior Technical Assistant attended a training programme on Competence Enhancement Programme on Soft Skills and Personality Development for Technical Officers of ICAR at ICAR-NAARM, Hyderabad from 1-10th June, 2016.

Dr. C. P. Balasubramanian, Principal Scientist attended a training programme on Management Development Programme on Leadership Development (a pre-RMP programme) at ICAR-NAARM, Hyderabad from 7-18th June, 2016.

Shri K. V. S. Satyanarayana, Administrative Officer attended a training programme on Pension and other Retirement Benefits at ISTM, New Delhi from 20-23rd June, 2016.

Dr. B. Sivamani, Scientist attended a training course on Advances in Functional Genomics and Proteomics for Farm Animal Biology at ICAR-NDRI, Karnal from 1-21st July, 2016.

Ms. M. U. Rekha, Scientist attended a training course on Recent Advances in Fish Reproductive Biotechnology for Propagation of Endangered Species at ICAR-NBFGR, Lucknow from 18-27th July, 2016.

Dr. T. Ravisankar and Dr. K. P. Kumaraguru Vasagam attended a training course on Intellectual Property Rights Producers and Best Practices at Chennai from 27-30th July, 2016.

Dr. A. Nagavel, Senior Technical Officer attended a training programme on Use & Maintenance of Advanced Instruments in Soil and Plant Analysis at ICAR-IISS, Bhopal from 8-13th August, 2016.

Dr. J. Syama Dayal, Principal Scientist attended a training programme on Right to Information Act, 2005 at Chennai from 22-23rd August, 2016.

Shri P. Srikanth, Junior Account Officer attended a training programme on Pension & Other Retirement Benefits at ISTM, New Delhi from 5-8th September, 2016.

Shri R. Aravind, Scientist attended a training workshop on Application of Bioinformatics in Proteome Analysis at Chennai from 19-23rd September, 2016.

Dr. N. S. Sudheer, Scientist attended a training course on Synthesis and characterization of nanomaterials for agricultural applications at ICAR-CIRCOT, Mumbai from 19-28th September, 2016.

Ms. Misha Soman, Scientist attended a training workshop

on Taxonomy of Crustacea at Thiruvananthapuram from 20-24th September, 2016.

Shri N. Jagan Mohan Raj, Senior Technical Assistant attended a training programme on Techniques in Microbiology at ICAR-NBAIM, Mau Nath Bhanjan from 5-18th November, 2016.

Ms. Babita Mandal, Scientist attended a training programme on Patent Specification Drafting at Nagpur from 24-25th November, 2016.

Ms. Leesa Priyadarsani, Scientist attended a training course on Communication Skills and Technical Writing at Hisar from 25th November to 15th December 2016.

Mr. Jose Antony, Scientist attended a training programme on Preparation of Fisheries Projects at NFDB, Hyderabad from 28th November to 2nd December 2016.

Shri R. Aravind, Scientist attended a training course on The RNA World at Chennai from 15-23rd December, 2016.

Shri K.G. Gopala Krishna Murthy, Personal Assistant attended a training programme on Enhancing Efficiency and Behavioural Skills at ICAR-NAARM, Hyderabad from 4-10th January, 2017.

Ms. M. U. Rekha, Scientist attended a training programme on Advances in Microscopy at ICAR-CIRCOT, Mumbai from 16-18th January, 2017.

Dr. R. Saraswathy, Principal Scientist attended a training-cum-awareness workshop on J-Gate@ CeRA for Southern region (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Telangana) at ICAR-DKMA, Bangalore on 27th January, 2017.

Mr. Dani Thomas, Scientist attended a training programme on Application of Molecular Markers in Fish Breeding at ICAR-CIFE, Mumbai from 31st January to 9th February 2017.

Ms. Suvana Sukumaran, Scientist, attended a workshop-cum-training programme on Crop Simulation Models in Climate Change Impact Assessment at ICAR-IISS, Bhopal from 14-18th February, 2017.

Shri R. Paranthaman, Technical Assistant attended HRD programme on Automobile Maintenance, Road Safety and Behavioural Skills for Regular Drivers in Technical Grade in ICAR Institutes / HQ at ICAR-CIAE, Bhopal from 20-24th February, 2017.

Dr. C. Gopal and Dr. M. Kailasam attended training-cum-workshop on Managing Technology Value Chains for Directors & Divisions Heads at Administrative Staff College of India, Hyderabad from 27th February to 3rd March 2017.

Shri S. Nagarajan, Senior Technical Officer attended a training programme on ICAR-ERP for ICAR Technical Personnel at ICAR-IASRI, New Delhi from 20-25th March, 2017.

Training Programs Organized

The technologies/knowledge base developed by the Institute were extended during the year to progressive fish farmers, private entrepreneurs, officials of State and Central Governments etc. through the following short-term training programmes:

Sl.No.	Title of the Training/Workshop (WS)/FGD	Date and Venue	No. of participants
Headquarters			
1	Hands-on training programme on Soil and water analysis	17-20th May, 2016	1
2	Hands-on training Nursery rearing of seabass fry in hapas for the fisher youth at Vennangupattu village, Kanchipuram District (TN)	1st July, 2016 & 22nd July, 2016	12
3	Hands-on training Pre-growout culture of seabass fingerlings in cages for the fisher youths at Vennangupattu village, Kanchipuram district	3rd August, 2016 & 7th August, 2016	12
4	On-farm aquaculture health camp	19th August, 2016	44
5	Training programme on Science and agricultural careers after school education for school students from Sri Sankara Senior Secondary School, Adyar, Chennai	26-28th September, 2016	38

6	Climate change impacts and adaptation measures in brackishwater aquaculture	28th September, 2016	40
7	Capacity building and harmonisation of PCR diagnosis of aquatic animal diseases with special reference to shrimp farming	3-5th October, 2016	22
8	Training programme on Seed production and culture of brackishwater candidate finfish species	3-7th October, 2016	9
9	Training on Livelihood opportunities among tribal families through brackishwater aquaculture technologies adoption for the *Irular* tribal families of Senjiammannagar of Tirupalaivanam, Kanvanthurai of Aurivakkam, Tiruvallur district, Tamil Nadu	4-6th October, 2016	20
10	Seed production and feed preparation for farming of Asian seabass *Lates calcarifer*	24-28th October, 2016	5
11	Hands-on training on Pre-grow out culture and grow out culture of Asian seabass for the fisher youth of Idaikazhinadu panchayat, Kanchipuram district	11th November, 2016 & 19th November, 2016	12
12	Hands-on training programme on Aquatic animal diseases diagnosis-cum-soil and water analysis	21-24th November, 2016	1
13	Feed analysis	21-24th November, 2016	1
14	Training workshop for *Irular* women on Brackishwater ornamental larval rearing at Thiruvidanthai village, Kanchipuram district	24th November, 2016	14
15	Need-based training on Shrimp and crab seed production and culture	13-17th December, 2016	3
16	Field level diagnosis, prevention and control of diseases of shrimp and finfish in brackishwater aquaculture	19-20th January, 2017	9
17	Advanced training in Aquaculture nutrition and feed technology	19-28th January, 2017	14
18	Need-based training on Mud crab seed production and culture	20-27th January, 2017	2
19	Training on Innovative and evolving brackishwater crustacean aquaculture	15-21st February, 2017	6
20	Hands-on training on Grow out culture of Asian seabass in cages for the fisher youth of Idaikazhinadu panchayat Kanchipuram district	1st March, 2017 & 24th March, 2017	12
21	Feed analysis	3-4th March, 2017	2
Kakdwip Research Centre			
22	Aquafeed formulation and feed management in brackishwater aquaculture	28th June to 2nd July 2016	7
23	Brackishwater aquaculture options for sustainability and profitability	18-23rd July, 2016	10
24	Brackishwater shrimp farming	26th September to 1st October 2016	15
25	Disease management in brackishwater aquaculture	21-26th November 2016	12

Workshops/Seminars/Meetings

ICAR-CIBA celebrated the foundation day

Muttukadu experimental station. Since its foundation in the year 1987, CIBA continues to play a crucial role in brackishwater aquaculture research and development. The institute celebrated the foundation day by creating awareness among the school children about the environmentally safe, socially acceptable and sustainable brackishwater aquaculture. A total of 539 students and 33 teachers from different schools such as Kendriya Vidyalaya, CLRI, Adyar; Pon Vidyashram, Injambakkam; Sri Sankara Senior Secondary School, Adayar; GT Aloha Vidya Mandir, Injambakkam; Bala Vidya Mandir, Adayar and St. Joseph's Higher Secondary School, Kovalam, visited Muttukadu Experimental Station of CIBA on this occasion. The students were taken in batches to shrimp hatchery, fish hatchery, crab hatchery, feed mill, pathology and soil and water laboratories and were shown the research activities related to each of these aspects. Live aquaculture species like shrimps, fishes, and crabs were kept on display and life cycles of the same were shown.A session on "career opportunities" in Fisheries & Aquaculture was also arranged on this occasion.

National level stakeholder consultation on development of sustainable brackishwater aquaculture in an economically viable, environment friendly and socially acceptable mode

conducted on 26th April, 2016 to ascertain the field level issues in different brackishwater aquaculture systems being practised across the coastal states so that relevant issues could be addressed through the research programmes of the Institute. Forty stakeholders including aquafarmers and officials from all the coastal states except Karnataka participated in the meeting. The theme of the

consultation was on the 'Development of sustainable brackishwater aquaculture in an economically viable, environmentally friendly and socially acceptable mode'. Dr. Ajith Sinha Patil, President of the Maharashtra Aquafarmers Association, Mumbai inaugurated the consultation. The participants were taken to Muttukadu Experimental Station of CIBA and had exposure to finfish, shrimp and crab hatcheries, pilot scale extruder feed mill, live feed culture and soil, water and pathogen screening laboratories.

National consultation on Early Mortality Syndrome (EMS) or Acute Hepatopancreatic Necrosis Disease (AHPND) of cultured shrimps

A National consultation on Acute Hepatopancreatic Necrosis Disease (AHPND) also called as Early Mortality Syndrome (EMS) was held on 16th June 2016 at CIBA, Chennai. Stakeholders including shrimp hatchery operators, farmers, input providers, aquaculture professionals, academicians and scientists participated in the deliberation. India with an EMS free status, the workshop was conducted to review the present status of AHPND in other countries, its impact on the shrimp aquaculture and to develop a National Action Plan to prevent the possible introduction of the bacterial pathogen causing EMS to India. Better management practices or BMPs and proactive and responsible culture practices to control emergence of diseases such as AHPND were highlighted during the consultation.

National fish farmers day

"National Fish Farmers Day" was celebrated on 10th July, 2016 at Vennangupattu, a coastal village in Kanchipuram district of Tamil Nadu in the presence of around 100 fish farmers and fisher youth. As part of the celebrations the Asian seabass *Lates calcarifer* fish seeds produced in CIBA hatchery were distributed to the Dr.A.P.J.Abdul Kalam fish producers group in the village for nursery rearing in the open waters and brackishwater cage farming. An interaction session on 'Prospects of undertaking cage culture of brackishwater fin fishes in open waters' was organised during the occasion.

ICAR foundation day

CIBA celebrateed 88th Foundation of Indian Council of Agricultural Research (ICAR) on 16th July 2016). Prof..P.G.Chengappa,ICAR National Professor Institute for Social and Economic Change and Former Vice Chancellor , University of Agricultural Sciences, Bangalore was the chief guest of the function, who gave a presentation on ' Development of Indian agriculture and contributions of NARS system'.

National workshop on antibiotic residue issue in shrimp aquaculture

National workshop on 'Antibiotic Residue Issue in Shrimp Aquaculture' was organized to create awareness and to sensitize the farmers and stakeholders on the issue of antibiotic residue and related rejection of export consignments by the overseas buyers on 18th August 2016. Representatives of different stake holders viz. farmers, NFDB, PFFI, SEAI, SAP, hatchery operators, consultants and private entrepreneurs took part in the workshop. Dr. B. K. Das, Director, CIFRI, Barrackpore, inaugurated the workshop. Dr. V. V. Sugunan, Senior consultant from NFDB, Hyderabad, Dr. Utpal Sar, Executive Director, NFDB, Hyderabad, Mr. Elias Sait, Secretary General, Seafood Export Association of India, Mr. V. Balasubramanian, Prawn Farmers Federation of India gave presentations on this important topic.

Aquaculture health camp in Nagapattinam district of Tamil Nadu

Organised a first of its kind "On farm Aquaculture Health Camp" at Chinnathumbur village in Nagapattinam district, Tamilnadu on 19th August, 2016 under the aegis of "National Surveillance Programme for Aquatic Animal Diseases (NSPAAD)". CIBA provided on-farm testing service for white spot disease (WSD) and *Enterocytozoon hepatopenaei* (EHP) using PCR-DNA test at free of cost. Similarly, soil and water samples from shrimp farms were collected, analysed and reports along with advisories on the pond soil condition and water quality parameters were also given to the farmers during the camp. For creating awareness on disease management, extension handouts prepared in vernacular language were distributed to the shrimp farmers on management of diseases, soil and water quality management and rational use of aquaculture inputs. Scientists had active interactions with farmers from the region to educate them on better management practices of shrimp farming and understand the field level issues.

CIBA trained farmer from Kerala received Pandit Deen Dayal Upadhyay Antodaya Krishi Puraskar- 2016

Shri. A. Baburaj a traditional brackishwater fish-farmer from Kozhikode district of Kerala nominated by ICAR-CIBA, Chennai has been awarded with "Pandit Deen Dayal Upadhyay Antodaya Krishi Puraskar- 2016" by ICAR. Shri Radha Mohan Singh, Hon'ble Union Minister for Agriculture and Farmers Welfare presented the award for zone XI at the function organised at Indian Institute of Spice Research, Kozhikode, Kerala on 25th September 2016.

Swachhta campaign at CIBA

As part of the Swachh Bharat or Clean India Mission, Swachhta Campaign was conducted at ICAR-CIBA, Chennai and Kakdwip Research Centre of CIBA, Kakdwip, with due gravity and purposefulness on October 2, 2016. The Director, scientists, officers, staff and research scholars of the Institute led the cleanliness drive in the Institute outside and inside campus at different locations including the public pathway.
At Kakdwip Research Centre of CIBA, West Bengal, too all the scientists, officers, staff and research scholars took active part in cleaning the office premises, garage and adjoining area and farm area.

National workshop on biofloc based aquafarming technology

National workshop-cum-training programme was conducted during September 15-17, 2016 to disseminate the knowledge on Biofloc-periphyton based brackishwater aquaculture technology to farmers, researchers and other stakeholders from various parts of India. Twenty four trainees from eight states of India participated in this training workshop. Biofloc being a rich source of quality protein with essential amino acids, minerals, vitamins and fatty acids, enhances the growth performance and its natural probiotic effects help in a better health status of cultured shrimp. In an effort to create awareness among the farmers about the prospects and challenges of biofloc based farming systems, a brain-storming interactive session was convened on 17th September, 2016 as part of the workshop.

Attracting and Retaining Youth in Agriculture (ARYA)

Agricultural careers after School Education" was organised by ICAR-Central Institute of Brackishwater Aquaculture during 26-28th September, 2016 for plus one students of Biotechnology and Biology from Sri Sankara Senior Secondary School, Adyar, Chennai.

