ANNUAL REPORT

2018-2019



CIBA ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

वार्षिक प्रतिवेदन

ANNUAL REPORT
2018-19



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Preface



The year 2018-19 was remarkable for ICAR-CIBA with the conduct of a world conference on brackishwater aquaculture, BRAQCON 2019, a significant event in the context brackishwater aquaculture, food security and societal development. It was a unique platform that brought a large number of Indian and overseas researchers, academicians, farmers, and other private sector stakeholders. The BRAQCON has been conceived as a biannual world conference, that provide an excellent opportunity to exchange latest scientific information and ideas, and more importantly it represents a new and exciting chapter in the scientific journey of CIBA

Brackishwater aquaculture plays a significant role in the nutritional and financial security of the country. The major mandate of CIBA has been innovate, catalyse and transform the brackishwater aquaculture towards the goal of sustainability. In India, it has been almost synonymous to the aquaculture of Pacific white shrimp, *Penaeus vannamei*. After achieving a record growth in the farmed shrimp production, currently the industry has been facing a worst situation, due to multitudes of reason ranging from emergent disease to the low market rates. The institute has been addressing this issue holistically by developing diversified production systems and species, and formulating science based strategies for better biosecurity protocols. A cost effective biofloc based nursery system has been developed and demonstrated in Odisha and Andhra Pradesh. Within 28 days of rearing, animals reached almost 1 g with a survival of 94%. This intervention effectively reduced the total production cost

Diversification of species has been well acknowledged as an option for achieving sustainable development. As Indian brackishwater aquaculture heavily depends on a single exotic species, it is imperative to find a ‘deshi’ option to complement and to release the single species development. Indian white shrimp, *Penaeus indicus*, has been identified as the national priority species for domestication and genetic improvement. Demonstration trials have been carried out in the different agro climatic zones, and it is confirmed that growth and production of this species at lower and higher salinity regimes are similar. Further, we are a step closer to the domestication of *Penaeus indicus* by developing F0 generation, and

successfully producing F1 generation of *P. indicus* under captivity. A procedure for in vitro fertilization of *P. indicus* has been successfully developed, and it provides an opportunity to remove the barriers of natural mating in breeding programs as well as in the hybridization programs particularly in closed thelycum species.

The recycling of the waste in the fish market and landing centres into useful product is one of the efficient management measures to improve the ecosystem health and diversification of livelihood of coastal fishers. Almost 25 to 50% of fish in the fish markets becomes waste; the institute has made an efficient method to transform these wastes into a useful commercial product, a plankton booster ('Plankton ^{Plus}') in aquaculture ponds. By supplementing this product in shrimp ponds, significant improvement has been obtained in the average daily growth, specific growth rate, total biomass gain and survival even when 30% less feed was offered.

We are promoting community based brackishwater aquaculture in coastal states to improve the quality of rural life and diversifying the livelihood opportunities. In general, brackishwater aquaculture is considered to be high valued and cost intensive, and therefore, rural poor were excluded from the real benefits of this form food production system that theoretically offered

Deciphering draft genome sequence of organisms has major impact on multiple research fields, and it would provide knowledge on entire genetic architecture of their biology. Genetics and biotechnology group of CIBA was able to decipher about 73% of the genome of Indian white shrimp, *Penaeus indicus*, using Pacbio sequel technology. By the end of this year we expect that we would have a complete genome sequence of this species. This understanding would catalyse research progress in several fields of biology, particularly selective breeding program of this priority species.

We are promoting community based brackishwater aquaculture in coastal states to improve the quality of rural life and diversifying the livelihood opportunities. In general, brackishwater aquaculture is considered to be high valued and cost intensive, and therefore, rural poor were excluded from the real benefits of this form food production system that theoretically offered. We, in collaboration with Mangrove cell, Maharashtra have initiated three-tier seabass farming program such as nursery rearing, pre-grow out and grow out

culture in mangrove coastal ecosystem as a community based farming. It provides novel employment opportunity to the coastal communities.

Although most aquaculture production is devoted to food production, ornamental fish production for aquarium trade is an important and vibrant component of aquaculture world over. Whilst most aquarium trade focuses on freshwater species, there is a continued interest in developing new salt water species. During the last year our fish breeding group was successful in developing a captive rearing technology for an important brackishwater ornamental species, silver moony, *Monodactylus argenteus*. This is an important step for the transition of ornamental fish trade of this species from wild caught stocks to more sustainable breeding based mode.

One of the highlights of the year 2018-19 was our nutrition scientific team won the prestigious ICAR team award, Nanaji Deshmukh ICAR. The team has successfully developed indigenous feed processing technologies and cost-effective feeds for all the life stages of potential candidate brackishwater shell fish and finfish species cultured in India. The team could successfully downsize the commercial feed mill machinery and customize the requirements and processing conditions as per the demand of the clients. Extensive research on indigenous ingredients and the expertise on feed formulations could lead to the development of cost-effective sustainable feeds benefitting the small and medium aquaculture farmers in the country.

As a research and development organization, the success is measured by the output of the scientists who implemented the research projects. The current year, CIBA scientists published thirty nine research articles in reputed national and international journals. CIBA's Technology management unit has seen a significant success during this year. In order to expand the adaptation of research, technologies and intellectual assets, the institute has made 31 partnership agreements with private farmers, industry and government.

It has been greatly rewarding to serve as the Director of this prestigious Institute, and closely work with motivated and resourceful players. Looking back at what CIBA has done during the last one year makes me happy. Our contribution is tangible and visible, although we have a long way to go in the journey of sustainability. I look forward to have much greater achievements in multidisciplinary brackishwater aquaculture research. It will help us to evolve a sustainable aquaculture.

There is much beyond what I narrated in this brief preface, and this is only a snapshot of CIBA's achievements of the current year. I invite you all to peruse the full report in print or online. The following pages are the testimony for our combined and dedicated passion to provide scientific solutions for challenges and problems in the brackishwater aquaculture.

We are incredibly grateful to all the stakeholders who supported us. I am immensely grateful to Dr Trilochan Mohapatra, the Director General of ICAR and Secretary DARE without his professional support all these research performance and achievements would not have been possible. I am deeply indebted to Dr J.K. Jena, Deputy Director General (Fisheries) for his keen support, enthusiasm and timely help. I sincerely thank Dr Pravin Puthra, Assistant Director General (Marine Fisheries) for his continued support and guidance.