National workshop on capacity building and harmonisation of PCR diagnosis of aquatic animal diseases

The first phase of capacity building and harmonisation of PCR diagnosis of aquatic animal diseases, the National training programme on "Molecular diagnosis of shrimp diseases" was held during 3rd - 5th October 2016 at ICAR-Central Institute of Brackishwater Aquaculture, Chennai. The programme with hands on training was organised in collaboration with the Coastal Aquaculture Authority (CAA), Marine Products Development Authority (MPEDA) and Rajiv Gandhi Centre for Aquaculture (RGCA), supported by National Fisheries Development Board (NFDB), Hyderabad. The present first phase would be followed by a two stage follow up programme,

in two phases, evaluation of the participating polymerase chain reaction (PCR) laboratories and PCR ring test. Twenty two representatives from private and Government laboratories of Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Gujarat from brackishwater aquaculture sector had participated in this national level training programme. Inaugurating the training programme, the Chief Guest, Mr.J.Sivagnanam, a progressive aqua farmer, highlighted the role to be played by the PCR testing laboratories for the sustainability of aquaculture operations in view of disease outbreaks due to white spot disease (WSD) and the new threat of *Enterocytozoon hepatopenaei* (EHP). He stressed the harmonisation of PCR tests among the laboratories is of paramount importance to restore the confidence of farmers and overall well-being of the shrimp farming sector.

Training workshop – cum – aquaculture health camp on climate change impacts and adaptation measures in brackishwater aquaculture

Organized Training workshop – cum – Aquaculture Health Camp on Climate Change Impacts and Adaptation Measures in Brackishwater Aquaculture at Ramanathapuram, Tamil Nadu on 28th September, 2016 under the support of "National Innovations in Climate Resilient Aquaculture (NICRA). At the workshop shrimp farmers of the region were provided with on-farm testing service. Water, soil and animal samples were collected from 40 farmer's ponds in Ramanathapuram District and analysed water quality parameters and surveillance of white spot disease (WSD) and *Enterocytozoon hepatopenaei* (EHP) using PCR-DNA test at free of cost. This has given the holistic picture about the water quality, pond bottom condition and health status of the aquatic animals of the district. About 85 farmers from the area participated in the Workshop. Pamphlets in vernacular language on soil and water quality management for shrimp culture, application of minerals in shrimp culture, soil redox potential an indicator of pond bottom condition, water probiotics, management of diseases such as WSD, EHP, acute hepatopancreatic necrosis disease (AHPND) were distributed to the farmers for creating awareness. The portable instruments used for the on-farm testing were displayed during the meeting, to provide

National seminar on prophylaxis in aquaculture

A national seminar on "Prophylaxis in Aquaculture" was organised under Consortium Research Platform on vaccines and diagnostics on 16th November 2016 at CIBA, Chennai. Chief guest Dr. Aniket Sanyal, Joint Director, IVRI inaugurated and released a compendium on "prophylaxis in Aquaculture".

Farming demonstration of Indian white shrimp, *Penaeus indicus* along the selected coastal states of India

For the first time, farming demonstration trials were conducted along the selected coastal states to evaluate the performance of Indian White Shrimp *Penaeus indicus* under the NFDB sponsored programme "Upgradation of Breeding and Culture Technology of Indian White Shrimp *Penaeus indicus* through stock evaluation and culture Demonstration" research project. *P. indicus* stocks from East coast (Odisha, West Bengal and Andhra Pradesh & Tamil Nadu) and West Coast (Kerala and Gujarat) were procured, transported and quarantined and utilised for breeding. The WSSV free seeds produced therein were evaluated through this culture demonstration that was carried out under monoculture/polyculture mode in six locations of different coastal states. Presently, Indian shrimp aquaculture involves mostly a single exotic species, the SPF Pacific whiteleg shrimp, *Penaeus (Litopenaeus) vannamei*. Among our candidate native species, Indian white shrimp, *P. indicus* can be the choice of species to be promoted as an additional native species along with the exotic species. To assess the performances of *P. indicus* in terms of growth, productivity and disease occurrences in comparison to *P. vannamei*, farming trials of indicus have been undertaken during the last two years under a National Fisheries Development Board (NFDB) funded project at CIBA Chennai. In order to exhibit the results of the demonstration to the shrimp farmers and other stakeholders and promote *P. indicus* as an additional indigenous species for diversification of shrimp aquaculture, 'Harvest mela and Farmers meet' were conducted at various locations where field demonstrations were taken up.

Farming demonstration at Balasore, Odisha during July to November 2016

The grow-out culture demonstration of *P. indicus* was carried out at a farmers' pond (Dandapat Aquatics), Sahada, Balasore, Odisha. Shrimps were stocked at two stocking densities, 10 and 35 pcs/ m^2 in earthen ponds of 2600 to 4000 sq.m, respectively, and farmed on a bio-secured zero water exchange system. Salinity during the culture period ranges from 2-12 ppt. Shrimps were fed with CIBA's formulated feed 'Indicus^{plus}' with 35% protein. At the end of 130 days of culture period, a final body weight of 28-30g was recorded at lower stocking density of 10/m2, whereas at the higher stocking density of 35/m^2, a final body weight of 17-20 g was recorded. A production up to 4.5 to 5 tons/ ha was obtained in high stocking density ponds. The farm gate price received was Rs 430/- per kg for larger sized shrimp (28-30g) from low stocking density ponds and Rs 330/- for smaller sized shrimp (17-20 g) from high stocking density ponds. The harvest cum farmers meet at Odisha was attended by large number of farmers to the tune of 500 plus.

Farming demonstration at Kakdwip, West Bengal during July to November 2016

At Kakdwip from July to Nov, 2016. Seeds were stocked at a density of 25 pc/ m^2 in two ponds and reared for 120 days based on bio secured zero water exchange system. These shrimp were fed with indigenously developed CIBA feed (Indicus^{plus} with 35% protein). After four months rearing, an average body weight of 18-20 grams with a production of up to 3.08 tonnes per ha and a survival up to 75% was achieved in spite of low saline conditions during culture. The performance of indicus up to 18-20 g is at par or better than *vannamei*. The culture demonstration of Indian white shrimp registered a comparable growth to that of Pacific white shrimp *P. vannamei* (16-17 g) farmed alongside the Indian white shrimp. However, growth was affected by low temperature and salinity in the latter part of culture. The harvested shrimp fetched a market price of Rs 330/ per kg at Kolkatta, West Bengal.

Farmers meet at Odisha and West Bengal

Entrepreneurs and officials from MPEDA, NACSA and Department of Fisheries, and representatives from other ICAR institutes also attended the harvest. The Odisha farmers showed interest in the farming of indigenous shrimp. In the interaction session West Bengal and Odisha farmers and State officials discussed about the culture technology for indigenous candidate species, with the scientist from CIBA. Addressing the large gathering of farmers, Dr. K.K.Vijayan, Director, ICAR-CIBA emphasized the urgent need to promote the farming of native indigenous species along with the exotic vannamei. He praised the entrepreneurial attitude of the West Bengal and Odisha farmers in the progress of aquaculture development in the state. Dr V. V. Sugunan, Chief consultant of NFDB, expressed the significance of introduction of an indigenous species like Indian white shrimp. Dr B. K. Das, Director ICAR-CIFRI. Dr U. C. Mohapatro, Deputy Director from MPEDA complimented CIBA for the development and transfer of sustainable technologies. Dr Akshaya Panigrahi, Principal Investigator of the project said that the performance of Indian white shrimp is comparable to the exotic SPF vannamei shrimp and holds a great potential as an alternate species of shrimp for coastal aquaculture in India. This demonstration highlighted the potential of Indian white shrimp, endemic to the Indian coast for breeding and seed production as an alternative to vannamei.

The indicus and vannamei harvest mela and Brackishwater Farmers' Meet at West Bengal was organised on 28th November 2016 at Kakdwip Research Centre (KRC) of CIBA, Kakdwip. The programme started with the harvest of *P.*

indicus and *P. vannamei*. The Farmers' meet at West Bengal was presided over by Dr. V.V. Sugunan, Senior Consultant, NFDB, Hyderabad. Dr. T.K. Ghoshal, Officer-in-charge, KRC of ICAR-CIBA welcomed the guests and farmers. Among the distinguished were, Dr. B.K. Das, Director, ICAR- Central Inland Fisheries Research Institute, Barrackpore, Dr. Utpal Kumar Sar, Executive Director, NFDB, Shri Partha Bandyopadhyay, Block Development Officer, Kakdwip. Dr. A. Panigrahi, Principal Scientist mentioned that *P. indicus*, although being non-SPF and not having undergone selective breeding, has performed well in terms of growth under culture conditions. Moreover, to realize the tremendous potential of this shrimp, not only as an alternative species but to replace the exotic shrimp and avoid dependence on other countries for broodstock, popularization of the species among farmers is required. Dr. Utpal Kumar Sar, in his speech, emphasized popularization of indigenous fishes and shrimp species, and avoidance of dependence on foreign species. During, farmers-scientists interaction session, few progressive farmers discussed about the pros and cons on *P. indicus* culture and expressed their willingness to culture in their farms. The programme was attended by 150 farmers from different coastal areas of West Bengal.

Agricultural education day

ICAR-CIBA, Chennai conducted 'Agricultural Education Day' on 3rd December 2016 to create awareness among the school children on the importance of agriculture and vitality of agriculture education. School students, a total of 66 along with 5 teachers from Kendriya Vidyalaya, Island grounds, Chennai; Kendriya Vidyalaya, CLRI, Adyar, Chennai and GTA Vidhya Mandir, Neelankarai, Chennai participated in the programme. Dr.V.M.Sankaran, Professor and Head, Department of Agronomy, Madras Veterinary College, Chennai was the Chief guest. He gave an exposure to the students on agricultural, horticultural, veterinary and fishery education avenues and career options that have good employment scope for the students. The supply of agricultural graduates is almost only half of the projected requirement. In students' interaction session which followed, the students got their queries clarified from the experts.

National Youth Day

National Youth Day was celebrated on 12th January 2017 by ICAR-CIBA, Chennai with participation of Scientists, Staff and Research Scholars, below the age of 35 years. Dr.K.K.Vijayan, Director, ICAR-CIBA remarked that apart from digitizing research documents and data, the time has come for making digital monetary transactions. He briefed about the e-Z prepaid card payment being arranged by ICAR-CIBA through State Bank of India. This will promote making of all official payments digitally by individual officers. He also encouraged the participants to make personal payments on digital mode to have proper documents and records, helping to reduce the generation of unaccounted money in the economy. These cashless payments will help to achieve the country to get its due by way of taxes. Participants were briefed about different methods of digital payments available. They were told to make others aware of advantages of making digital payments popularizing digital modes of payments. The meeting was attended by all Head of Divisions and Units and Dr. T. Ravisankar, Principal Scientist and SIC, ITM-ABI Unit proposed vote of thanks.

Training programme for Export Inspection Agency (EIA) officials on field level diagnosis, prevention and control of diseases of shrimp and finfish in brackishwater aquaculture

A short training programme on "Field level diagnosis, prevention and control of diseases of shrimp and finfish in brackishwater aquaculture" was conducted on 19-20th January 2017 for the Export Inspection Agency (EIA) officials by the Aquatic Animal Health and Environment Division (AAHED). Nine officers of EIA from EIA centres located at Mumbai, Veraval, Chennai, Nellore, Vishakhapatnam, Kochi and Kolkata participated in the training programme. This was a need based programme organised for the officials of EIA as a required by the Canadian Food Inspection Agency (CFIA), Canada.

Topics dealing with important diseases of both shellfish and finfish were covered in this programme. The participants were enriched with knowledge for field level presumptive visual identification of important diseases of shrimp and finfish reared in brackishwater aquaculture sector. The trainees were given an overview of diseases in brackishwater aquaculture including OIE listed diseases and those prevailing and emerging in the brackishwater aquaculture in India. Issues with regard to visual diagnosis of diseases were highlighted and need for level-2 and level-3 diagnostics was stressed for accurate diagnosis of diseases of aquatic animals. Participants were also exposed to the research effort of ICAR-CIBA and the existing world class facilities pertaining to disease diagnosis. A field guide for diagnosis, prevention and control of diseases of shrimp and finfish in brackishwater aquaculture was provided to the trainees. The officers were taken to shrimp farms located near Chennai and exposed to the methods of sampling at farm visual examination, collection of specific samples and tissues, fixation, preservation and transport of live and preserved samples for disease investigation.

Earlier during the inauguration of the programme on 19th January 2017, Dr. K.K.Vijayan, Director, ICAR-CIBA stressed on the importance of this training programme considering the quality of shrimp and finfish we require to produce, if India has to sustain its overseas markets. There has been an increasing demand from the importing countries with regard to quality especially with regard to the food safety including antibiotic residues in seafood. Quality of seafood was also important for domestic consumption, which was often neglected. He highlighted the capacity of CIBA which had world class laboratory facilities and expertise in aquatic and environmental health management and looked forward for stakeholder collaboration in both Govt and private sector for the promotion of the Indian brackishwater aquaculture products in India and overseas.

Launching of desi formulated shrimp feed developed by ICAR-CIBA for vannamei at the farmers meet in Andhra Pradesh

Sri Prathipati Pulla Rao, Honouarble Minister for Agriculture, Animal Husbandry, Dairying and Fisheries, Government of Andhra Pradesh commercially launched the CIBA Vannami*Plus* feed, distributed Soil and Water Health Cards, and released CIBA publications in the Brackishwater Aquaculture Farmers Meet organised by ICAR- Central Institute of Brackishwater Aquaculture under National Innovations in Resilient Agriculture (NICRA) project on 4th Feb 2016 at Bapatla, Andhra Pradesh. He appreciated the efforts taken by CIBA in developing the cost effective balanced shrimp feed Vannami*Plus* using indigenous ingredients with a cost of

Rs. 55-65 per kg in the context of ever increasing feed cost which accounts for 60-65% of the total production cost, the major constraint affecting the growth and profitability of the shrimp farming sector. He also thanked CIBA for transferring the Vannami^{Plus} feed technology to progressive and leading shrimp farmer, Sri. M.Karuna Raju and Sri Krishnam Raju of M/s. Sai Aqua Feeds, Bapatla, Guntur (Dt), AP on a PPP mode in order to bring down the feed cost and to increase the profitability to the shrimp farmers. He congratulated them for scaling up this technology and started the production of this cost effective feed and urged the farmers to use the desi technologies, for achieving sustainability in profit and production. He also appreciated the services of CIBA in issuing the Soil and Water Health Cards to about 80 shrimp farmers in the neighborhood of Bapatla, that are useful for scientific shrimp farming and in developing adaptation measures to mitigate the adverse impacts of climate change on aquaculture. At the event he released a farmer friendly publication entitled "Frequently Asked Questions (FAQs) Pertaining to *Penaeus vannamei* Shrimp Farming" and other publications on soil and water quality management, shrimp disease diagnosis and management, and shrimp as health food brought out by CIBA in English and Telugu language to create awareness among the farming community. Dr. K. K. Vijayan, Director, ICAR-CIBA in his introductory speech stressed the role of public private partnership in developing indigenous technologies for the benefit of farmers, and emphasised the need of promoting joint initiatives with research institutions such as CIBA, state government and the stakeholders. Dr. J.K. Jena, Deputy Director General (Fisheries), ICAR, New Delhi in his presidential address highlighted the importance of aquaculture sector in providing nutritional security to the ever increasing Indian population, and elaborated the role of Andhra Pradesh in aquaculture development both in freshwater and brackishwater sectors. He also impressed upon the farmers to take the opportunity of soil and water health cards issued by CIBA for better scientific farming.

Sri Rama Sankar Naik, IAS, Commissioner of Fisheries, Govt. of AP appreciated CIBA for partnering with farmers and stressed the need for replication of this model in the major shrimp farming areas of the state, where he assured the wholehearted support of the Govt of Andhra Pradesh.
Sri Annam Satish Prabhakar, MLC, Guntur District while delivering the Guest of Honor address, elaborated the efforts taken by the State Government for aquaculture development. The PPP partner and farmer entrepreneur Sri. P. Krishnam Raju, Sai Aqua Feeds elaborated the genesis of idea of setting up of feed mill and its role in reducing the cost of production. He appreciated CIBA's whole hearted cooperation in execution of feed mill installation and their commitment in solving the teething problems. He also stressed for cooperative mode in operating feed mill for increasing the profitability for the neighbouring farmers.

National productivity week

The National Productivity Week – 2017, was celebrated during 12th – 18th February 2017. The original theme of the celebration is "From Fish Waste to profits through Reduce, Recycle and Reuse". Dr. B. Shanthi, Principal Scientist, Social Sciences Division (SSD) was nominated as the Nodal officer to organise and conduct the programmes of the celebration. A committee was also constituted comprised of Dr. K. Ambasankar, Principal Scientist & In-charge of Nutrition Group, Dr.M. Kumaran, Principal Scientist, SSD and Dr P. Mahalakshmi, Senior Scientist & OIC, AKMU, to formulate a Plan of Action for 2017-18, for improving the productivity of the institute.

The following programmes were organised at the institute under the National Productivity Week celebration.

(1) Campaign among the students

To create awareness among the Bachelor of Engineering students of Tagore Engineering College, Vandalur, Chennai, an Awareness Programme was organised on 13th February 2017. Dr. B. Shanthi delivered a guest lecture on how fish waste is being recycled and reused for fish meal and fish feed and how this serves as an entrepreneurship development activity in processing farm made fish feed by the coastal poor women and tribal people. This has created an awareness among the college students on the brackishwater fish productivity in the coastal villages, better utilization of fish waste for fish meal and fish feed manufacturing and processing of farm made fish feed in the farm model fish feed.

(2) Committee meeting

A group discussion was held on 15th February 2017 for improving the productivity in the institute. The themes chosen for discussion included (1) Improvement in the research output (2) Improving the competency of scientific, technical and administrative personnel (3) Encouragement and recognition (4) Institute visibility (5) Inter personnel relationship among the institute staff. A similar group discussion was also held on 18th February 2017 at Kakdwip Research Centre of CIBA and the outcome specific to Kakadwip were, (1) initiated on fish waste utilization at KRC to produce cost effective feed with fish production improvement and (2) to communicated the technology to State Department time to time for their mass scale implementation at field level.

(3) Group Discussion: A group discussion was held on 15th February 2017 with the Heads and Section-in-Charges of the Divisions in CIBA and the Committee members to chalk out the Plan of Action for improving the productivity of the institute. A presentation was made highlighting the themes for discussion. Each theme was discussed, in detail and plans suggested were incorporated. The final Plan of Action was drafted combining the aspects drawn both at Head Quarters and KRC of the Institute.

(4) Special Guest Lecture / talks

A special guest lecture was arranged on 16th February 2017 on the celebration of National Productivity Week – 2017. Mr. F. Parthiban, Assistant Professor, Department of Fish Processing Technology, Fisheries College and Research Institute, Tamil Nadu Fisheries University, Ponneri, delivered an informative guest lecture on "Fish waste utilization", in which, he explained different processing techniques used and different fish products developed from fish waste and their commercial value and use in different sectors, such as human medicine, food industry, cosmetics, etc. This was followed by experience sharing by Mr. Mahees Abu Buker, a dry fish trader in Chennai on dry fish processing and trading for domestic consumption and export. Finally, Mr. and Mrs. Davasami, the Irular tribal beneficiaries of CIBA from New Perungalathur, Chennai explained the fish feed processing and products developed using CIBA designed Farm Model Fish Feed Unit, installed by CIBA in their village. The Guest lecture and talks were followed by lively interaction among the participants of the event, i.e., the scientists, technical officers, other staff members and research students.

(5) Training cum demonstration on the processing of "Fish silage"

A special training session was arranged to demonstrate the better use of fish waste in aquafeed preparation on 18th February 2017, in which lectures and practical demonstrations were conducted among

the trainees on the use of "Fish silage" for aqua feed preparation.

Dr. K. Ambasankar, delivered a lecture and demonstrated on the processing of "Fish Silage" to the trainees. He explained that, "Fish Silage" is a liquid product made from fish or parts of fish and acid. The fish waste is used for the production of fishmeal which has a world market of considerable size. The chemical preservation by acid or bases either with or without hydrolysis can be done to derive the product known as "Fish Silage". In the demonstration, the fish waste from various fish processing stalls were collected, macerated and converted into acid silage by subjecting it to fermentation using organic acid. The known quantity of waste were weighed, macerated and transferred into a plastic container. Propionic acid was added @ 2% of wet weight into the container and stirred in such a way that the acid could come in contact with all the waste materials. Periodic mixing was carried out every two hours interval to ensure uniform fermentation. The silage was formed with a required pH of less than 4 within three days. This material can be mixed with other ingredients and used as animal as well as aqua feed ingredient.

Dr. B. Shanthi, delivered a lecture among the trainees on "Fish waste utilization, waste recycling and preparation of farm made fish feeds and marketing by coastal women self-help groups and tribal people". The trainees were interacted and benefitted from this programme.

Industry stakeholder consultation on blue economy: Jointly organised by FICCI and ICAR-CIBA

As a part of India's Business Engagement with Indian Ocean Rim (IOR) countries, Industry stakeholder consultation on Blue economy was conducted jointly by FICCI and ICAR-CIBA on 27th February 2017 at Chennai.

This was an initiative by the FICCI task force on Blue Economy to build the economic connect with IOR. The programme was initiated with welcome remarks by Mr.Ar Rm Arun, Chairman-FICCI-Tamil Nadu State Council & Chairman, Valingro Group. In his opening remarks, Former Ambassador Mr. Rajiv Bhatia chairing the consultation, apprised the gathering about the objectives highlighting on blue economy as a business opportunity incorporating sustainable ways for ocean based trade. The objective of the task force was to explore investment and economic activity, examine issues of doing business with IOR countries, provide recommendations for enhancing business in priority sectors, and connecting with Sagarmala initiative, by Govt of India. The key areas include fisheries and aquaculture, biotechnology, mining, minerals, renewable energy, manufacturing, shipping, ports and maritime logistics, tourism and leisure, construction, ICT, education and research. Dr. S.V. Alavandi, Head, AAHED presented the bird's eye view of CIBA's research activities towards the goal of blue economy and future programmes envisaged with special reference to brackishwater aquaculture, under the FICCI taskforce. He highlighted the potentials areas CIBA could offer technology back up for IOR countries for achieving blue economy. Dr.T. Ravisankar highlighted the rich marine biodiversity, aquaculture potential and related business in the IOR and fish trade flow from IOR countries. He indicated that fine-tuning production technologies by collaboration among IOR countries was necessary for improving fish production and aquaculture, and IOR countries can even control global fish prices as they produce major share of global fish exports. Prices of aquaculture produce in IOR countries were brought down because of the competition within the region and benefited developed countries, hence the co-operation among the IOR countries could change the market dynamics for higher export prices and improving the economy in the region.

The participants shared their views in relation to sectors such as fisheries, aquaculture and biotechnology, tourism, renewable energy, shipping, ports and maritime logistics etc. Dr. M. Sakthivel, Founder, Aquaculture Foundation India emphasised that with limited land resources, coastal waters and sea had enormous potential for production of aquaculture and mariculture with production of fish, sea weeds, biodiesel and bio-fertilizers using natural resources, potable deep seawater supply and tidal energy. Also there is need to have special focus on coastal aquaculture, fish processing activities and to train and educate local fisheries community. Ban on sharks, sea cucumbers and price fluctuations were also discussed. It was felt that tourism in the form of surfing, snorkelling, gaming and including local fishermen and women with eco-tourism in marine parks will contribute to blue economy. Drugs from marine chemicals and hydrocarbon extraction were also discussed. Issues of fishermen crossing boundaries for want of better fish catch were highlighted. Banning purse seine / mesh size regulation along with sea ranching and Potential Fishing Zones with ISRO/INCOIS were also suggested as remediesMr. Murari, IAS (retd) Advisor to FICCI and Govt. of India in his concluding remarks mentioned that there was an urgent need for cold chain, upgradation of deep sea fishing vessels especially for tuna fishing, improving fishing vessels', energy efficiency, vessel building and preventing wastage of small size and lesser valued fish getting discarded in seas by deep sea fishermen. The Chairman indicated that considering the importance of fisheries sector, there was a need to conduct a national level consultation on fisheries sector, where FICCI could play a major role in bringing institutions and stakeholders together. Representative stakeholders from industry, state and central Government and research organizations, universities and farming community took part in the meeting.

Smt. J. Mercykutty Amma, Hon'ble Minister of Fisheries, Govt of Kerala visits ICAR-CIBA

Smt. J. Mercykutty Amma, Honourable Minister of Fisheries, Harbour Engineering and Cashew Industries, Govt. of Kerala visited ICAR- CIBA on 13th Feb, 2017. Honourable Minister was accompanied by the Fisheries Secretary, Kerala state and Fisheries Officers. Dr K.K. Vijayan, the Director, ICAR-CIBA welcomed the team and explained the role played by CIBA in promoting brackishwater aquaculture in this country by citing the various achievements of CIBA and ongoing research on various aspects. Earlier in the morning, the Minister and her team visited CIBA's Muttukadu Experimental Station, where they visited pilot scale feed mill, crab hatchery, micro algal research facilities, fish hatchery and shrimp hatchery. Honourable minister and her team were very much impressed on the feed mill facility and indigenous feed developed by CIBA for different life stages of farmed finfish and shell fishes. The minister stressed the need of working together of state government and research institution such as CIBA in the development of brackishwater aquaculture sector in Kerala. She suggested the scientists of ICAR-CIBA to come up in the propagation of cost effective technologies amenable to Indian conditions for betterment of fish farmers and coastal population who depend on this water for their livelihood and nutritional security. Also she recalled the MoU signed between the ICAR-CIBA and Matsyafed of Kerala, and suggested to use the partnership for the developmental initiatives for the brackishwater farming development in Kerala. Later, the Director of Fisheries interacted with the Director and all the scientists of ICAR-CIBA. He suggested to initiate joint ventures between CIBA and Kerala Government in the areas of feed development, production of quality seed for indigenous shrimp such as *Peneaus indicus* , modular hatchery technology for Karimeen (Pearlspot), crab hatchery, multispecies hatchery and integrated farming systems such as *Pokkali* polyculture.

International women's day

International Women's Day is a global day celebrating the social, economic, cultural and political achievements of women. ICAR- CIBA which functions with good understanding of the equality and diversity of gender in the workplace, organised International women's day celebration on 8th March 2017 at Srinivasapuram. The village woman working with CIBA on the popularization of brackishwater culture in cages as an alternative livelihood programme actively interacted with CIBA scientists and reiterated their resolve in their new partnership with CIBA

Dr.K.K. Vijayan, Director, ICAR-CIBA welcomed the new initiatives with the village, especially with woman members involved in alternate livelihood programme with CIBA. Ms. Kalaimathy, Secretary, National Slum Dwellers Federation and Ms.Vinothini, Board Member of Fisherwomen Co-operative Society spoke how to balance positions in both home and their community activities. Shri. Suresh, Member, Panchayat and Fishermen co-operative society thanked Director CIBA for the activities initiated by CIBA in Adyar creek and estuary with the involvement of Srinivasapuram fishermen. Followed by that Women staff from CIBA encouraged and motivated them to come forward to educate themselves with ICAR-CIBA technologies and to work in more spheres of fisheries activities.

Another part of the programme was conducted in CIBA headquarters in the afternoon on cleanliness, sanitation and hygiene under Swachh Bharat Mission. Dr. K. Vijayakumaran, Principal Scientist, Madras Centre of CMFRI, was the chief guest who addressed the gathering. To encourage, appreciate and motivate the contractual staff, housekeeping workers and canteen staff of CIBA HQ and Muttukadu Experimental Station of CIBA, token gifts were distributed by the Chief Guest and Director to all the women members who are working with CIBA as contractual staff.

AWARDS AND RECOGNITIONS

Dr. R. Ananda Raja, Scientist receiving the best oral presentation award

Dr. R. Ananda Raja, Scientist, was awarded the best oral presentation award in the international conference on recent advances in aquaculture held at Andhra University, Vizag, AP from 16th to 17th, Dec, 2016.

Dr. R. Ananda Raja, Scientist, was conferred with the Best paper award during the International Conference on Aquatic Animal Health and Parasitic Diseases, ICAAP-2017 at Annamalai University, Tamilnadu 6th to 7th March, 2017.

Dr. G. Biswas, Scientist, was awarded with K. Chidambaram memorial award from Fisheries Technocrats Forum, Chennai, for significant contributions to development of technology for culture of Asian seabass.

Dr. G. Biswas, Scientist, was awarded with Dr. TVR Pillay and Dr. M. V. Gupta best Indian fisheries scientist (overseas)- 2015 and Dr. V. G. Jhingran, best overseas post graduate thesis, 2015 from Professional Fisheries Graduates Forum, Mumbai, India.

Ph.D. Awards

Shri R. Gangadharan was awarded Ph.D. Degree by the University of Madras on 20th October 2016 for his thesis entitled "Geomatic approach for assessment of coastal ecosystem in and around shrimp farming area" under the guidance of Dr. P. Nila Rekha, Principal Scientist, Crustacean Culture Division.

Shri S. Thiyagarajan was awarded Ph.D. Degree by the University of Madras on 8th December 2016 for his thesis entitled "Isolation and characterization of lytic bacteriophages of *Vibrio harveyi* and their evaluation as biocontrol agent of luminescent bacterial disease of *Penaeus monodon* larvae" under the guidance of Dr. S. V. Alavandi, Principal Scientist & Head, Aquatic Animal Health and Environment Division.

Mr. S. Syed Raffic Ali was awarded Ph.D. Degree by the University of Madras on 8th February 2017 for his thesis entitled "Effect of dietary prebiotics on health and growth of Asian seabass, *Lates calcarifer*" under the guidance of Dr. K. Ambasankar, Principal Scientist & SIC, Nutrition Group.

Ms. R. Jancy Merlin was awarded Ph.D. Degree by the University of Madras on 10th February 2017 for her thesis entitled "Steroid mediated oocyte maturation and vitellogenesis in giant tiger shrimp, *Penaeus monodon*" under the guidance of Dr. C. P. Balasubramanian, Principal Scientist, Crustacean Culture Division.

Linkages and Collaborations

The Institute maintained linkages with the following national and international organizations

NATIONAL

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 Tecnology, 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 2015-16

Training Calendar 2016-17

CIBA Special Publications

Hand book on Biofloc Technology: Concepts, Benefits and Application in Aquaculture. CIBA Special Publication No. 82.

Responsible use of antimicrobials in Indian aquaculture: Opportunities and challenges. CIBA Special Publication No. 83.

Consortium research platform on vaccines and diagnostics compendium on prophylaxis in aquaculture

Frequently Asked Questions FAQs Pertaining to *Penaeus vannamei* Shrimp Farming. ISBN: 978-81-932937-1-3 **(**English & Telugu).

Vennamei Iraal Valarppu Vivasayeekalin Sandegangalum Vilakkangalum (Vannamei Shrimp Farming Farmers Queries and Explanations. ISBN: 978-81-932937-2-0 (Tamil).

Training Manuals

Molecular Diagnosis of Shrimp Diseases - A Training Manual.CIBA-TM Series 2016 No. 4.

Innovative and evolving Brackishwater Crustacean Aquaculture. CIBA-TM-Series-2016 No.5 127 pp.

Aquaculture Nutrition and Feed Technology. 2017. CIBA TM series 2017 No.6. 105pp.

Field guide for diagnosis, prevention and control of diseases of shrimp and finfish in brackishwater aquaculture.CIBA-TM Series.2016 No.7.

Seed Production and Culture of Brackishwater finishes – A Training manual. CIBA TM series.

CIBA Extension Series

Managing hepatopancreatic microsporidiasis An emerging threat to shrimp farming. CIBA extension Series No: 49. (English, Tamil and Bengali).

Acute Hepatopancreatic Necrosis Disease / Early Mortality Syndrome (AHPND/EMS).CIBA extension Series No. 50.(English, Tamil, Telugu and Bengali).

Prevention & Management of white spot disease of shrimp.CIBA extension Series No. 51.(English, Tamil, Telugu and Bengali).