Dr K K Vijayan
Director

कार्यकारी सारांश

चालू वर्ष 2018-19 सीबा के लिए एक महत्वपूर्ण एवं फलदायक वर्ष रहा है। संस्थान, सतत खारा जलजीव पालन के विकास हेतु अनुसंधान एवं विकास कार्यों में संलिप्त है। संस्थानिक और बाहरी संगठनों द्वारा वित्तपोषित 29 अनुसंधान परियोजनाओं और अनेक आउटरीच गतिविधियों से सीबा ने खारा जलजीव पालन के विज्ञान में उल्लेखनीय योगदान दिया है। अनुसंधान और विकास संगठन होने के नाते इसकी सफलता और प्रभावकारिता को वैज्ञानिकों/अनुसंधानकर्ताओं के आउटपुट से तौला जाता है। चालू वर्ष में सीबा के वैज्ञानिकों ने विभिन्न प्रख्यात राष्ट्रीय और अंतर्राष्ट्रीय जर्नलों में सहकर्मी की समीक्षा वाले 39 अनुसंधान लेख प्रकाशित किए हैं। चालू वर्ष के दौरान स्टेकहोल्डरों से 31 वाणिज्यिक करारनामों पर हस्ताक्षर किए गए हैं। संस्थान ने अनुसंधान की गुणवत्ता को बनाए रखा और संस्थान को प्राप्त आईसीएआर का प्रतिष्ठित टीम एवार्ड, सीबा के मत्स्य पोषण प्रभाग को उत्कृष्ट अंतर्विषयक टीम के लिए नानाजी देशमुख आईसीएआर एवार्ड इसका प्रमाण है। सीबा के प्रधान वैज्ञानिक डॉ. एम. कुमारन को स्वामी सहजानंद सरस्वती उत्कृष्ट विस्तार वैज्ञानिक पुरस्कार प्राप्त हुआ। संस्थान की पिछले वर्ष की कुछ अनुसंधान एवं विकास की उपलब्धियों को नीचे दर्शाया गया है।

तालाब में संवर्धित इंडियन व्हाइट श्रिम्प स्टॉक का विकास

भारत में झींगा पालन, जो लगभग पूरी तरह विदेशी प्रजाति *पीनियस वन्नामेय* पर आधारित है, अब यह उभरते रोगों, घटती उत्तरजीविता दर, उत्पादन लागत में बढोत्तरी तथा हाल ही में मूल्यों में गिरावट के कारण चौराहे पर खड़ा प्रतीत होता है। इन स्थितियों में झींगा पालन की सततता बनाए रखने हेतु स्थानीय प्रजाति का विकास एक व्यवहारिक विकल्प है। भारतीय सफेद झींगा, *पी. इंडिकस* को पालतू बनाने एवं आनुवांशिक सुधार के लिए उपयुक्त प्रत्याशी किस्म के रूप में पहचान की गई। बंद/तालाब में संवर्धित *पी. इंडिकस* की प्रजनन संपदा के विकास हेतु प्रयोगात्मक परीक्षण किए गए, जो किसी भी चयन कार्यक्रम के लिए एक प्राथमिक आवश्यकता है। हैचरी में संवर्धित *पी. इंडिकस* के पोस्ट लार्वा को मिट्टी के तालाबों में ब्रूड स्टॉक (25-35 ग्रा.) तक पालन किया गया है, इन एफ0 पीढी का बंद स्थितियों के अंतर्गत सफलतापूर्वक प्रजनन कराया गया और एफ1 पीढी की संततियों को आगे पालन किया जा रहा है।

भारतीय सफेद झींगा (*पीनियस इंडिकस*) तथा मिल्कफिश (*चनोस चनोस*) का पॉलीकल्चर

जलजीव पालन संसाधनों में पोषण तत्वों को नष्ट होने से बचाने के लिए तथा कम लागत से झींगा पालन के लिए झींगों का पॉलीकल्चर एक व्यहार्य विकल्प प्रमाणित हुई है। *पी. इंडिकस*

(संग्रहण घनत्व : 25 पीएल/वर्गमीटर) और *सी. चनोस* (0.25 नग/वर्गमीटर और 0.5 नग/वर्गमीटर) के पॉलीकल्चर में उत्पादन संबंधी निष्पादन के मूल्यांकन हेतु एक 75 दिनों का प्रयोग किया गया। *पी. इंडिकस* के साथ मिल्कफिश (0.5 नग/वर्गमीटर) संग्रहीत तालाब में उच्चतम उत्तरजीविता (79.33±1.88%) तथा उत्पादन (1451.28±22.15 कि.ग्रा./हे.) दर्ज किया गया, तथापि 0.25 नग/वर्गमीटर संग्रहण घनत्व से संग्रहीत मिल्कफिश के तलाब में उल्लेखनीय रूप से उच्चतर औसत शारीरिक भार प्राप्त हुआ।

पीनियस वन्नामेय के लिए बायो-फ्लॉक आधारित संवर्धन प्रौद्योगिकी

पर्यावरण अनुकूल जलजीव पालन की दिशा में बायो-फ्लॉक प्रौद्योगिकी एक उभरता विकल्प है। जल विनिमय कम होना, घटता आहार उपयोग तथा उन्नत जैवसुरक्षा इस प्रौद्योगिकी की विशेषता है। *पीनियस वन्नामेय* पीएल को 28 दिनों तक 3500 पीएल/वर्गमीटर संग्रहण घनत्व की दर से संस्थान द्वारा विकसित 350 मेट्रिक टन क्षमता वाले नर्सरी टैंक में संवर्धन किया गया। नर्सरी में पालित जीवों का शारीरिक भार 0.92±0.15 ग्रा. तथा उत्तरजीविता दर 94.20±2.86% दर्ज की गई।

आरएएस इन्वीरॉनमेंट में वृद्धि निष्पादन, जलीय गुणवत्ता और प्रतिरक्षा प्रतिक्रियाओं पर एक्वा-मिमिक्री का मूल्यांकन

कार्बन स्रोत को उपलब्ध कराते हुए एवं पूरक आहार के रूप में रोटीफर देते हुए एक आरएएस आधारित नर्सरी संवर्धन कार्य किया गया। प्रत्येक उपचार में 15 दिनों के अंतराल पर उत्तरजीविता एवं वृद्धि की लनगरानी की गई। उपचारों में सी : सामान्य, टी**1** : केवल बायो-फ्लॉक, टी**2** : बायो-फ्लॉक एवं रोटीफर, टी**3** केवल रोटीफर सम्मिलित है। प्रयोग के अंत में बायो-फ्लॉक के साथ रोटीफर की स्थिति बेहतर वृद्धि (3.89±0.25) और उत्तरजीविता (91%) दर्शायी है जो सामान्य जीवों (3.24±0.29, 85%) से उल्लेखनीय रूप से भिन्न है।

विभिन्न लवणीय स्तरों में संवर्धित भारतीय सफेद तरूण झींगों का वृद्धि निष्पादन और परासारिता (आस्मोलारिटी)