Application of minerals in shrimp culture.CIBA extension series 52. (English, Tamil, Telugu and Bengali)

Soil and water quality management for shrimp farming. CIBA extension series 53 (English, Tamil, Telugu and Bengali).

Redox potential – An indicator of aquaculture pond health. CIBA extension series 54 (English, Tamil, Telugu and Bengali).

Judicious use of inputs in shrimp aquaculture.CIBA extension Series No. 55 (Tamil).

Livelihood opportunities among tribal families through brackishwater aquaculture technologies adoption.CIBA extension series no. 56.

Shrimp as Health Food. CIBA Extension Series No. 57.

Climate resilient aquaculture farm design for flood prone vulnerable coast.CIBA Extension Series No. 58.

Culture of Hilsa (*Tenualosa ilisha*) with Formulated Feed in Brackishwater Pond at North East Coast of India.CIBA Extension Series No. 59.

Milkfish - a species with low farming cost for small and marginal farmers (In Bengali: Milkfish- Khudra o Prantik Chashider Janyo Upajukta Swalpo Kharoche Chashjogya Ekti Machh) (Hand-out)

e-Publication

No confirmed case of Acute Hepatopancreatic Necrosis Disease/ Early Mortality Syndrome (AHPND/EMS) in India. CIBA e-Publication Series No.19 – Revised.

Technical Advisory on steps for first time confirmation of an exotic disease – A case study with AHPND / EMS.CIBA e-Publication Series No.24 – Revised

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7. Kumaran, M., 2016. Technology information flow in coastal aquaculture and integrating information channels for an effective extension service, In: Social Entrepreneurship in Aquaculture (V.R.P. Sinha, Gopal Krishna, P. Keshavanath and Nalini Ranjan Kumar (Eds.), Narendra Publishing House, New Delhi. 363-379.

8. Mahalakshmi, P., Shanthi, B., Ravisankar, T., Chandrasekaran, V.S., 2016. ICT aided entrepreneurship development in aquaculture. In: Sinha, V.R.P., Gopal Krishna, Keshavanath, P. and Nalini Ranjan Kumar (Eds.). Social Entrepreneurship in Aquaculture. Narendra Publishing House, Delhi, India, pp. 346-361.

9. Muralidhar, M., Panigrahi, A., Saraswathy, R., 2016. Water foot print accounting in aquaculture systems. In: Kar, G., et al. (Eds.), Manual on Water footprint computation in agriculture (Crop, Livestock and Fisheries) Publication No.76, ICAR-Indian Institute of Water Management, Bhubaneswar. pp. 59-67.

10. Muralidhar, M., Vasanth, M., Chitra, V., Thulasi, D., Kathyayani, S., Jannathulla, R., 2017. Greenhouse gases emission and mitigation from brackishwater aquaculture systems. In: Belavadi, V.V., et al. (Eds.), Agriculture under Climate Change. Threats, Strategies and Policies. pp. 268-272. ISBN- 978-93-85926-37-2

11. Muralidhar, M., Vijayan, K.K., 2016. Risks associated with extreme weather in aquaculture and their management. In: BapujiRao, B., Rao, V.U.M. (Eds.), Agrometeorological techniques for risk assessment and management of extreme events. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India, pp. 60-67. ISBN:978-93-80883-40-3

12. Shanthi, B., Mahalakshmi, P., Chandrasekaran, V.S., 2016. Entrepreneurship development among coastal fishers through brackishwater aquaculture technologies. In: Sinha, V.R.P. ,Gopal Krishna, Keshavanath, P. and NaliniRanjan Kumar (Eds.). Social Entrepreneurship in Aquaculture. Narendra Publishing House, Delhi, India, pp. 325-333.

13. Thulasi, D., Vasanth, M., Muralidhar, M., Saraswathy, R., Kumararaja, P., Lalitha, N., Nagavel, A., 2017. Effect of reduced condition in shrimp pond sediment on sulfide and methane production. Book chapter in Proceedings of 104th Indian Science Congress. Role of Animal Sciences in National Development. pp. 269-275. ISBN- 81-7019-461-7.

14. Vijayan, K., K., Balasubramanian, C. P., Gopal, C., Kailasam, M., 2016. Diversification of brackishwater Aquaculture: options and strategies. National seminar on aquaculture diversification: The way forward for blue revolution, December 1-3, ICAR CIFA, Bhubaneswar.

Reports/Bulletin

1. Mahalakshmi, P, Gopal, C., Solanki, H.G., Borichangar, R.V., Vanza, J.G., 2016. Asynchronous e-Learning module for aquaculture development in Gujarat. In: proceedings of IRF international conference, ISBN: 978-93-85832-29-1, 28 August 2016, Chennai, pp 4-7.

Oral presentations

1. Alavandi, S.V., Vijayan, K.K., 2016. Viruses in marine ecosystems are diverse, regulate microbial diversity, plankton blooms, play role in nutrient cycling, and some cause disease of aquatic animals. International Conference on Global Perspectives in Virus Disease Management, VIROCON, Bengaluru.
2. Anand, P.R., Kumaran, M., Thirumurthy, S., Jayanthi, M., Dayal, J.S., Kumararaja, P., Muralidhar, M., 2017. Vulnerability of shrimp aquaculture to climate change – a case study in Karnataka. Proceedings of 104th Indian Science Congress. Tirupati. 37-43.
3. Anand, P.S.S., Dayal, J.S., Rajamanickam, S., Balasubramanian, C.P., Gopal, C., Vijayan, K.K., 2017. Growth performance and nutritional analysis of *Artemia* biomass in tank system. In: Book of abstract 13th Agricultural science Congress on Climate smart Agriculture during 21-24 February 2017 at UAS, Bengaluru, pp: 291
4. Avunje, S.,Ray, A.K., Chougala, A.S., Vidya, R., Kumar, S., Alavandi, S.V., 2016. Production of bacteriophages for biocontrol of luminescent vibriosis in shrimp hatchery. International Conference on Global Perspectives in Virus Disease Management, VIROCON, Bengaluru. Pp- 34.
5. Chitra, V., Muralidhar, M., Dayal, J.S., Kumar, J.A., Nagavel, A., 2017. Studies on mineral leaching from shrimp feeds into waters varying in salinity. XIII Agricultural Science Congress – 2017 on Climate smart agriculture, Bengaluru. p.65
6. Dubey, N.K., Shekhar, M.S., Kumar, K.V., Kumar, J.A., Balasubramanian, C.P., Gopkrishna, G., Vijayan, K.K., 2016. Transcriptome generation and functional pathway analysis of *Penaeus indicus*. National Conference on Recent Trends in Biotechnology (BioTrends-2016), NIOT, Chennai, 19th -21st October, 2016.
7. Gomathi, A., Dubey, N.K., Shekhar,M.S., 2016. Gene silencing of *Penaeus monodon* single von Willebrand factor C-domain (pmSVC)by dsRNA inhibits WSSV replication transcriptome generation and functional pathway analysis of *Penaeus indicus*. National Conference on Recent Trends in Biotechnology (BioTrends-2016), NIOT, Chennai, 19th -21st October, 2016.
8. Gopikrishna, G., 2017. Molecular markers in fish breeding-an overview. Training programme on Application of Molecular markers in Fish Breeding held from January 31st to February 9th, 2017 under the CAFT in Fisheries Science at ICAR-CIFE Mumbai, 9th February 2017
9. Hussain, T., Philipose, K.K., Lekha, J., Subburaj, R., Bera, A., Sukumaran, K., Kailasam, M., 2016. Effect of stocking density on growth, survival rate and sibling cannibalism in Asian seabass during early fry rearing. National seminar on " Aquaculture Diversification : the Way forward for Blue Revolution " Organised by the ICAR - CIFA in Association of Aquaculturist, Kausalyaganga , Bhubaneshwar, Odisha During 01 -03 December 2016. PP. 02 (Oral presentation). PP 02.
10. Jannathulla, R., Dayal, J.S., Ambasankar, K., Muralidhar, M., 2017. Evaluation of fungal fermented guar meal in the diet of *Penaeus vannamei*. Proceedings of 104th Indian Science Congress. Tirupati. 51-62.
11. Kathyayani, S., Muralidhar, M., Dayal, J.S., Kumar, J.A., 2017. Effect of climate induced environmental stressors on the mineral profile and biochemical parameters of Pacific white shrimp, *Penaeus vannamei*. XIII Agricultural Science Congress – 2017 on Climate smart agriculture, Bengaluru. p.77.
12. Kathyayani, S., Muralidhar, M., Dayal, J.S., Kumar, J.A., 2017. Effect of environmental stressors on selected immune functions and mineral profile of Pacific white shrimp, *Penaeus vannamei*. 104th Session of Indian Science Congress Association, Tirupati, p. 253.
13. Kumar, S., Avunje, S., Vidya, R., Alavandi, S.V., Vijayan, K.K., 2016. Phage therapy: its application and challenges in aquaculture rearing systems. International Conference on Global Perspectives in Virus Disease Management, VIROCON, Bengaluru.
14. Kumararaja, P., Manjaiah, K.M., 2016. Removal of heavy metals from aqueous solution by silane modified bentonite: synthesis, characterization and equilibrium study. International Conference on Contaminated Site Remediation- CleanUp India 2016, Coimbatore 276-277.
15. Kumararaja, P., Muralidhar, M., Saraswathy, R., Lalitha, N., Suvana, S., Nagavel, A., 2016. Adsorptive removal of phosphate by aluminium pillared bentonite from aquaculture discharge water. International Conference on Contaminated Site Remediation-CleanUp India 2016, Coimbatore, 213-214
16. Lalitha, N., Vasanth, M., Muralidhar, M., Saraswathy, R., Kumararaja, P., Vinu, D., Nagavel, A., Muralidhar, M., 2017. Microbial biomass carbon and its correlation with soil organic carbon and carbon dioxide emission in aquaculture ponds. XIII Agricultural Science Congress – 2017 on Climate smart agriculture, Bengaluru. p.466.
17. Mahalakshmi, P., Gopal, C., Solanki, H.G., Borichangar, R.V., Vanza, and J.G., 2016. Asynchronous e-Learning module for aquaculture development in Gujarat. In: proceedings of IRF international conference, ISBN: 978-93-85832-29-1, 28 August 2016, Chennai, pp 4-7.
18. Mahalakshmi, P., Shanthi, B., Ravisankar, T., Chandrasakaran, V.S., 2016. ICT aided entrepreurship development in aquaculture. In: Book of Abstracts PAF 3rd Congress on Social Entrepreurship in Aquaculture, April 27-29, 2016, ICAR-CIFE, Mumbai, pp 46-47.
19. Makesh, M., Raja, P., Gopi, V., Bera, A., Sukumaran, K., Rekha, M.U., Subburaj, R., Kailasm, M., Vijayan, K.K., 2016. Management of viral nervous necrosis in Asian Seabass *Lates calcarifer* broodstock. International Conference in Global Perspective in Virus Disease Management. ICAR-IIHR. Bengaluru. 8th – 10th Dec. pp 31.
20. Muralidhar, M., 2016. Impact of climate change and extreme climatic events on coastal aquaculture – preparedness and policy measures for sustaining

food security. International Conference on 'Climate Change, Water, Agriculture and Food Security, p.25.

21. Muralidhar, M., 2016. Soil and water quality management for sustainable shrimp farming. Trainer's training programme (TTP) on "Shrimp farming, hatchery seed production and regulations, organized by Coastal Aquaculture Authority at Chennai as part of upgradation of skills & capacity building to AP State Fisheries Departmental Officers during 26-28 April, 2016.

22. Muralidhar, M., 2017. Invited talk on greenhouse gases emission and mitigation from brackishwater aquaculture systems. XIII Agriculture Science Congress 2017 on Climate Smart Agriculture, Bengaluru.

23. Muralidhar, M., Kumararaja, P., Saraswathy, R., Suvana, S., Lalitha, N., Nagavel, A., Vijayan, K.K., 2016. Soil and water health card significance for sustainable brackishwater aquaculture. National Seminar on Soil Health Assessment with Mridaparikshak, Bhopal.

24. Panigrahi, A., Sundaram, M., Ambiganandam, A., Sivakumar, M. R., Saranya, C., Otta, S.K., Anand P.S.S., Vijayan, K.K., 2017. Comparative evaluation of biofloc based nursery rearing technology for penaeid shrimp. National Seminar on Priorities in Fisheries and Aquaculture. Rangeilunda, Berhampur.

25. Poornima, M., 2016. Capacity and performance-self-assessment surveyfor preparation of national action plan to reduce and manage the risks of acute hepatopancreatic necrosis disease (AHPND) on cultured shrimp. National consultation on Acute Hepatopancreatic Necrosis Disease (AHPND), Chennai.

26. Poornima, M., Makesh, M., Alavandi, S.V., Vijayan, K.K., 2016. Challenges to finfish aquaculture diversification with special reference to economically important viral diseases. International Conference on Global Perspectives in Virus Disease Management, VIROCON, Bengaluru.

27. Raja, R.A., Sridhar, R., Balachandran, G., Palanisammi, A., Ramesh, S., 2016. Pathogenicity profile of Vibrio parahaemolyticus in farmed Pacific white shrimp, *Penaeus vannamei*. International conference on Recent Advances in Aquaculture (RAA-2016), Visakhapatnam.

28. Raja, R.A., Sridhar, R., Balachandran, G., Palanisammi, A., Ramesh, S., 2017. Multiplex PCR for the detection and differentiation of *Vibrio parahaemolyticus* in farmed penaeid shrimp, *Penaeus vannamei* using the toxR and tlh genes. International conference on aquatic animal health and parasitic disease-ICAAP-2017" Parangipettai.

29. Saraswathy, R., Balaji, A., Muralidhar, M., Kumararaja, P., Lalitha, N., Nagavel, A., Jayavel, R., 2016. Carbon nanotube based sensor for ammonia detection in aquaculture ponds. National seminar on Recent Trends in Nanotechnology and Aquaculture Technologies, Tirupati.p.53.

30. Saravanan, P., Amarnath, B., Alavandi, S.V., Vijayan, K.K., Otta, S.K., 2016. Deciphering the correlation of selected defense genes of tiger shrimp, *Penaeus monodon* against white spot syndrome virus infection. International Conference on Global Perspectives in Virus Disease Management, VIROCON, Bengaluru.

31. Sethi, S.N., Rekha, M.U., Tomy, S., 2016. Salinity tolerance of endangered Canara Pearlspot, *Etroplus canarensis* with respect to captive breeding programs. First International Agrobiodiversity Congress, New Delhi, 6-9th November 2016.

32. Shanthi, B., Mahalakshmi, P., Chandrasekaran, V.S., 2016. Assessing the impact of environmental changes on the livelihoods of coastal women with socio-economic and gender analysis (SEAGA). Paper presented in 6th Global Symposium on Gender in Aquaculture and Fisheries (GAF5) Special Symposium at the 11th Asian Fisheries and Aquaculture Forum, Bangkok, Thailand. 3-7 August, 2016. Engendering Security in Fisheries and Aquaculture. Abstract No.083.

33. Shanthi, B., Mahalakshmi, P., Chandrasekaran, V.S., 2016. Entrepreneurship development among coastal fishers through brackishwater aquaculture technologies. Proceedings of PAF 3rd Congress on Social Entrepreneurship in Aquaculture during 27-29 August 2016 at ICAR-CIFE, Mumbai.. pp 51-52.

34. Shanthi, B., Mahalakshmi, P., Ravisankar, T., Chandrasekaran, V.S., 2016. Gender participation in food production through adoption of brackishwater aquaculture technologies. Abstract submitted for presentation in the workshop on Gender and Food Security in India, held on August 29th 2016 at New Delhi by International Food Policy Research Institute (IFPRI), Washington, USA.

35. Shanthi, B., Mahalakshmi, P., Chandrasekaran, V.S., Vijayan, K.K., 2016. Alternative livelihood options for the coastal tribal people through brackishwater aquaculture technologies. Paper presented in 11th Asian Fisheries and Aquaculture Forum, Bangkok, Thailand. 3-7 August, 2016. pg.12 of abstract book.

36. Shekhar, M.S., Vijayan, K.K., 2017. Biotechnological interventions in brackishwater aquaculture: an insight. National Conference on Neo-classical Approaches in Zoological Sciences, University of Madras, Chennai, 16-17th February, 2017

37. Sivamani, B., Kumar, K.V., Sherly, T., Gopikrishna, G., 2016. Nucleotide variations in immune response genes of tiger shrimp along the Indian coast. National conference on Frontiers in Genetics and Genomics at the Department of Genomic Science, Kerala Agricultural University, Padanakkad, Kasaragod, Kerala, 7-8th April 2016

38. Subburaj, R., Thiagarajan, G., Karaiyan, K., Rekha, M.U., Bera, A., Kumararaja, P., Kailasam, M., 2016. Long distance transportation of spawn from breeding centre to fry rearing unit – A simplified approach to expand the seabass (*Lates calcarifer*) seed production technology in the farmer's locality presented in National seminar on " Aquaculture Diversification : the Way forward for Blue Revolution " Organised by the ICAR - CIFA in Association of Aquaculturist, Kausalyaganga , Bhubaneshwar, Odisha During 01 -03 December 2016. NFA – 06, PP 25

39. Suvana, S., Jha, P., Muralidhar, M., Patra, A. K., 2017. The effect of liming on carbon mineralization in acid soils. Proceedings of 104th Indian Science Congress. Tirupati 176-177.

40. Thulasi, D., Vasanth, M., Muralidhar, M., Saraswathy, R., Kumararaja, P., Lalitha, N., Nagavel, A., 2017. Effect of reduced condition in shrimp pond sediment on sulfide and methane production. Proceedings of 104th Indian Science Congress. Tirupati. p. 184.

41. Thulasi, D., Vasanth, M., Muralidhar, M., Saraswathy, R.,Nagavel, A., 2017. Sulfide and methane production in microcosm varying in feed protein and water salinity. In Book of abstracts - XIII Agricultural Science Congress – 2017 on Climate smart agriculture, Bengaluru. p. 452.

42. Zacharia, P.U., Gopalakrishnan, A., George, G., Muralidhar, M., Vijayan, K.K., 2016. Climate change impact on coastal fisheries and aquaculture in the SAARC region: Country paper – India. Paper presented in SAARC Agriculture Centre Video Conference on Climate Change Impact on Coastal Fisheries and Aquaculture. 25 p.

Participation in conferences, meetings, workshops, symposia

International

1. Project Review Meeting under Indo-UK collaborative project on "Poverty alleviation through prevention and future control of the two major socio-economically important diseases in Asian aquaculture", held at University of St.Andrews and University of Aberdeen, Scotland during 7-11 November 2016 – Dr. K.K. Vijayan & Dr. M. S. Shekhar.

2. FAO Second International Technical Seminar / Workshop on Acute Hepatopancreatic Necrosis Disease (AHPND) and Second Inter-regional Workshop on EMS/AHPND Risk Management and Risk Reduction Strategies at National and Regional Levels at Bangkok, Thailand during 23-28th June 2016 – Dr. S. V. Alavandi.

3. Regional consultation on responsible production and use of feed and feed ingredients for sustainable growth of aquaculture in Asia – Pacific at NACA, Bangkok, 7th to 9th, 2017 – Dr. K. Ambasankar.

National

Dr. K. K. Vijayan, Director

4. Workshop on "Promotion of Rural Aquaculture for improving the protein security of India with special reference to Kerala at Kerala University of Fisheries and Ocean Studies (KUFOS), at KUFOS, Panangad on 4th July 2016.

5. National Seminar on Perspective Aquaculture Plan of Kerala at Department of Fisheries, Govt. of Kerala, at Kollam on 9th July 2016.

6. Conference on "Haryana Towards Blue Revolution" at D.N. Farms, at Hissar, Haryana on 23rd July 2016.

7. Fifth 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 Bhawan, New Delhi on 25th July 2016.

8. Regional Consultation on "Enhancing Productivity and Profitability of Pulses for addressing food and nutrition security" at MSSRF, Chennai on 7th August 2016.

9. Road Show on Global Rajasthan Agritech Meet (GRAM), organized by Federation of Indian Chambers of Commerce and Industry (FICCI) with Government of Rajasthan at Hotel Taj Coromandel, Chennai on 10th August 2016.

10. National Level Conference on Tangible Benefits of Marine Biotechnology Research in Food, Health, Energy and Industrial Sectors at Department of Biotechnology, Hindustan College of Arts and Science, Chennai on 24th August 2016.

11. Expert Round table on "Antibiotic use and waste management in aquaculture to limit emergence and spread of antibiotic resistance" at Centre for Science and Environment, New Delhi on 21st September 2016.

12. 13th Foundation Day of National Biodiversity Authority (NBA) at NBA, Ticel Biopark, Chennai on 1st October 2016.

13. Brackishwater Farmers Interaction Meet organized by KRC of CIBA, Kakdwip at Uttar Chandanpiri, Kakdwip on 20th October 2016.

14. Brackishwater Farmers Meet and Harvest Mela in the culture demonstration site under the NFDB project "Upgradation of breeding and culture technology of indigenous species Indian white shrimp, *P.indicus*" at Shahada, Balasore, Odisha on 29th November 2016.

15. National Seminar on 'Aquaculture diversification: the way forward for blue revolution' at Central Institute of Freshwater Aquaculture in collaboration with Association of Aquaculturists, Bhubaneswar on 1st December 2016.

16. International Conference on "Global Perspectives in Virus Disease Management" - VIRCON 2016 held at Indian Institute of Horticultural Research, Bangalore on 9th December 2016.

17. 29th Kerala Science Congress held at Mar Thoma College, Thiruvalla, Pathanamthitta during 28-30th January 2017.

18. 30th Meeting of the Technical Committee to oversee and monitor the functioning of Aquatic Quarantine Facility, at Coastal Aquaculture Authority, Chennai on 3rd February 2017.

19. Meeting for preparation of EFC/SFC document at SMD (Fisheries), ICAR, New Delhi during 6-7th February 2017.

20. 29th Meeting of the Executive Committee of National Fisheries Development Board at Krishi Bhavan, New Delhi on 8th February 2017.

21. Assessment Committee Meeting for assessment of CAS for the promotion of Senior Scientist to Principal Scientist under Revised CAS at Agricultural Scientist

Recruitment Board, New Delhi on 9th February 2017.

22. ICAR Directors Conference at A.P.Shinde Hall, NASC Complex, Pusa, New Delhi held during 14-15th February 2017.

23. Assessment Committee Meeting for assessment of CAS for the promotion of Senior Scientist to Principal Scientist under Revised CAS at Agricultural Scientist Recruitment Board, New Delhi on 14th February 2017.

24. Meeting of the Committee on Agriculture regarding examination of the Demand of Grants (2017-18) of the DAHDF, organized by the Ministry at Parliament House, New Delhi on 17th February 2017.

25. Sixth Meeting of the Project Screening Committee constituted under the Guidelines for establishing of operation of SPF Shrimp Broodstock Multiplication Centre at Krishi Bhavan, New Delhi on 17th February 2017.

26. Assessment Committee Meeting for assessment of CAS for the promotion of Senior Scientist to Principal Scientist under Revised CAS at Agricultural Scientist Recruitment Board, New Delhi on 27th February 2017.

27. 213th Meeting of the Board of Directors of Tamil Nadu Fisheries Development Corporation Limited at Secretariat, Chennai on 24th March 2017.

28. Meeting of the Senior Officers of Fisheries Department, ADAK and CIBA to discuss on brackishwater aquaculture, called by the Hon'ble Minister of Fisheries, Govt. of Kerala at Thycaud, Thiruvananthapuram on 27th March 2017.

29. Sixth Meeting of the Advisory Board of the National Centre for Aquatic Animal Health, Cochin University of Science and Technology (CUSAT) to discuss and finalize the strategic plans towards overall development of the Centre at KUSAT, Kochi on 28th March 2017.

30. 55th Executive Committee Meeting of Rajiv Gandhi Centre for Aquaculture on 29th March 2017 at MPEDA, Kochi on 29th March 2017.

31. Research Advisory Committee Meeting of CIBA at CIBA, Chennai during 4-5th April 2016.

32. Annual Institute Research Council Meeting of CIBA at CIBA, Chennai during 3-5th May 2016.

33. Interactive Meeting of the Directors of Fisheries Institutes, at SMD, ICAR, New Delhi, 9th June 2016.

34. Interface Meeting between DAHDF and ICAR, in the presence of Director General, at ICAR, New Delhi on 10 June 2016.

35. 47th Meeting of Institute Management Committee of CIBA organized by CIBA at Chennai on 18 June 2016.

Participation in Workshops/Seminar/Meeting by Scientists

36. National Conference on "Frontiers in Genetics & Genomics (FIG-2016)" at Department of Genomic Science, Central University of Kerala at Kerala, 7th to 8th April, 2016 – Dr. B. Sivamani.

37. Indo-Norwegian Seminar on "Aquaculture Legislation" at Ministry of Agriculture & Farmers Welfare, Department of Animal Husbandry and Dairying & Fisheries, New Delhi, 8th April, 2016 – Dr. M. Jayanthi.

38. Annual Review Workshop 2015-16 of KVKs in Zone VIII and to deliver a lecture talk on "Frontier technologies in brackishwater aquaculture for improving profitability" at ICAR-Agricultural Technology Application Research Institute, Bengaluru at KVK Wayanad under Kerala Agricultural University, 20th to 23rd April, 2016 – Dr. T. Ravishankar.

39. National consultation on ornamental fish at NFDB, Hyderabad, 27th to 28th, April 2016. Dr. Krishna Sukumaran.

40. PAF 3rd Congress on "Social Entrepreneurship in Aquaculture" at Pillay Aquaculture Foundation, ICAR-Central Institute of Fisheries Education and Indian Fisheries Association at ICAR-Central Institute of Fisheries Education, Mumbai, 27th to 29th April, 2016 - Dr. T. Ravisankar, Dr. B. Shanthi , Dr. M. Kumaran and Dr. P. Mahalakshmi.

41. National Consultation on "Ornamental Fish" at National Fisheries Development Board, Hyderabad, 28th April, 2016 – Dr. Krishna S.

42. Stakeholders' Meet on "Skill Development Programmes in Fisheries Sector" at Tamil Nadu Fisheries University, Chennai, 6th May, 2016 – Dr. G. Gopikrishna.

43. 2nd meeting of the Expert Committee to Develop Technical Design for Aquatic Animal Quarantine units (AAQU) and Disease Diagnostic laboratories (DDL) at Krishi Bhavan, New Delhi, 6th May 2016 – Dr. S. V. Alavandi.

44. Meeting on standard operating procedure (SOP) for aquatic quarantine of specific pathogen free (SPF) shrimp parent post larvae (PPL) at CAA, Chennai, 26th May 2016 – Dr. S. K. Otta.

45. ICAR-DAC Interface meeting with Dept. of Agriculture, Govt. of W.B. at ICAR-ATARI Kolkata, 31st May, 2016 – Dr. T. K. Ghoshal.

46. First review workshop of ICAR consortium of research platform on genomics at NBFGR, Lucknow, 7th June, 2016 – Dr. M. S. Shekhar.

47. Workshop of Agri Business Incubation ICAR-NIRJAFT, Kolkata, 15th June, 2016 – Dr. T. K. Ghoshal.

48. 2nd National Seminar on "Conservation, Restoration and Sustainable Management of Mangrove Forests in India", at Centre for Mangroves and Coastal Ecology (CMCE), Institute of Forest Biodiversity (IFB), Visakhapatnam, 15th to 17th June, 2016 – Dr. M. Jayanthi.

49. Scientific Advisory Committee meeting of Ramkrishna Ashram, KVK at Nimpith, 18th June, 2016 – Dr. T. K. Ghoshal.

50. Brainstorming Workshop on "Application of metagenomics and microbiome for augment fish production and productivity" at ICAR-Central Institute of Freshwater Aquaculture, 21st June, 2016 – Dr. S. Avunje.

51. 23rd Meeting of ICAR Regional Committee-II at ICAR-National Academy of Agricultural Research Management, Hyderabad, 24th to 25th June, 2016 – Dr. T. K. Ghoshal.

52. International Conference on "Algal Technologies (ICAT-2016) at Sevas Educational Society and Rahul Budh Vihar Prabhandak Committee, Punjab, 14-16th July 2016 – Mrs. Babita. M.

53. Conference cum farmers interaction meet on "Haryana Towards Blue Revolution" at DN Farms, 23rd July 2016 – Dr. K. Ambasankar.

54. Hilsa project review meeting with Union Agriculture Minister at Ministry of Agriculture, Govt. of India, Krishi Bhavan, New Delhi, 25th July, 2016 – Dr. D. De.

55. Awareness Workshop on "Guidelines for Access to Biological Resources under the Biological Diversity Act, 2002" at Biotech Consortium India Limited (BCIL), Bangalore, 28th July, 2016 – Dr. Sherly Tomy.

56. Meeting on "Modalities for implementation of scheme on aquaculture crop insurance" at National Fisheries Development Board, Hyderabad, 10th August, 2016 – Dr. M. Kumaran.

57. National Seminar on "Recent Trends in Nanotechnology and Aquaculture Technologies (RTNAT-2016)" at Sri Venkateswara University, Department of Fishery Science and Aquaculture, Tirupathi, 18-19th August 2016 – Dr. R. Saraswathy.

58. RTI training at Anna Institute of Management, Chennai, 22-23rd, August, 2016 –Dr. J. S. Dayal.

59. International Conference on "Education and E-Learning (ASAR-ICEEL-2016)" at Asian Society for Academic Research (ASAR), Chennai, 28th August, 2016 – Dr. P. Mahalakshmi.

60. Technical Committee meeting, Directorate of Fisheries, Odisha Govt, at Cuttack, 29th August, 2016 – Dr. S. V. Alavandi.

61. International Conference on "Microalgal and Cyanobacterial Biotechnology (MACB 2016)" at National Facility for Marine Cyanobacteria, Bharathidasan University, Tiruchirappali, 30th August-1st September 2016 – Mr. K.P. Sandeep.

62. Sixth Advisory Committee Meeting of Hilsa project at ICAR-CIFRI, Barrackpore, West Bengal, 30-31st August, 2016 – Dr. D. De

63. Meeting on DPR preparation for "Holistic Fisheries Development in the Islands" at NFDB, Hyderabad, 8th September, 2017 – Dr. C. Gopal and Mr. Jose Antony.

64. Meeting on Technical Committee at Model Shrimp Farm & Training Centre, Poyya, 9th September, 2016 – Dr. M. Kailasam & Mr. Dani Thomas.

65. Workshop on "Application of Bioinformatics in Proteome Analysis" at Madras Veterinary College, Chennai, 19-23rd September 2016 – Mr. R. Aravind.

66. Delivered a lecture at International Seminar on "Advances in Crustacean Research" University of Kerala & Indian Science Congress Association at Thiruvananthapuram (Jointly Organized), 20th September – Mr. Biju I. F.

67. Roundtable on "Antibiotic use and waste management in aquaculture to limit emergence and spread of antibiotic resistance" at Centre for Science and Environment, New Delhi, 21st September 2016 – Dr. P. K. Patil.

68. Stakeholder engagement on nutrition at MSSRF, Chennai, 21st September, 2016 – Dr. K. Ambasankar.

69. RTI Workshop at NAARM, Hyderabad,25th September, 2016 – Dr. J. S. Dayal.

70. External Member in the selection committee constituted for the purpose at ICAR-CMFRI, Chennai, 17th October, 2016 – Dr. C. P. Balasubramanian.