विभिन्न लवणीय स्तरों में संवर्धित *पी. इंडिकस* के तरूण झींगो (0.4-0.5 ग्रा.) का वृद्धि निष्पादन, जलीय गुणवत्ता, परासारिता तथा सीरम मिनरल प्रोफाइल के अध्ययन हेतु एक 50 दिवसीय प्रयोग किया गया। परासारित अध्ययन से स्पष्ट हुआ है कि परिवेशी जलीय लवणता के साथ सीरम परासारिता अनुपातिक रूप से बदल जाता है।

आजीविका के रूप में ज्वारनदमुखी परितंत्र में *पीनियस इंडिकस* का नर्सरी संवर्धन

कलपक्कम (तमिलनाडु) के निकट उयलीकुप्पम गांव के स्वयं सेवी समूह के लिए भारतीय सफेद झींगा पीनियस इंडिकस के एक नर्सरी संवर्धन मॉडल का निरूपण किया गया। *पीनियस इंडिकस* (400 नग) के 1.5 ग्रा. भार वाले तरूण झींगों को 4 हापाओं (2 मी. X 1 मी. आमाप) में 60 दिनों तक संवर्धन किया गया। *पी. इंडिकस* झींगों का औसत भार 8.50 ग्रा. और 90% उत्तरजीविता प्राप्त हुई।

कीचड़ केकड़ों के पालन के लिए निमज्जित पिंजरा प्रणाली (सबमर्सीबल केज सिस्टम) का विकास

कीचड़ केकेड़े बेन्थिक जीव होते हैं, अत: पेलाजिक/तैरने वाले पिंजरें सापेक्षिक रूप से उच्चतर सतह और उपसतह के तापमान के कारण इन जीवों की कार्यिकी पर प्रतिकूल डालते हैं। उपसतह/तैरने वाले पिंजरों की पहलुओं के समाधान हेतु निमज्जित पिंजरों का विकास किया गया है। निमज्जित प्रणाली में शारीरिक भार का औसत लाभ >100 ग्रा. है जब कि तैरने वाली पिंजरा प्रणाली में यह कम (<15 ग्रा.) है, जिससे यह सूचित होता है कि परम्परागत तैरने वाली पिंजरा प्रणाली से निमज्जित प्रणाली बेहतर है। निष्कर्ष के रूप में कहा जा सकता है कि केकड़ों के विकास के लिए परम्परागत पद्धति की तुलना में निमज्जित सह तैरने वाले पिंजरों में केकड़ा पालन प्रणाली से उच्चतर वृद्धि प्राप्त होती है।

महाराष्ट्र के मैंग्रोव क्षेत्र में खुले जल में पिंजरा जलजीव पालन

मैंग्रोव सेल, महाराष्ट्र के सहयोग से सीबा ने स्वयं सेवी समूहों की प्रतिभागिता द्वारा सिन्धूदुर्ग में मैंग्रोव तटीय जल और आसपास के क्षेत्र में तीन चरणीय सीबास फार्मिंग प्रारम्भ किया। स्वयं सेवी समूहों की प्रतिभागिता से 6 नर्सरियां, एक प्रि-ग्रो-आउट तथा 33 ग्रो-आउट केज कल्चर तैयार किया गया। स्वयं सेवी समूहों ने सीबास नर्सरी तथा प्रि-ग्रो-आउट संवर्धन कार्य से कुल 3.16 लाख रूपयों का राजस्व अर्जित किया। ग्रो आउट पालन से आशा है कि 400-500 ग्रा. तक पालन किया जा सकता है और इसका आकलित राजस्व उत्पत्ति 10-12 लाख होगी।

सीबास और ग्रीन मसल्स का एकीकृत बहु-पोषी जलजीव पालन (आईएमटीए)

भारत के पश्चिमी तट में प्रत्याशी पखमीन एवं कवचमीन मछलियों के पारिवारिक उत्पादन मॉडल के विकास एवं प्रवर्धन हेतु मलवन, सिन्धूदुर्ग के गाद क्रीक में आईएमटीए प्रारम्भ किया गया। वर्तमान समय में सीबास मछलियां, संग्रहण आमाप 60 ग्रा. से बढ़कर 400 ग्रा. की हो गई हैं और इनकी उत्तरजीविता दर 79.30-90.03% है। सीबास की 400-500 ग्रा. की मछलियों की उपज मध्य जून, 2019 में प्राप्त होने की संभावना है और उत्पन्न कुल राजस्व का आकलन 2-2.5 लाख रूपए हैं।

रंगीन 'सिल्वरफिश' के रूप में तरूण मिल्कफिश

दुधिया सफेद भडकीला, चमकता शरीर, चपलता, अर्ध-पारदर्शी V आकार का पुच्छ पख, त्वरित गति से तैरने की पद्धति, व्यापक लवणता के प्रति सहिष्णुता, टैंक शैवाल का भक्षक और रोग प्रतिरोधी गुण तरूण मिल्कफिश मछलियों को संभावित रंगीन/अलंकारिक मछली बनाता है जिसे सिल्वरफिश कहा जाता है। अन्य रंगीन मछलियों के साथ सुसंगत के कारण इन मछलियां की एक जोड़ी मछलियों की कीमत 50-100 रूपए है।

पश्चिम बंगाल में डेक्कन हिल्सा के रूप में मिल्कफिश का उत्पादन

मिल्कफिश की मांग और स्थानीय बंगालियों की पसन्द पर विचार करते हुए सीबा ने पश्चिम बंगाल में मिल्कफिश को 'डेक्कन हिल्सा' के रूप लोकप्रिय बनाने का प्रयास किया। चार भिन्न पालन परितंत्रों में उत्पादन कर, 1.3 टन मिल्कफिश उपज प्राप्त किया गया जिसे बंगालियों ने डेक्कन हिल्सा के रूप में स्वीकार किया।

भारतीय झींगा पालन में फार्म निवेशों के उपयोग की पद्धति

वर्ष 2017 के दौरान झींगा उत्पादन वाले राज्यों आन्ध्र प्रदेश, तमिलनाडु, गुजरात और महाराष्ट्र में निवेशों के उपयोग की पद्धति जानने हेतु एक सर्वेक्षण किया गया। अध्ययन से ज्ञात हुआ है कि मृदा और जल की गुणवत्ता में सुधार हेतु बड़े पैमाने पर पर्यावरण संशोधकों का उपयोग किया जा रहा है और इसके बाद का स्थान प्रोबायोटिक्स (जल, मृदा और आंत प्रोबायोटिक्स) और निस्संक्रमकों का है। अध्ययन के दौरान सूक्ष्मजीव विरोधी उत्पादों के उपयोग संबंधी सूचनाएं नहीं मिली हैं।

तालाबों में हिल्सा मछलियों का ग्रो-आउट पालन

पश्चिम बंगाल में हिल्सा मछलियों के विपणन की अच्छी सम्भावनाएं हैं और खाने योग्य आमाप की मछलियों की भारी मांग है। दो माह आयु वाली अंगुलिकाओं पेल्लेटेड आहार के उपयोग से को दो भिन्न प्रणालियों जैसे मिट्टी के तालाब और आरएएस में आगे का संवर्धन किया गया। ग्यारह माह बाद मछलियों का आमाप 80 ग्रा. हो गया है और मिट्टी के तालाबों में निष्पादन बेहतर रहा है।

लवणता के प्रति धारीदार रेबिट फिश *सिगानस जावस* की व्यापक सहिष्णुता

तेज विकास दर, शाकाहारी आहार प्रवृत्ति तथा आर्थिक महत्व के कारण स्ट्रीक्ड स्पाइन फुट रेबिट फिश *सिगानस जावस* को महत्वपूर्ण खाद्य मछली माना जाता है। इन मछलियों की लवण सहिष्णुता जानने हेतु 30 दिनों का एक प्रयोग किया गया। इस प्रयोग से पहली बार

सिगानस जावस की व्यापक लवण सहिष्णुता का प्रलेखन किया गया, जो खारा जलजीव पालन के लिए एक संभावित शाकभोजी खाद्य मछली है।

नर *पीनियस इंडिकस* झींगों की प्रजनन गुणवत्ता

पेनोयड झींगों का शुक्राणु कोश और शुक्राणओं की गुणवत्ता अक्सर बीज उत्पादन की सफलता का विशेषकर बंद स्थितियों में, निर्धारण करता है। यह सूचना मिली है कि सामान्यत: बंद स्थितियों के अंतर्गत रिप्रोडक्टिव ट्रैक्ट का विकास तथा शुक्राणु कोश की उत्पत्ति बाधित होती है। जनन संबंधी विकास की प्रक्रिया के मूल सिद्धांतों के मूल्यांकन हेतु नर झींगों का मूल्यांकन टैंकों और तालाबों में किया गया और इनकी तुलना वन्य रूप से प्राप्त झींगों से की गई। वन्य रूप से प्राप्त झींगों की तुलना में टैंकों और तालाबों में संवर्धित झींगों में शुक्राणुओं की संख्या काफी कम पायी गयी।

पीनियस इंडिकस की शुक्राणु कोश गुणवत्ता पर अल्पकालिक शीत भंडारण का प्रभाव

नर युग्मकों (गैमीट) के भंडारण से कृत्रिम निषेचन हेतु प्रजनकों के रखरखाव की समस्या हल हो सकती है। गुग्मकों, शुक्राणु कोश की गुणवत्ता पर शीत भंडारण के प्रभाव को मूल्यांकित करने हेतु इन्हें 4^0 से. के तापमान पर संग्रहीत किया गया और भिन्न भिन्न अंतरालों पर इनका मूल्यांकन किया गया। पांचवे दिन के नमूने की तुलना में प्रथम दिन के नमूने में सामान्य शुक्राणु काफी अधिक पाए गए। पांच दिनों के परिरक्षण में भंडारित शुक्राणु कोश में एक्रोसोम प्रतिक्रियाएं देखी गईं। पांच दिनों के बाद शुक्राणु कोशिकाएं विघटित होने लगी हैं और जीविष्णुता (वयाबिल्टी) भी नही देखी गई। इस अध्ययन से शुक्राणु कोश के परिरक्षण पद्धति में शीत भंडारण की प्रयोजनीयता प्रमाणित होती है।

भारतीय सफेद झींगा *पीनियस इंडिकस* का कृत्रिम परिवेशीय निषेचन और संकरण क्षमता

पेनोयड झींगों के कृत्रिम परिवेशीय निषेचन पद्धति का सफलतापूर्वक विकास किया गया। पी. इंडिकस का अंत: विशिष्ट निषेचन में सफलता प्राप्त की गई जिसमें निषेचन दर 4.8% और 29% नौप्ली को पोस्ट लार्वा में विकसित किया गया।

पीनियस इंडिकस के बंदी प्रजनकों की शारीरिक विशेषताओं पर विभिन्न आहारीय व्यवस्थाओं का प्रभाव

बंद स्थितियों के अंतर्गत *पी. इंडिकस* को परिपक्वन आहार (प्रतिदिन शारीरिक भार का 5%, 10% तथा 25%) तथा बंद स्थितियों में पालन से होने वाले शारीरिक बदलाव जैसे वृद्धि, मोल्टिंग रिदम तथा परिपक्वन हार्मोन स्तर पर प्रभाव के मूल्यांकन हेतु यह अध्ययन किया गया। झींगों को शारीरिक भार के15% आहार दिए जाने वाली समूह में मोल्टिंग आवृत्ति

अधिक पायी गयी। आगे 45 दिनों के बंद स्थितियों में पालन से इस समूह में न्यूनतम GIH mRNA पाया गया।

सीबास बीज उत्पादन की नई ऊंचाईयां

सीबा, बंद प्रजनन और सीबास बीज उत्पादन में अग्रणी है, हाल ही में बंद स्थितियों में प्राकृतिक अंडजनन प्रोटोकॉल को मानक बनाया है। पिछले वर्ष जनित 5**.53** मिलियन अंडों में से 2.66 मिलियन अंडों का स्वाभाविक अंडजनन तथा 2.87 मिलियन अंडों का प्रेरित अंडजनन हुआ। वर्ष 2018-19 में एक सर्वकालिक उच्च**,** 0.59 मिलियन पोनों को बेचा गया जिससे 1.72 मिलियन का राजस्व प्राप्त हुआ। इसके अतिरिक्त, 1.20 लाख बीजों को कृत्रिम आहार के पूरी तरह अलग करके महाराष्ट भेजा गया।

मिल्कफिश (*चनोस चनोस*) के दो भिन्न भौगोलिक सम्पदाओं के प्रजनन का निष्पादन

पूर्वी तट से पृथक किए गए मिल्कफिश के दो भौगोलिक सम्पदाओं की जनन क्षमताओं की तुलना में, चेन्नई की सम्पदा का निष्पादन बेहतर पाया गया जिसमें अंडजनन का विस्तारित अवधि देखी गयी। दोनों की सम्पदाओं में एक से अधिक अंडजनन हुआ और बंद स्थितियों में मिल्कफिश का वर्षभर प्रजनन का अवसर देखा गया।

प्रक्षेत्र में पालित पैतृक सम्पदा के उपयोग से ग्रे-मुल्लेट के बंद प्रजनन में अच्छी प्रगति