71. National Conference on Recent Trends in Biotechnology (Bio Trends-2016) and Annual Meet of the Society for Biotechnologists (India) at National Institute of Ocean Technology & Society for Biotechnologists (India) at Chennai (Jointly Organized), 19-21st October 2016 - Dr. P. K. Patil and Dr. N. S. Sudheer.

72. 11th Meeting of Fish, Fisheries and Aquaculture Sectional Committee, FAD 12 at BIS, Manak Bhavan, New Delhi, 26th October, 2016 – Dr. K, Ambasankar.

73. International Conference on "Climate Change, Water, Agriculture and Food Security (ICCWAFS 2016)" at Water and Land Management Training and Research Institute (WALAMTARI), Norwegian Institute of Bioeconomy Research (NIBIO), MSSRF-Chennai, International Water Management Institute (IWMI), Tamil Nadu Agricultural University, ClimaAdapt and Norwegian Embassy at ICRISAT, Hyderabad, 2-3rd November 2016 – Dr. M. Muralidhar.

74. Review meeting of ICAR Outreach Research Activity on Fish Feeds of Fisheries SMD of ICAR at NASC, New Delhi, 3-4th November, 2016 – Dr. K. Ambasankar.

75. National Seminar on "Soil Health Assessment with Mridaparikshak" at ICAR-Indian Institute of Soil Science at Bhopal, 4th to 5th November – Ms. S. Suvana.

76. "Ist International Agrobiodiversity Congress 2016 (IAC 2016)" at Indian Society of Plant Genetic Resources & Biodiversity International at New Delhi (Jointly Organized), 6-9th November 2016 – Dr. S. Sethi.

77. Workshop on "Clinical Application on In vivo Imaging-2016 at Translational Research Platform for Veterinary Biological (TRPVB) at TANUVAS, Chennai, 22-24th November 2016 - Mr. J. Joseph S. R.

78. Policy dialogue on "Mainstreaming Biodiversity into the Fisheries Sector" at NBA Conference Hall, Chennai, 25th November 2016 - Dr. C.P. Balasubramanian.

79. National Seminar on "Aquaculture Diversification: The way forward for blue revolution"at ICAR-Central Institute of Freshwater Aquaculture & Association of Aquaculturists (AoA) at ICAR-CIFA, Bhubaneswar, 1-3rd December 2016 - Dr. A. Panigrahi, Dr. Prem Kumar, Mr. T. Hussain and Mr. R. Subburaj.

80. 5th Advisory Committee Meeting on Hilsa Conservation and Research with Hon'ble MIC, Fisheries, Govt. of W.B. at Kolkata, 9th Dec., 2016 – Dr. T. K. Ghoshal and Dr. D. De.

81. VIROCON 2016 International Conference on "Global Perspectives in Virus Disease Management" at ICAR-Indian Institute of Horticulture Research at Bangalore, 7-10th December 2016 - Dr. M. Makesh, Dr. M. Poornima, Dr. S. K. Otta and Dr. Sujeet Kumar and Dr. S. Avunje.

82. International Conference on "Contaminated Site Remediation (CleanUp India 2016)" at Tamil Nadu Agricultural University at Coimbatore, 13-15th December 2016 – Dr. P. Kumararaja.

83. International Conference on "Recent Advances in Aquaculture (RAA-2016)" at Department of Marine Living Resources, College of Science and Technology at Andhra University, Visakhapatnam, 16-17th December 2016 – Dr. R. Ananda Raja.

84. Search cum selection committee meeting for the award of ICAR National Fellow at Krishi Anusandhan Bhawan-II, Pusa, New Delhi, 19th December, 2016 – Dr. D. De.

85. 20th Meeting of the Committee on "Introduction of Exotic Aquatic Species into Indian Waters" at ICAR, Krishi Bhawan, New Delhi, 23rd December 2016 – Dr. S. K. Otta.

86. Meeting on "National Action Plan for Antimicrobial Resistance" at ICAR, KAB-II, New Delhi, 27th December – Dr. P. K. Patil.

87. 104th Indian Science Congress "Science & Technology for National Development" at Sri Venkateswara University at Tirupati, 3-7th January 2017- Ms. Suvana .S and Mr. Dani T.

88. Task Force Meeting on Aqua Sector at Chief Secretary Office, Vijayawada, 9th January, 2017 – Dr. K. Ambasankar.

89. Workshop on "Agri-Tech Innovation and Entrepreneurs for Identifying Commercially Viable Projects"at NASC, New Delhi, 18-20th January 2017 – Dr. T. Ravisankar.

90. National Consultation Meeting at ICAR-National Institute of Abiotic Stress Management, Baramati, Pune, 30th January, 2017 – Mr. T. Hussain.

91. One-day Multi-stakeholder Dialogue on Hilsa and River Management organized by International Water Association at Kakdwip, West Bengal, 3rd February, 2017 – Dr. D. De and Dr. Prem kumar.

92. Technical Knowledge Exchange Workshop on "Vulnerability of Sundarban in a Changing Climate" at Bangladesh-India Sundarban Region Cooperation Initiative at Ramakrishna Mission Institute of Culture in Kolkata, 3rd February 2017 - Dr. T. K. Ghoshal, Dr. G. Biswas and Ms. Leesa Priyadarshini.

93. National Conference on "Trends in Environmental Engineering Management and Science (TEEMS '17)" at Centre for Environment Studies, Anna University at Chennai, 9th to 10th February, 2017 – Dr. Kumararaja.

94. International Conference on "Profit on Aquaculture – 2017" at Uddaraju Anandaraju Foundation (Bhimavaram), Asian Institute of Technology (Bangkok), Department of Fisheries (Andhra Pradesh) & Sri Venkateswara Veterinary University (Tirupati) at Dr. BV Raju Educational Institutions, Vishnupur, Bhimavaram, Andhra Pradesh, 11-14th February 2017 - Dr. A. Panigrahi.

95. National Conference on "Neo-classical Approaches in Zoological Sciences" University of Madras, Chennai, 16-17thFebruary, 2017 – Dr. M. S. Shekhar.

96. Crop Simulation Models in Climate Change Impact Assessment at ICAR-IISS Bhopal, February 14th to 18th, 2016 – Dr. Suvana Sukumaran.

97. XIII Agricultural Science Congress 2017 at University of Agricultural Sciences, Bengaluru, 21-24th February 2017 - Dr. P. S. Shyne Anand and Dr. N. Lalitha.

98. Annual Review Meeting of National Agricultural Science Fund (NASF) at NASC complex, New Delhi, 23rd February, 2017 Dr. D. De.

99. CIFA- NFDB Collaborative Awareness Workshop on "Importance of Quality Fish Seed and Growth Evaluation of Jayanti Rohu in Low Saline Water" at Madanganj, Namkhana, South 24 Parganas, West Bengal, 27th February, 2017 – Dr. D. De and Dr. G. Biswas.

100. International Conference on Aquatic Animal Health and Parasitic Disease - ICAAP-2017" at Center of Advanced Study in Marine Biology, Annamalai University, India, 6-7th March 2017 - Dr. R. Ananda Raja.

101. National Seminar on "Priorities in Fisheries and Aquaculture (PFA-2017)" at College of Fisheries, Rangeilunda, OUAT, Orissa Fisheries College Alumni Association, Rangeilunda, Inland Fisheries Society of India, Barrackpore and ICAR-Central Inland Fisheries Research Institute, Barrackpore at College of Fisheries, Rangeilunda, Odisha, 11-12th March 2017 - Dr. A. Panigrahi and Dr. Satyanarayan Sethi.

102. Regional Seminar and Farmer's Interaction on Coastal Ecosystem of India: Recent Development and Future Strategies organized by the Indian Society of Coastal Agricultural Research at ICAR- Nation Institute of Research on Jute and Allied Fibre Technology, Kolkata, 18th March, 2017 – Dr. G. Biswas.

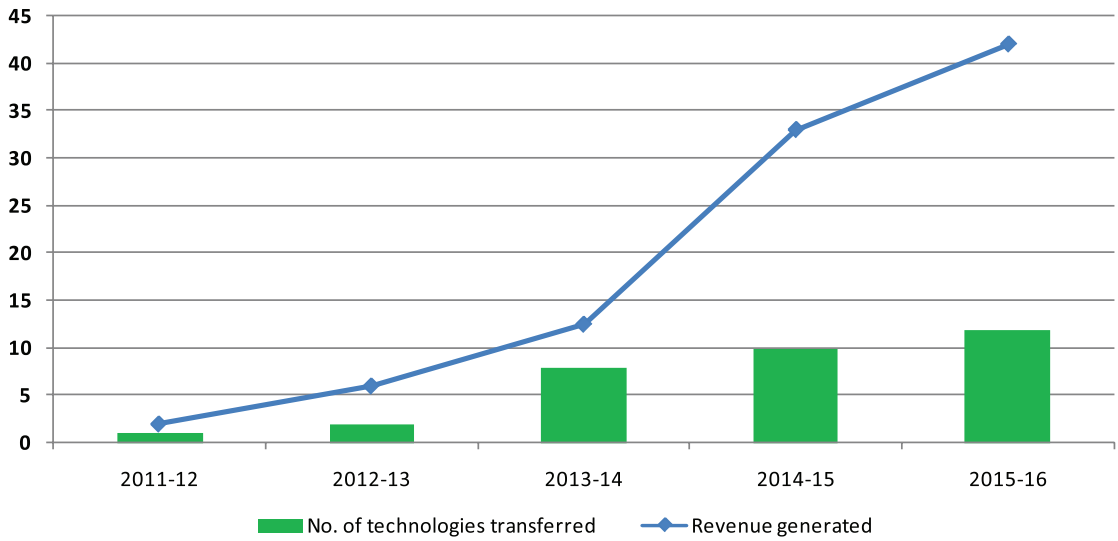
103. 20th and 21st national committee meeting on Introduction of Exotic Aquatic Species into Indian Waters at DAHDF at New Delhi, 23– 24th December – Dr. S. K. Otta.

Consultancies, technology development and transfer

Institute Technology Management and Agri Business Incubator unit

Institute Technology Management and Agri Business Incubator unit is functioning in ICAR-CIBA with ICAR-National Agricultural Innovation fund. The unit has been performing consistently and generating revenue of Rs. 25 lakhs and above every year from commercialisation.

Revenue generation



Technical support and partnership farming for adoption of pearlspot seed production and nursery rearing models

ICAR-CIBA signed MoU with Shri.A.Baburaj and Shri.Bijoy farmers from Kerala on 26th April 2016 for technical support and partnership farming for adoption of pearlspot seed production and nursery rearing models. The institute will provide scientific support and technical collaboration to the client to develop pearlspot seed production and nursery rearing models.

Partnership in pond based broodstock development, breeding and nursery rearing of grey mullet in west coast (Pallipuram, Ernakulam)

ICAR-CIBA signed an MoU with Shri. Nissar, a farmer from Ernakulam region for pond based broodstock development, breeding and nursery rearing of grey mullet in West Coast on 19th July 2016 at CIBA headquarter. The objective of the Demonstration is Pond based broodstock development of grey mullet, induced breeding and nursery rearing of grey mullet.

ICAR- CIBA signed MoU with brackishwater farmer's group for technical support to develop sustainable polyculture models in Kerala

ICAR- Central Institute of Brackishwater Aquaculture, Chennai signed an MoU with Shri. Suresh Babu and his associates from Ernakulam Dist., Kerala for technical partnership and assistance relating to develop innovative farm based polyculture model in brackishwater system on 27th August 2016 at CIBA, Chennai. Under the agreement, CIBA will partner with the farmer group in integrating hatchery and farming of suitable brackishwater species with the guidance in ensuring the use of cost-effective quality seed, feed and health management.

ICAR-CIBA signed MoU with Westland Marine Private Limited, Nellore, for the technology transfer of "Indigenous formulated shrimp feed" developed by CIBA, for sustainable shrimp farming, Chennai

Increasing cost of formulated shrimp feed is a growing concern in sustainable farming, because it drives the cost of production upwards and decrease the profit margin for the farmers. ICAR-CIBA has developed a cost effective and quality feed using indigenous feed ingredients for *vannamei* farming, the 'Vanami$^{Plus'}$. The technology was transferred to a series of private entrepreneurs for up scaling and commercial production on a non-exclusive basis. As new addition to the list, on 27th August 2016, ICAR-CIBA signed a MoU with Dr. Manoj Kumar Reddy, Westland Marine Private Limited, Nellore for transfer of shrimp feed technology. Westland marine is into aquaculture since late 1980's and carrying shrimp farming in about 100 acres of water spread area in and around Gudur division of Nellore district, Andhra Pradesh. The company envisages to use 'Vanami $^{plus'}$ of CIBA in their own farms and also supply the small and medium size farmers in their close locality which is expected to have an impact on the local farming community by reducing the production cost of shrimp

Collaborative Research Partnership (CRP) between ICAR- CIBA and Hatsun Agro Products Ltd to develop an organic microbial product (MP) for aquatic animal health and improved production

Memorandum of understanding was signed between ICAR-CIBA and M/S Hatsun Agro Products Ltd. Chennai on 29th Aug 2016 for a collaborative research project on development of biodynamic products for application in shrimp aquaculture. The joint research project is being focused on developing and optimizing the products based on the microbial biotechnology from low value animal and dairy bio-byproducts (BBP) for their potential application in the field of agriculture and aquaculture. The technology is expected to boost the pond health and animal health, both fish and shrimp, with higher production keeping environmental sustainability. Such products will help in the profitability of shrimp and fish production. This green technology can be also used for the production of organic shrimp.

Memorandum of Understanding for Consultancy for Evaluation of Natural Product for Antiviral Activity with M/s Revelations Biotech Pvt. Ltd., Hyderabad.

ICAR-CIBA signed a Memorandum of Understanding with M/S Revelations Biotech Pvt. Ltd., Hyderabad on 19th September, 2016 for collaborative research for development and standardization of natural product for antiviral activity for betterment of shrimp aquaculture. The combined research work is aimed to develop a product for controlling White Spot Syndrome Virus (WSSV) in shrimp farm by utilising from natural resources and standardize treatment protocol. The work will look into the biosafety and environmental impact of the product. Research will also be extended to understand the mode of action of the product.

Signing of MoU for culture demonstration of Indian White Shrimp (*Penaeus indicus*) with farmers

ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai signed a MoU with three shrimp farmers Ms. Shyamala Subramanian, a woman farmer from Tamil Nadu, Shri.Sudhakaran from Kerala and Shri.Anjan Dandapat, from Odisha for culture demonstration of Indian White Shrimp (*Penaeus indicus*) on 29th October 2016. Dr. Akshaya Panigrahi, PS and Team Leader, gave a brief about the MoU being signed for shrimp culture demonstration with the farmers who wish to start production. He has specially mentioned the new thrust and efforts taken by the present Director and all Scientists, as CIBA team.

Memorandum of Understanding for collaborative research programme between ICAR-CIBA, Chennai and VIT, Vellore.

An MoU was signed between ICAR-CIBA, Chennai and Centre for Bioseparation Technology, VIT University, Vellore, Tamil Nadu on 28th January 2017 with the following objectives. (a) collaborate in research on disciplines related to generation of monoclonal antibodies for the development of rapid immunodiagnostics for application in brackishwater fish and shrimp, (b) undertake collaborative research activities in other areas of mutual interest to both CBST-VIT and ICAR-CIBA and (c) cooperate in other means for exchanging scientific knowledge and information and other research facilities on mutual agreement and to the combined advantage, and co-publication of research outputs.

Institute Technology Management Unit

ICAR- Central Institute of Brackishwater Aquaculture celebrates ICAR foundation day on 16th July 2016

Prof. P.G. Chengappa, chief guest addressing the gathering on foundation day celebration

A program was organized to celebrate 88th Foundation of Indian Council of Agricultural Research on 16th July 2016 at Central Institute of Brackishwater Aquaculture. Prof. P.G. Chengappa, ICAR National Professor, Institute for Social and Economic Change and Former Vice Chancellor, University of Agricultural Sciences, Bengaluru was the chief guest of the function, who gave a presentation on ' Development of Indian agriculture and contributions of NARS system'.