वर्ष 2017 में मुल्लेट का अंडजनन हुआ और पहली बार अंडों का निषेचन हुआ, परन्तु लार्वा केवल 8 दिनों तक जीवित रहें हैं, तीव्र प्रयासों बृहत स्तर पर 0.75 मिलियन लार्वा का उत्पादन किया गया। लार्वा 28 दिनों तक जीवित रहें हैं। आगे लार्वा संवर्धन के अनुकूलन कार्य प्रगति पर है।

तालाब की स्थितियों में संवर्धित *लिजा पार्सिया* का परिपक्वन

लिजा पार्सिया की प्रजनन परिपक्वता के लिए 300 मछलियों पर एक प्रयोग किया गया, जिसमें अनुकूलतम जल की गुणवत्ता और आहार से बंद स्थितियों में परिपक्वता का प्रमाण मिलें हैं। प्रजनन परिपक्वता के लिए 300 नंबर लिजा परसिया (गोल्ड्सपोट मलेट) के साथ किए गए एक अध्ययन ने इष्टतम पानी की स्थिति और फ़ीड के साथ कैप्टिव परिपक्वता की आसानी का सबूत दिया। अंडाणु जिनका व्यास 100 μm से भी कम है, वे प्रकृति से नॉन-विटेल्लोजेनिक होते हैं और बंद स्थितियों में अधिकतम जीएसआई और अंडाणुओं का व्यास क्रमश: 606.55±17.02 और 18.31±2.0 प्राप्त किए हैं। इस अध्ययन से प्रमाणित होता है कि *लिजा पार्सिया* के प्रजनकों को आसानी से तालाब की स्थितियों में विकसित किया जा सकता है।

मैंग्रोव स्नेप्पर का बंद स्थितियों में परिपक्वता की अच्छी प्रगति

मैंग्रोव स्नेप्पर के बंद प्रजनन प्रौद्योगिकी को लक्ष्य बनाकर, 90 वयस्क मछलियों का ब्रूडस्टॉक होल्डिंग सिस्टम में रखरखाव किया जा रहा है। जून से अक्टूबर, 2018 तथा फरवरी से मार्च, 2019 के दौरान स्रावी नर मछलियों को देखा गया, जिससे सूचित होता है कि 8-21% नर मछलियां परिपक्वता प्राप्त कर रहीं हैं। तथापि, मादा परिपक्वन प्राप्त नहीं हुआ है और अंडकों के विकास के संकेत मिलें हैं।

आरएएस आधारित होमस्टेड फिश ब्रीडिंग मॉडल में स्पॉटेड स्काट की प्रेरित परिपक्वता और अंडजनन

स्पॉटेड स्काट के प्रजनन को सरल बनाने हेतु 3000 ली. क्षमता, सेन्द्रल ड्रैनेज सिस्टम तथा 12.9 घनमीटर/प्रतिदिन प्रवाह दर वाला एक आरएएस तैयार कर उसमें प्रयोग किया गया। वयस्क स्काट मछलियों हार्मोनों के भिन्न खुराकों तथा संयोजनों से प्रेरित किया गया। मादा मछलियों LHRHa 25 µg/कि.ग्रा./माह से सफलतापूर्वक प्रेरित हुईं जब कि नर मछलियों में LHRHa + 25 + 25 µg/कि.ग्रा./माह की दर से 17-αMT के मिश्रित खुराक से शुक्राणु घनत्व में वृद्धि में सहायता मिली है। आरएएस आधारित होमस्टेड मॉडलों में इन अनुकूलित खुराकों से अंडजनन और लार्वा उत्पादन में सहायता मिलेगी।

सिल्वर मूनी *मोनोडेक्टीलस अर्जेन्टियस* का बंद प्रजनन

हार्मोनल प्रेरण से संभावित खाराजलीय रंगीन मछली का बंद प्रजनन और बीज उत्पादन प्राप्त किया गया। निषेचन 18 घंटों में हुई और अंडों का व्यास 860±14.11 µm तथा निषेचन दर 90% रही है। नव विकसित लार्वा की लम्बाई 1.60-1.67 मि.मी. पायी गयी। वन्य रूप से प्राप्त मछलियों से हटकर बंद प्रजनन से निर्यात के लिए व्यापक उत्पादन का मार्ग प्रशस्त करेगा।

भारतीय झींगा पालन के लिए डब्ल्यूएसएसवी, ईएचपी और आईएमएनवी के बड़े खतरे

वर्ष 2015-19 के दौरान झींगा प्रक्षेत्रों में रोगों की सक्रिय निगरानी में पाया गया है कि झींगा उत्पादन करने वाले दो प्रमुख राज्यों तमिलनाडु और प्रदेश में व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्सूएसएसवी) तथा एन्टेरोसाइटोजून हेपाटोपेनेय (ईएचपी) प्रमुख रोगजनक हैं। डब्ल्सूएसएसवी का फैलाव 11-40% और ईएचपी का फैलाव 21-43% है। वर्ष 2018-19 के दौरान संक्रामक माइवनक्रोसिस वायरस (आईएमएनवी) एक और चुनौती के रूप में उभरी है, जिसका फैलाव 15% है।

पॉलीकीट कृमियों के माध्यम से झींगों में *एन्टेरोसाइटोज़ून हेपाटोपेनेय* संक्रमण

सीबा के अध्ययनों से स्पष्ट हुआ है कि डब्ल्सूएसएसवी और ईएचपी जैसे रोगजनकों को झींगों तक पहुंचाने में वॉलीकीट कृमियां वाहक की भूमिका निभाते हैं। ईएचपी क्षैतिज रूप से फलती है, संक्रमित झींगों से पॉलीकीट में और पॉलीकीट से झींगों में। तथापि पॉलीकीट के विभिन्न विकासात्मक अवस्थाओं में ऊर्ध्वाधर संचरण के प्रमाण नहीं मिले हैं।

परवेशी तापमान पर समुद्री जल में ईएचपी के बीजाणु एक वर्ष तक संक्रामक रहते हैं

समुद्री जल में परवेशी तापमान पर ईएचपी के बीजाणुओं की संक्रमणता एक वर्ष से अधिक समय तक रहती है। इस प्रकार की भंडारण स्थितियों में सक्रियता डेढ वर्ष बाद छूटी है। तथापि 40 से., -200 से., तथा -800 से में भंडारित बीजाणु में, एक माह के बाद बजाणुओं की व्यवहार्यता पूर्ण रूप से नष्ट और संक्रमणता नाटकीय रूप से कम हो गयी है।

ईएचपी बीजाणुओं के उद्भेदन (जर्मीनेशन) को प्रयोगात्मक तौर पर प्रेरित किया जा सका है।