Prof. P.G. Chengappa in his address sketched the growth of Indian agriculture post-independence and role of National Agriculture Research System. He emphasised the need for inclusive development and linking small farmers to markets. He demonstrated the changing pattern of food consumption in the last 40 years in India toward high value items of fruits vegetables, egg, fish and dairy products, meat and meat products. He emphasized that research programs of ICAR need to be modified according to the changing pattern of food consumption in the country and unified national agriculture market through e-commerce platforms. He was hopeful of the new policy of the 'National Agriculture Marketing' which will be a game changer for agriculture in India and expressed this concern over the infrastructure like, warehouses which will be the major bottleneck in agriculture marketing is the which needs to be addressed immediately.

Firm-farm linkage program through contract farming being mooted in the country recently is expected to boost the agriculture income. Research and extension polices in the NARS need to be reoriented to achieve the goal of doubling the agriculture income by 2025. Main focus areas should be to increase the productivity, reducing the cost of production, emphasis on high value crops, product diversification and integrated farming. There is an urgent need to increase the efficiency of supply chain.

Earlier in his inaugural address Dr. K.K. Vijayan, Director, CIBA emphasised the need for celebrating ICAR foundation day and understanding Indian agriculture systems to focus our research priorities accordingly. Dr.T.Ravisankar, Principal Scientist and Incharge, Agri Business Incubator welcomed the guest and audience and Dr. P.K. Patil, Senior Scientist introduced the Chief Guest and conveyed the vote of thanks.

Funding support obtained

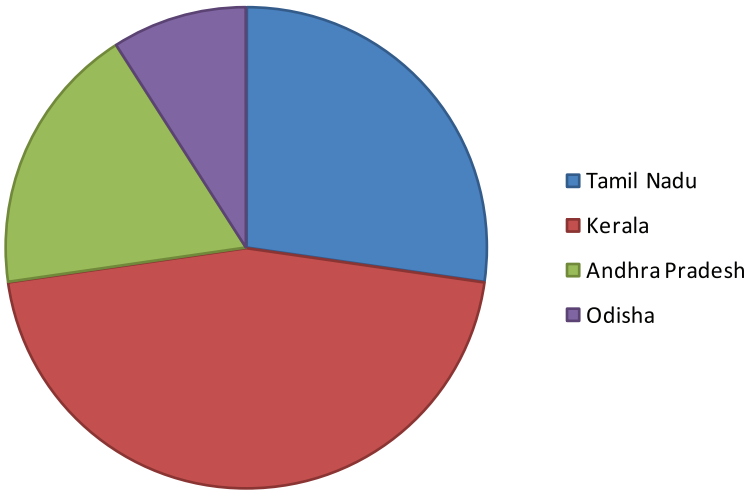
ICAR grant-Rs.6.40 lakhs

ICAR-NAIF- Rs. 27.94 lakhs

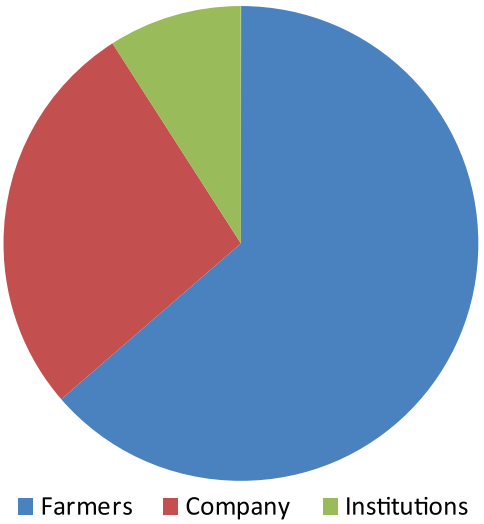
Major activities

- During the year 2016-17 eleven MoUs were signed in the areas of farming, nursery rearing, nutrition, health and culture demonstration.
- Modalities of technology outreach include technology transfer, collaborative research and knowledge partnership.

PPP MoUs –State wise



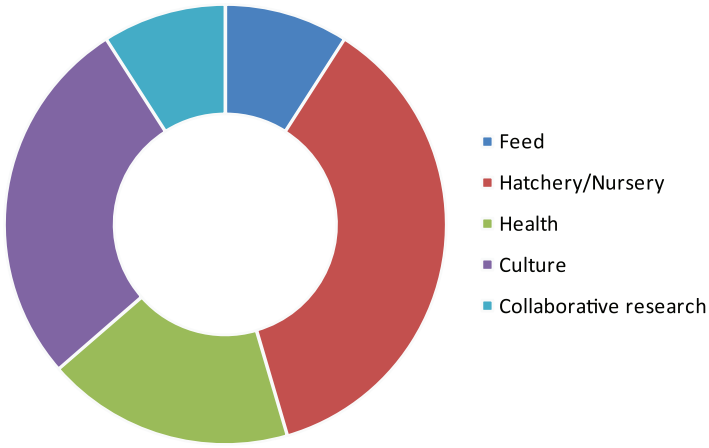
PPP MoUs –Client type wise



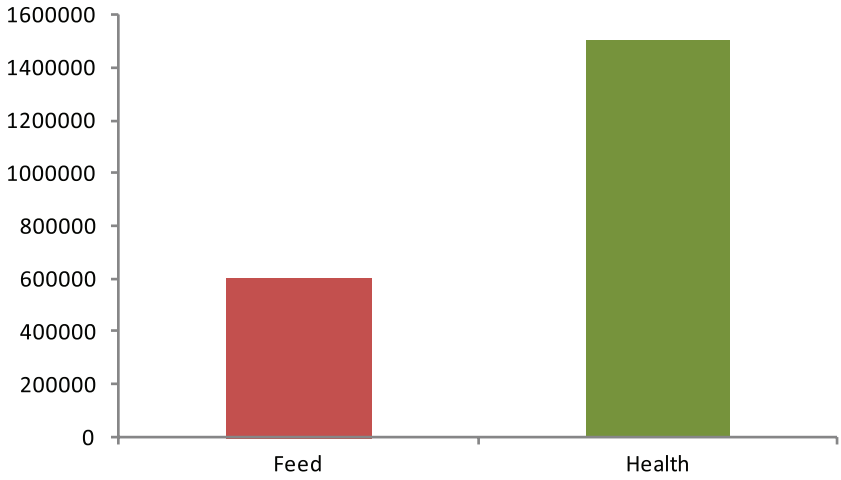
Salient finding /leads

- Conscious effort was taken to engage stakeholders from all the coastal states of India. Four states were covered this year.
- On client type, corporate sector, farmers and research institutions like Vellore Institute of Technology (VIT) were also given adequate importance. A total number of three corporate entities, one institution and seven farmers were brought in as clients.
- Four MoUs for hatchery/nursery technology, three for culture, two for health, one for feed and one for collaborative research programme were signed.
- Out of the revenue received, the health related MoUs brought in Rs.15.0 Lakhs and accounted for 71 percent.

PPP MoUs-Component wise



PPP MoUs-Component wise



Research and 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. M.V.Gupta
Members	Dr.(Mrs) Krishna Srinath
	Mr. Udaya Ram Jyothy
	Dr.R.A.Selvakumar
	Dr.P.A.Lokabharathi
	Dr.Sridhar Sivasubbu
	Dr.Madan Mohan
	Dr.K.K.Vijayan
Member Secretary	Dr.M.Jayanthi

The 21st meeting of the Research Advisory Committee (RAC) of CIBA was held on 4-5th April 2016 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. M.Jayanthi

The 33rd IRC Meeting was held on 3-4th May 2016 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
Dr. Bindu R. Pillai, PS & Head, ICAR-CIFA, Bhubaneswar
Dr. P. Vijaya Gopal, PS, ICAR- CMFRI, Kochi
Dr. Joe Kizhakudan, PS, ICAR- CMFRI, Chennai

The Assistant Finance &Accounts Officer, ICAR-IIHR, Bengaluru

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
Smt. V. Usharani, AAO
Shri. P. Srikanth, Junior Accounts Officer

Non-Official Members

Sh. S. Satish Kumar
Sh. R.P. Venkatachalam

The 47th IMC meeting held on 18th June 2016 & 48th IMC Meeting held on 27th January 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

(Shri P. Srikanth, UDC, Member, IJSC is also a member of CJSC of ICAR)

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 Members	Dr. J. Syama Dayal, P.S & Dr. Nila Rekha, P.S
Technical Member	Dr. A. Nagavel, Senior Technical Officer
Administrative Members	Mrs. Usha Rani, A.A.O & Shri P. Srikanth, J.F.A.O Shri. A. Manoharan, Assistant
Supporting 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. K. Vinaya Kumar Shri. S. Nagarajan Smt. E. Mary Desouza
External Member	Dr. Lita Sunder, Madras Christian College

WOMEN'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

Member, Scientific Advisory Committee for Dr.Perumal Krishi Vigyan Kendra.

Executive Committee Member - National Centre for Sustainable Aquaculture (NaCSA).

Member, Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur.

Member, State Level Committee on Animal Genetic Resources (SLCAnGR), 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, Advisory Committee on Hilsa Conservation and Research.

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, DAHDF, Govt. of India, New Delhi.

Member, Coastal Aquaculture Authority, Chennai.

Member, Governing Body of State Fisheries Resource Management Society (FIRMA), Thiruvananthapuram.

Member, Society for Fisheries Technologists.

Member, Marine Biological Association of India.

Member, Advisory Board for Fisheries Sector Development, Planning Department, Govt. of Andhra Pradesh.

Member, Project Monitoring Committee for monitoring the project works related to setting up of the Specific Pathogen Free Shrimp Seed Multiplication Centre at Sompeta Mandal of Srikakulam District in Andhra Pradesh.

Member, Working Group, ESSO-NIOT.

Member, Project Screening Committee for operation of SPF Shrimp Broodstock Multiplication Centre (BMC), DAHDF, Govt. of India, New Delhi.

Member of Faculty, Board of Studies of Cochin University of Science and Technology (CUSAT), Kochi.

Member, Technical Committee for setting up Multiplication Centre for SPF *P.monodon,* DAHDF, Ministry of Agriculture, Govt. of India.

Chairman, Technical Evaluation Committee (TEC) for evaluating multispecies marine finfish hatchery at Pamanji-ESSO NIOT.

Member, Sub-Committee to review and update the guidelines for import of ornamental fishes, Ministry of Agriculture and Farmers Welfare, DAHDF, Govt. of India, New Delhi.

Member, Committee to review issues related to the Guidelines on Best Management Practices for Aquaculture, Ministry of Agriculture & Farmers Welfare, Department of Animal Husbandry, Dairying and Fisheries, Govt. of India, New Delhi.

Member, High Power Society "Society for Promotion of Shrimp Farming in Punjab", Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, Punjab.

Member, State-wise Coordination Committees for doubling Farmer's income by March, 2022, ICAR, New Delhi.

Member, Society of Aquaculture Professionals.

Member, Society of Coastal Aquaculture and Fisheries.

Member, International Steering Committee of ASA: ICCB for the International Conference on "Climate change adaptation: Ecological sustainability and resource management for livelihood security,

Andaman Science Association, Port Blair.

Member, National Advisory Committee: Aquatic Virology for the International Conference of Indian Virological Society (IVS) on "Global Perspectives in Virus Disease Management", IIHR, Bangalore.

Member, Scientific Committee of the International Conference on Climate Change and Sustainable development, Annai Fathima College of Arts and Science, Madurai.

Member, Advisory Board for "Second National Students Convention on Innovative approaches for academic excellence in higher fisheries education", ICAR-CIFE, Mumbai.

Member, International Advisory Committee for the International Symposium on "Aquatic Animal Health and Epidemiology for Sustainable Asian Aquaculture", organized by NBFGR, Lucknow and AFS, Mangalore.

Other Staff of CIBA

Expert Member, Committee, Coastal Aquaculture Authority to suggest suitable recommendations for amending the CAA Rules, 2015 and guidelines issued thereunder to facilitate implementing them at field level. - M. Muralidhar

Member, Technical and Inspection Committee for regulating establishment and operation of SPF shrimp broodstock multiplication Centres in the coastal areas, Depart of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Family Welfare, Government of India - M. Muralidhar

Sectional Committee Member, Bureau of Indian standards and working for the development of ISI standard for fish and shrimp feeds – K.Ambasankar

Principal Member, Fish and Fisheries and Aquaculture Sectional committee FAD 12 of BIS - K.Ambasankar

Principal Member, Aquaculture Sub-committee under FAD 12.1 of BIS - K.Ambasankar

Resource person, Meeting on 'Aquaculture Insurance' organized by the NFDB, at Hyderabad on 10.08.2016.- M.Kumaran

Expert Member, Scientific Advisory Committee meeting of KVK, Tirur, TNAU, Tiruvallur district on 24.08.2016.- M.Kumaran

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

Member, ICAR Regional Committee No. II - T.K.Ghoshal

Member, Scientific Advisory Committee of Ramakrishna Ashram Krishi Vigyan Kendra, Nimpith - T.K.Ghoshal

Member, Scientific Advisory Committee of Sasya Shyamala Krishi Vigyan Kendra, Narendrapur - T.K.Ghoshal

Nominated to attend a meeting at CAA, Chennai for STANDARD OPERATING PROCEDURE (SOP) FOR AQUATIC QUARANTINE OF SPECIFIC PATHOGEN FREE (SPF) SHRIMP PARENT POST LARVAE (PPL) on 26th May 2016 - S.K.Otta.

Inspection committee of CAA for Inspection of hatchery applied for import of broodstock and seed production of SPF *P. vannamei* at Porbandar District of Gujarat, 7th October, 2016 – Dr. C. Gopal.

Inspection committee of CAA for Inspection of hatcheries applied for import of broodstock and seed production of SPF *P. vannamei* at East Godavari District of Andhra Pradesh, from 28th to 29th Septrember, 2017– Dr. Shyne Anand.

Inspection committee for Inspection of hatchery applied for import of broodstock and seed production of SPF *P. vannamei* at Porbandar District of Gujarat, 15th to 16th March, 2017 – Dr. C. Gopal.

Swachhta Pakhwada Programmes organised by ICAR-CIBA

ICAR-CIBA actively contributed to the Clean India Mission by organising several cleanliness campaign and awareness program for the school students and general public during Swachhta Pakhwada during 16-31st October, 2016. The villagers and students were sensitized the importance of sanitation, personal and environmental hygiene, nature and natural resource management, water harvesting and conservation, self-help principles and health aspects. Cleaning materials such as broom sticks, dustbins, buckets, mugs etc., were distributed to the school and self-help groups to create awareness. Swachhta Pledge was taken by staffs of ICAR-CIBA on 17th October 2016.

Cleanliness Campaigns Organised by ICAR-CIBA

1. On 20th October 2016 at Govt. Middle School, Kokilamedu village, Kanchipuram District, Tamil Nadu
2. On 22nd October 2016 at SenjiammanNagar and Avarikadu villages, Tiruvallur district, Pulicat, Tamil Nadu
3. On 25th October 2016 at T. KulathurVillage, Chitamur block, Kanchipuram district, Tamil Nadu
4. On 26th October 2016 at KRC campus premises, West Bengal
5. On 27th October 2016 at Ganeshnagar, P.S. Namkhana, South 24 Parganas district, West Bengal
6. On 28th October 2016 at Madhabnagar under Patharpratima block of Sundarban, West Bengal
7. On 31st October 2016 at MES of CIBA, Muttukadu, Tamil Nadu

Cleanliness campaigns at T. Kulathur Village, Kanchipuram district, Tamil Nadu

Cleanliness campaigns at Headquarters, ICAR-CIBA

Distinguished visitors

Headquarters

Sl. No	Details of visitors	Date of visit
1	Dr. Ajith Sinha Patil, President of the Maharashtra Aquafarmers Association, Mumbai	26.04.2016
2	Dr. P. Ravichandran, Member Secretary, Coastal Aquaculture Authority, Chennai	16.06.2016
3	Shri Tarun Kumar Singh, Department of Animal Husbandry, Dairying & Fisheries, Government of India, New Delhi	16.06.2016
4	Mr. K. Nanjapathi, Yoga guru	21.06.2016
5	Dr. Subash Rau MD, DNB, MRCP (UK)	
6	Dr. P.G. Chengappa, Vice-Chancellor (Retd.), University of Agricultural Sciences, GKVK Campus, Bangaluru	16.07.2016
7	Dr. B.K. Das, Director, CIFRI, Barrackpore	18.08.2016
8	Dr. V. V. Sugunan, Senior Consultant from NFDB, Hyderabad	18.08.2016
9	Dr. Utpal Sar, Executive Director, NFDB, Hyderabad	18.08.2016
10	Mr. Elias Sait, Secretary General, Seafood Export Association of India	18.08.2016
11	Shri. Suresh Babu, Ernakulam Dist., Kerala	27.08.2016
12	Mr. Ramachandran, Chief Finance Officer (CFO), M/S Hatsun Agro Products Ltd	29.08.2016
13	Dr. P. Ravichandran, Former Member Secretary, Coastal Aquaculture Authority, Chennai	17.09.2016
14	Dr. V. Selvam, Executive Director, MSSRF, Chennai	17.09.2016
15	Mr. J. Sivagnanam, Progressive Aqua Farmer, Chennai	03.10.2016
16	Dr. Baskaran Manimaran, Former Vice-Chancellor, Tamil Nadu Fisheries University, Chennai	05.10.2016
17	Dr. R. Jayaraman, Director, Coastal Aquaculture Authority, Chennai	05.10.2016
18	Dr. Aniket Sanyal, Joint Director, IVRI	16.11.2016
19	Dr. B.P. Srinivasa, Principal Scientist, IVRI, Bengaluru	16.11.2016
20	Dr. J. Mohanty, Principal Scientist, ICAR-CIFA, Bhubaneswar	16.11.2016
21	Mr. Murari, IAS (retd) Advisor to FICCI	27.02.2017

22	Mr. Rajiv Bhatia, Former Ambassador	27.02.2017
23	Mr. Ar Rm Arun, Chairman-FICCI-Tamil Nadu State Council & Chairman, Valingro Group	27.02.2017
24	Dr. M. Sakthivel, Founder, Aquaculture Foundation India	27.02.2017
25	Smt. J. Mercykutty Amma, Honourable Minister of Fisheries, Harbour Engineering and Cashew Industries, Govt. of Kerala	13.02.2017
26	Dr. Karthikeyan, IAS, Director of Fisheries, Kerela	13.02.2017

Kakdwip Research Centre

Sl. No	Details of visitors	Date of visit
1.	Mr. Prakash Thakur, Assistant Director, EPF	18.09.2016
2.	Dr. Sankha Chakraborty, Assistant Director of Fisheries (Brackishwater)	20.10.2016
3.	Mr. Prasanta Chatterjee, Subject Matter Specialist (Fisheries), KVK	20.10.2016
4.	Dr. B. K. Das, Director, ICAR-CIFRI, Barrackpore	21.11.2016
5.	Dr. V.V. Sugunan, Senior Consultant, NFDB, Hyderabad	28.11.2016

Personnel

Director: Dr. K. K. Vijayan

Headquarters

Head of Divisions

Dr. C. Gopal, Principal Scientist & Head, Crustacean Culture Division
Dr. G. Gopikrishna, Principal Scientist & Head, Nutrition, Genetics & Biotechnology Division
Dr. S. V. Alavandi, Principal Scientist & Head, Aquatic Animal Health and Environment Division

Principal Scientists

Dr. K. P. Jithendran
Dr. V. S. Chandrasekaran
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. Akshaya Panigrahi
Dr. M. Kumaran
Dr. (Mrs.) M. Poornima
Dr. (Mrs.) R. Saraswathy
Dr.M.Makesh

Senior Scientists

Dr. Prasanna Kumar Patil
Dr. (Mrs.) Sherly Tomy
Dr. Subhendu Kumar Otta
Dr. K. P. Kumaraguru Vasagam
Dr. Satyanarayan Sethi
Dr. (Mrs.) P. Mahalakshmi

Scientist (Senior Scale)

Shri Ashok Kumar Jangam

Scientists

Dr. K. Vinaya 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. (Mrs.) Vidya Rajendran
Dr. Satheesha Avunje
Shri K. P. Sandeep
Mrs. M. U. Rekha
Ms. Babita Mandal
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.I.F. Biju
Smt.Mary Lini

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
Dr. A. Nagavel
Shri R. Subburaj
Shri S. Nagarajan
Shri S. Rajamanickam

Technical Officers

Shri N. Ramesh (Promoted w.e.f. 06.08.2015)
Shri S. Saminathan (Promoted w.e.f. 18.01.2016)
Shri N. Jagan Mohan Raj (Promoted w.e.f. 15.02.2016)
Shri R. Balakumaran (Driver) (Promoted w.e.f. 29.06.2016)

Senior Technical Assistant

Shri D. M. Ramesh Babu
Shri G. Thiagarajan
Shri K. Paranthaman (Driver) (Promoted w.e.f. 01.01.2016)

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. G. Ramesh (Relieved on 31.10.2016 on promotion as Administrative Officer to ICAR-IIHR, Bangalore)
Shri R. Kandamani
Mrs. V. Usharani

Junior Accounts Officer

Shri P. Srikanth

Personal Assistants

Mrs. S. Nalini
Shri K. G. Gopala Krishna Murthy

Assistants

Shri S. Pari
Shri A. Manoharan
Mrs. E. Amudhavalli
Shri A. Sekar

Stenographer Gr. III

Mrs. K. Hemalatha
Mrs. K. Subhashini

Upper Division Clerks

Mrs. E. Mary Desouza
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 M. Santhosam (Retired on 30.06.2016)
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. Raghu
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

Kakdwip Research Centre
Principal Scientists

Dr. T. K. Ghoshal
Dr. Debasis De

Senior Scientist

Dr. Sanjoy Das

Scientists

Dr.Gouranga Biswas
Dr. Prem kumar
Ms. Christina Lalramchhani

Technical Officer

Shri P. S. Samanta (Promoted w.e.f. 21.11.2015)

Senior Technical Assistant

Mrs. Chhanda Mazumder (Promoted w.e.f. 28.11.2015)

Administrative Staff
Private Secretary

Shri S. K. Halder

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

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

Infrastructure Development

1. Construction of compound wall at Headquarters, Chennai.
2. Construction of aquaculture laboratory for climate change workover the existing health laboratory at CIBA Headquarters, Chennai
3. Additional floor over the existing Trainees Hostelwas constructedat CIBA Headquarters, Chennai.
4. Old PVC/ mosaic flooring in various laboratory/ rooms and corridor were replaced with vitrified tiles at Headquarters, Chennai.
5. A semi-permanent shed over the parking area at CIBA, Headquarterswas completed at R.A.Puram, Chennai – 28.
6. Repair and renovation of the Wet Lab at Headquarters, Chennai.
7. Provision of energy saving 40-45W LED street light fitting at Headquarters, Chennai.
8. Supply, installation, testing and commissioning 200 KVA and 75 KVA generator at fish hatchery at CIBA, Muttukadu.
9. Supply, installation, testing and commission of 200 KVA and 75 KVA generator at shrimp hatchery at CIBA, Muttukadu.
10. Underground sump of 50-ton capacity was constructed at experimental station of CIBA, Muttukadu.
11. Renovation of existing electrical supply to pumps, aerators, water supply systems, farm lighting,etc. in Sector- C of Regional Center of CIBA, Kakdwip.
12. Construction of compound wall and fencing in Sector- C of Regional Center of CIBA, Kakdwip.
13. Repair and replacement of electrical wirings in the farm area (Sector-A), providing transformer between A and B sector and electrical load distribution works in the office building of Regional Center of CIBA, Kakdwip.
14. Installation of (a) H.T. Oil Circuit Breaker/ Switchgear, (b) Transformer/ Switchgear/Meter room and (c) Transformer & H.T. Oil switch Meter & transformer room for enhancement of power load from 50 KVA to 200 KVA at Regional Center of CIBA, Kakdwip.
15. Constructionof substation at Regional Center of CIBA, Kakdwip.
16. Desilting of ponds and laying brick pitched road around Sector- C of Regional Center of CIBA, Kakdwip.
17. Constructionof trainee's hostel at Regional Center of CIBA, Kakdwip.
18. Construction of brick laying (inside walls) of pond dykes in B section at Regional Center of CIBA, Kakdwip.

Library and Documentation

a. Library holdings

CIBA Library currently holds 2,671 books, international and national journals at Headquarters, Chennai and Kakdwip Research Centre of CIBA in West Bengal. The details of library holdings as on 31.03.2017 are provided in the diagram.

b. Library and e-Resource Centre

CIBA Library has been upgraded as Library and e-Resource Centre with five workstations having facility to access e-books, online journals, institute publications and scientist's 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 7 p.m. to enable students to use it effectively. This has been communicated to key colleges in and around Chennai.

c. Digital repository

Under this initiative, all the 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 source software) and linked to the international databases to facilitate visibility of CIBA research achievements across the globe.

d. On line access to the CIBA Subscribed & CeRA - journals and Document delivery service

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 library. The library section supplied photocopies of journal articles requested from various ICAR institutes, scientists and research scholars under CeRA-Document Delivery Request (DDR).

c. Exchange services

CIBA library maintained exchange relationship with national and international organizations working on fisheries and aquaculture on mutual interest. The library maintained free mailing of institute's annual report and other institute publications to various research organizations, universities and other agencies to give greater visibility to institute research and development programmes.

d. Information services to the stakeholders

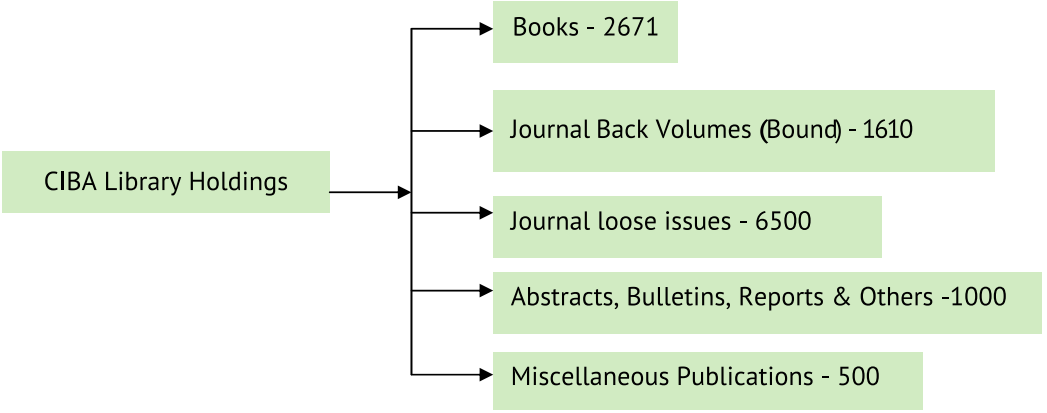
CIBA library acted as a reference library by providing access to the reference books and journals available in the library to the scientific personnel of other research organizations, academicians, university/college students, research scholars, stakeholders and other related visitors.

The library provided reprographic service (photocopying) to the users on nominal payment basis.

e. ISBN numbers

CIBA has obtained 50 ISBN numbers for five years from the Ministry of Human Resources Development for its publications. Six books have been allotted ISBN numbers as of March, 2017.

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, Sundarban, in West Bengal.

Honourable Minister of Fisheries, Govt of Kerala, Smt. J. Mercykutty Amma, visited ICAR- CIBA, Chennai on February 13th, 2017

Contact Address:

Headquarters

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▼

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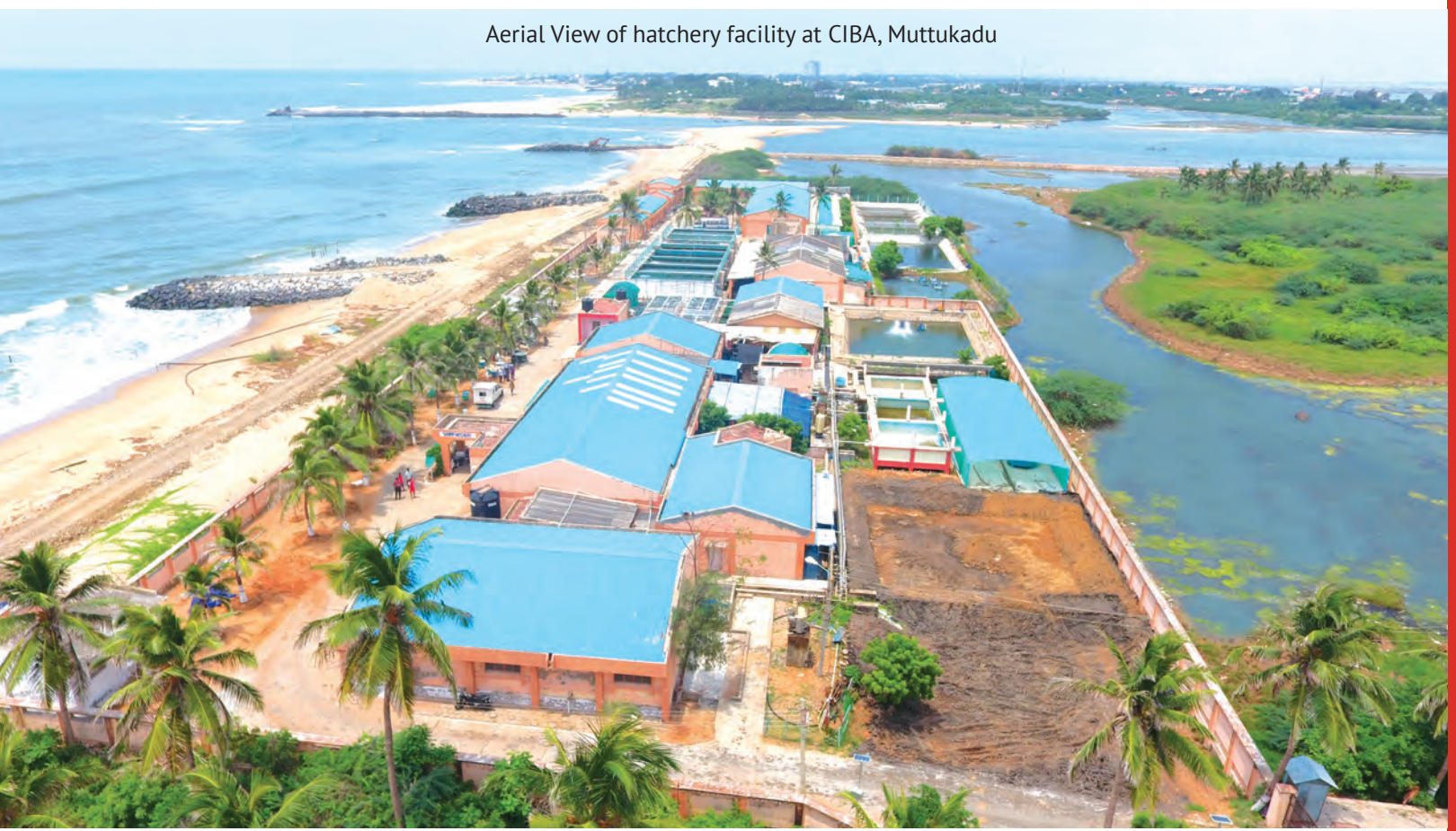
Tamil Nadu
Telephone : +91 44 27472344, 27472061

"Brackishwater aquaculture for food, employment and prosperity"

Pond reared mature Hilsa shad at Kakdwip Research Centre of CIBA, West Bengal

Aerial View of hatchery facility at CIBA, Muttukadu



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