पोटाशियम हाइड्राक्साइड तथा फ्लोक्साइन जैसे डाइस के उपयोग से ईएचपी बीजाणुओं के उद्भेदन को प्रेरित किया गया। उद्भेदन की सम्पूर्ण क्रिया दो क्षण से भी कम समय में पूर्ण हो जाती है। उद्भेदित बीजाणु कोशिका को भेद कर और अपनी झिल्ली को चुभोकर आस-पास के संभावित मेजबान कोशिका को संक्रमित करती है।

झींगों में डब्ल्यूएसएसवी का ऊर्ध्वाधर संचरण

प्रयोगात्मक रूप से संक्रमित *पीनियस इंडिकस* में, डब्ल्यूएसएसवी संक्रमित गर्भाशय कोशिकाओं में वीपी28 प्रोब के प्रति प्रतिक्रियात्मक इंट्रान्यूक्लीयर बॉडीस देखा गया है जिससे स्पष्ट होता है कि डब्ल्यूएसएसवी के निम्न स्तर का संक्रमण से भी ऊर्ध्वाधर संचरण की सम्भावना होती है।

अन्ध्र प्रदेश में कीचड़ केकड़ों *स्काइला सेर्राटा* की खेती में व्यापक मार्त्यता

वर्ष 2018 में आन्ध्र प्रदेश राज्य में कृष्णा जिले के नागयालंका में कीचड़ केकड़ों की खेती में बड़े पैमाने पर मृत्यु दर देखी गई। मृत केकड़ों व्हाइट स्पॉट सिड्रोम वायरस के प्रति समारात्मक पाए गए। उनमें मेटाजोन क्रस्टासियन पारासाइट, स्टाल्क्ड बार्नेकल, ओक्टोलास्मिस एसपीपी का भी भारी संक्रमण पाया गया। स्वस्थ तालाबों की तुलना में संक्रमित केकडों के हेमोलिम्प में कुल प्लेट काउंट और कुल वाइब्रियो काउंट में वृद्धि देखी गई।

सीबास में तिलापिया लेक वायरस (TiLV) का संचरण

तिलापिया के साथ सीबास की खेती वाले प्रक्षेत्रों में रोग निगरानी के दौरान, सीबास में TiLV से प्रभावित हेमोरहेजिक एनसेफालिटिस से जुड़ी क्रोनिक मार्त्यता देखी गई। संक्रमित तिलापिया से सीबास में अंतर प्रजातीय संचरण के परीक्षण हेतु चुनौतीपूर्ण प्रयोग में देखा गया कि TiLV से सीबास में उच्च समुच्चय मृत्यु दर के साथ सफल संचरण हुआ है।

खाराजलीय पखमीन में परजीवीय संक्रमण

वर्ष 2016-19 के दौरान खाराजलीय प्रत्याशी मत्स्य प्रजातियों तथा केकड़ों के परजीवीय रोगों के प्रोफाइलिंग से ज्ञात होता है कि 6 प्रमुख परजीव जैसे *अर्गुलस, कैलीगस, लेरनानथ्रोपस, जेलानीकॉडेल्ला, अनिसाकिस* और *आक्टोलासमिस* मौजूद हैं। तथापि मलेट और मिल्कफिश में कोई परजीवीय संक्रमण दर्ज नहीं हुई है।

जोआ सिंड्रोम का मैक्रोबियल प्रोफाइलिंग

जोआ-2 सिंड्रोम की एटियालॉजी जानने के लिए मेटाजेनोमिक अध्ययन किया गया। समग्र रूप से स्वास्थ्य के लिए विशिष्ट 46 वंश, अस्वस्थता के लिए विशिष्ट 328 वंश तथा दोनों के लिए समान 371 वंशों को देखा गया। जोआ-2 से प्रभावित नमूनों में कुछ वंशों जैसे डेवोसिया, अवर्गीकृत रोडोबैक्टेरासी, नॉनलबेंस, मुरीकौडा, अवर्गीकृत फ्लावोबैक्टीरियलेस तथा सूडोआल्टेरोमोनास की प्रचुरता पाई गई।

सीबामाक्स का मैक्रोबियल प्रोफाइलिंग

16s rDNA आधारित मेटाजेनोमिक मैक्रोबियल प्रोफाइलिंग से स्पष्ट हुआ है कि नाइट्रोजन उपापचय में अनेक अनोखे जीवाणु सम्मिलित हैं। अमोनिया आक्सीकरण में *नाइट्रोसोमोनास* और *नाइट्रोबैक्टर* के अतिरिक्त काल्डीलिनिएसी कुल संबंधित जीवाणु समूह की भी आधिक्यता है। एओबी तथा एनओबी समृद्धता में पहचान की गई सूक्ष्मजीवों का बड़ा भाग *प्रोटियोबैक्टेरिया* समुदाय से संबंधित है।

वाइब्रियो हार्वेयी क्लेड में कोरम सेंसिंग सिस्टम का गुणचित्रण

विषैलेपन के समझने के लिए, वाइब्रियो हार्वेयी क्लेड के 60 जेनामों के कोरम सेंसिंग सिस्टम का गुणचित्रण किया गया। *वी. हार्वेयी* क्लेड के सभी पृथककरणों में आटोइनड्यूसर 2 सिंथेसाइजिंग *luxS* जीन मौजूद हैं। तथापि, *वी. हार्वेयी, वी. कैम्पबेल्ली, वी. जासीसिडा* और *वी. ओवेनसी* में आटोइनड्यूसर 1 सिंथेसाइजिंग जीन *luxM* मौजूद है परन्तु वी. *नेट्रीजेन्स* और *वी. रोटिफेरियानस* में गैर-मौजूद है।

व्यवहार्य और मृत ईएचपी बीजाणुओं में विभेद करने हेतु त्वरित पहचान करने की तकनीक

ईएचपी बीजाणुओं की व्यवहार्यता के मूल्यांकन के लिए एक अभिरंजन (स्टैनिंग) तकनीक का विकास किया गया। कैलकोफ्लूअर व्हाइट से अभिरंजित व्यवहार्य बीजाणु वायलेट फिल्टर (395-415 nm) में फिरोजा-नीले रंग में प्रतीत होता है। साइटाक्स ग्रीन से अभिरंजित मृत बीजाणु ब्लू एक्साइटेशन फिल्टर (470-490 nm) में पीले-हरे अंडाकार शरीर वाले तथा वायलेट फिल्टर (395-415) में सफेद-पीला प्रतीत होते हैं।

मछली में इरिडोवायरस संक्रमण की पहचान हेतु SYBR Green आधारित रियल टाइम पीसीआर परख तकनीक का विकास।

मछली में इरिडोवायरस संक्रमण की पहचान हेतु SYBR Green आधारित रियल टाइम पीसीआर परख तकनीक का विकास किया गया जिसकी पहचान करने की सीमा 10 वायरल अणु हैं। इरिडोवायरस पहचान करने हेतु एक मेम्बरेन कोफैक्टर प्रोटीन जीन आधारित पीसीआर का मानकीकरण किया गया।

वन्य *पीनियस इंडिकस* अंडजनकों में डब्ल्यूएसएसवी का मातृ संचरण (मेटर्नल ट्रासमिशन)

युग्मकों के माध्यम से प्रत्यक्ष रूप से डब्ल्यूएसएसवी का ऊर्ध्वाधर संचरण को प्रमाणित करना अभी बाकी है। इस कल्पना के परीक्षण के लिए, डब्ल्यूएसएसवी से संक्रमित मादा मछलियों के प्रजनन ऊतकों का क्यूआरटी पीसीआर के माध्यम से डब्ल्यूएसएसवी रोग की पहचान की गई और पाया गया कि प्रजनन ऊतकों में डब्ल्यूएसएसवी के 50 से 60 प्रतियां ही हैं, और संक्रमित मादाओं के 36% प्रजनन ऊतकों में ही डब्ल्यूएसएसवी की मौजूदगी देखी गयी। तथापि स्वस्थान पर संकरण अध्ययनों में डब्ल्यूएसएसवी के सकारात्मक संकेत नहीं मिले हैं।

अंतड़ियों के मैक्रोब्स का पृथक्करण तथा गुणचित्रण

बायोफ्लॉक प्रणाली लाभप्रद पाया गया और आंतिडयों क्षेत्र में लाभदायक बैक्टीरियो की उपनिवेशीकरण में सहायक होती है। कुल 94 नस्लों (स्ट्रेइन) की जांच की गई और पाया गया कि 36 नस्ल एमिलेज एंजाइम उत्पन्न करते हैं, 20 नस्ल प्रोटियेज, **27** नस्ल लिपेज, 6 नस्ल सेल्लुलेज और 8 नस्ल जइलानेज उत्पन्न करते हैं। कुल 21 वियोजको (आइसोलेट्स) को आगे की पहचान हेतु चयन किया गया और बायोफ्लॉक ट्रीटमेंट्स से *कोबेटिया, एक्सीगुओबैक्टेरियम, बेसिलस, मेरिनिलेक्टीबेसिलस, स्टाफाइल्लोकोकस* तथा *नोवोस्पिंगोबियम* के विभिन्न प्रजातियों की पहचान की गई। *बेसिलस* और

एक्सीगुओबैक्टेरियम के सामान्य नस्लों में ही देखा गया। इन सभी नस्लों में से, जीनस *एक्सीगुओबैक्टेरियम* की पहचान सभी ट्रीटमेंट्स और कंट्रोल में की गई।

जल विश्लेषण किट का वाणिज्यिकरण

विभिन्न स्रोतों और भिन्न भिन्न लवणीयता स्तर के तालाब जल में घुलित आक्सीजन, अमोनिया (0.1 से 2 पीपीएम), नाइट्राइट (0.05 से 1 पीपीएम), कैल्शियम एवं मैग्निशियम खनिज, कुल कठोरता, कार्बोनेट, बाइकार्बोनेट तथा कुल क्षारीयता के मापन हेतु एक मल्टी-पारामीटर पोर्टेबल वाटर एनालाइसिस किट का विकास किया गया और इसका वाणिज्यिकरण न्यू बायो साईंस कम्पनी, मैसूर के साथ किया गया।

जलजीव पालन वेब टूल

जल निकायों की वहन क्षमता के आकलन के लिए एक ऑनलाइन एक्वाकल्चर प्लानिंग वेब टूल 'कैरीकैपद्ध' विकसित किया गया और आंध्र प्रदेश राज्य सरकार द्वारा जलजीव पालन विकास के अनुकूलन और संसाधन उपयोगकर्ताओं के बीच टकराव से बचने के लिए एक्वा ज़ोनेशन कार्य के लिए इसका उपयोग किया जा रहा है।

मृदा जल स्वास्थ्य कार्ड और स्थान विशिष्ट बीएमपी

तमिलनाडु के चिदंबरम और नागपट्टिनम जिलों के जलजीव पालकों को लगभग 55 मृदा और जल स्वास्थ्य कार्ड वितरित किए गए। भौगोलिक भिन्नता को समझने के लिए एसडब्ल्यूएचसी डाटाबेस का विश्लेषण किया गया, जो स्थान विशिष्ट बीएमपी को तैयार करने में मदद करता है।

विभिन्न पालन पद्धतियों के अंतर्गत पोषक तत्व गतिशीलता

शून्य जल विनिमय के साथ 25 पीपीटी लवणता के अंतर्गत सिम्युलेटेड (कृत्रिम) मिट्टी और पक्के तालाब में *पी. वन्नामेय* पालन पर किए गए अध्ययन से पता चला है कि रेखित तालाबों (लाइन्ड पांड्स) में पानी की गुणवत्ता, विशेषकर अपचयोपचय क्षमता तुलनात्मक रूप से बेहतर है और मेटाबोलाइट्स रेखित तालाबों में कम थे। यद्यपि, मिट्टी के तालाबों में विकास दर 21% अधिक थी।

जलवायु में आकस्मिक परिवर्तन के अंतर्गत *पी. वन्नामेय* का अनुकूलन

लवणता में आकस्मिक रूप से लवणता 25 से 5 पीपीटी तक पर घटने की स्थितियों में *पी. वन्नामेय* की अनुकूलन क्षमता पर किए गए अध्ययन से पता चला है कि हालांकि जल ऑस्मोलैलिटी में व्यापक भिन्नता है, 5 घंटे में सीरम ऑस्मोलैलिटी 510-687 mOsmol/कि.ग्रा. की कम सीमा में है तथा 24 घंटे में यह सीमा कम तथा स्थिर (639-665

mOsmol/किग्रा) की गई। यह दर्शाता है कि *पी. वन्नामेय* अपनी ओस्मोरेगुलेटरी क्षमता के कारण लवणता में परिवर्तन के प्रति जल्द अनुकूलन करने में सक्षम है।

पी. वन्नामेय पालन में वृद्धि और नाइट्रोजन चयापचय संकेंद्रण पर मिट्टी पॉलिमर अवशोषण का प्रभाव

पी. वन्नामेय पालन में साप्ताहिक अंतराल पर 2.5 ग्रा./100 लीटर की दर से मिट्टी के पॉलीमर यौगिकों के अनुप्रयोग ने पहले सप्ताह के दौरान टीएएन (TAN) को 88.3 और 78.9 प्रतिशत कम कर दिया और यह अंतिम सप्ताह में निम्न (60 और 90 नग/वर्ग मीटर) और उच्च (90 सं/वर्ग मीटर) संग्रहण घनत्व में क्रमशः 45.1 और 43.2 प्रतिशत घट गया।

जल गुणवत्ता पर ऑक्सीजन रिलीज करने वाले यौगिक का प्रभाव

विकसित 3, 4 और 5 कि.ग्रा./हेक्टेयर की दर से ऑक्सीजन रिलीज करने वाले उत्पाद के अनुप्रयोग से घुलित ऑक्सीजन स्तर को क्रमशः 7.5, 9.2 और 12.1 पीपीएम तक बढ़ गया और अनुप्रयोग के 2 घंटे बाद कुल अमोनिया नाइट्रोजन स्तर को 0.25 पीपीएम से 0.025 तक कम कर दिया। घुलित ऑक्सीजन स्तर और अन्य जलीय गुणवत्ता प्राचलों के आधार पर, अनुकूलतम खुराक 3 कि.ग्रा./हेक्टेयर पाया गया।

पंजाब और हरियाणा में अंतर्स्थलीय लवणीय जलजीव पालन के लिए उपयुक्त स्थलों का आकलन

पंजाब और हरियाणा के चयनित जिलों से अंतर्स्थलीय लवणीय जल की लवणता, पीएच, कठोरता और क्षारीयता क्रमशः 2-20 पीपीटी, 7.2 से 8.3, 540-6570 पीपीएम और 126-601 पीपीएम तक पायी गयी। स्रोत जल कैल्शियम से भरपूर हैं, लेकिन मैग्नीशियम और पोटेशियम की कमी दूर करने हेतु पूरक खनिजों का उपयोग बाध्यकारी है। राजस्थान की अंतर्स्थलीय लवणीय मृदाओं में जल घुलनशीलता और विनिमेय योग्य पोटाशियम में भिन्नता 15 से 223 कि.ग्रा./हेक्टेयर और 27 से 814 कि.ग्रा./हेक्टेयर के बीच है।

जल की विभिन्न लवणताओं में कुल अमोनिया नाइट्रोजन का माइकोटिक जैवोपचार

भिन्न भिन्न लवणताओं 1, 15, 30 और 45 पीपीटी में *प्लुरोटस प्रजातियों* के उपयोग से कुल अमोनिया नाइट्रोजन (1 और 2 मि.ग्रा./ली.) के माइकोटिक जैवोपचार के लिए एक *कृत्रिम परिवेशीय* अध्ययन किया गया। 72 घंटे के भीतर कुल अमोनिया नाइट्रोजन में 1, 15 और 30 पीपीटी में 80% से अधिक और 45 पीपीटी में 80% से कम की कमी आयी।

झींगा जलजीव पालन में अन्य पोषक तत्वों के संबंध में कार्बन की गतिशीलता

विभिन्न लवणीयताओं में तालाब के तलछटों में नाइट्रोजन और फास्फोरस जैसे अन्य पोषक तत्वों के साथ कार्बन की सांद्रणता में भिन्नता का अध्ययन किया गया। लवणता के साथ जैविक कार्बन और उपलब्ध नाइट्रोजन की मात्रा में कमी पाई गई, जबकि उपलब्ध फॉस्फोरस मात्रा में विपरीत प्रवृत्ति देखी गई। लवणता के साथ जल में घुलनशील कार्बन में वृद्धि देखी गई, जो 1.4 मि.ग्रा./कि.ग्रा. से 2.5 मि.ग्रा./कि.ग्रा. के बीच है : डब्ल्यूएससी 45> डब्ल्यूएससी 25> डब्ल्यूएससी 11> डब्ल्यूएससी 6.

झींगों में डब्ल्यूएसएसवी के प्रकोप पर पालन तापमान की भूमिका

रोग चुनौती के 6 दिनों के भीतर 30°से और 32°से के परवेशी तापमान में झींगों की 100% मृत्यु दर पायी गई और पीसीआर परीक्षण में मृत/रुग्ण झींगों में प्रथम चरण की सकारात्मकता देखी गई। झींगों को 34°से और 35°से तापमान में पालने से क्रमशः 0% और 7% मृत्यु दर देखी गई और दोनों ही तापमानों में दूसरे चरण की सकारात्मकता पायी गई। इस अध्ययन से डब्ल्यूएसएसवी संक्रमकता और सामूहिक मृत्यु दर पर तापमान की भूमिका की पुष्टि होती है।

जलजीव पालन तालाबों में जीएचजी उत्सर्जन

पी. वन्नामेय पालन तालाबों में उपज प्राप्ति के प्रथम और दूसरे माह के दौरान जीएचजी का अधिक उत्सर्जन देखा गया विशेषकर कार्बनडाइऑक्साइड। तालाब को सुखाने तथा चूना डालने की प्रथा ने ग्लोबल वार्मिंग की संभावनाओं को बढ़ाया है। पालन के दौरान, आहार में 40% किण्वित सोयाबीन और बेसिलस स्ट्रेंस 10^6 सीएफयू/मि.ली. की खुराक के समावेशन तथा सूक्ष्मजीवीय हस्तक्षेप से कार्बनडाइऑक्साइड और मिथेन की तुलना में नाइट्रोजन उत्सर्जन कम हुआ है।

झींगा के लिए वृद्धि नियामक के रूप में भूरे समुद्री शैवाल एक्सट्रैक्ट का अनुप्रयोग

तरूण झींगों के लिए वृद्धि नियामक के रूप में भूरे समुद्री शैवाल (*एस्कोफाइलम नोडोसम*) एक्सट्रैक्ट का उपयोग किया गया। सूक्ष्म शैवाल मिश्रण से तैयार आहार देने पर तीन गुना तरलीकरण में भी **20%** अधिक वृद्धि दर्ज की गई। हालांकि, समुद्री शैवाल एक्सट्रैक्ट की उच्च सांद्रणता से वृद्धि तथा उत्तरजीविता पर नकारात्मक प्रभाव पड़ा।

लैक्टिक एसिड बैक्टीरिया के पूरक आहार से *पी. वन्नामेय* की वृद्धि और उत्तरजीविता में सुधार

लैक्टिक एसिड बैक्टीरिया (एलएबी) के दो वियोजकों (आइसोलेट्स) नामत: *लैक्टोकोकस लैक्टिस* उपप्रजाति *लैक्टिस* एसडीकेआरसी-5 और *लैक्टोबैसिलस* वियोजक (एसडीकेआरसी-6) के पूरक आहार के साथ *पी. वन्नामेय* पर एक आहारीय परीक्षण किया गया। आहारीय परीक्षण के 63 दिनों के बाद, एलबीए पूरक आहार दिए गए समूह में सामान्य की तुलना में 14% उच्चतर वृद्धि और 10% अधिक उत्तरजीविता दर्ज की गई।

एशियाई सीबास में क्रस्टेशियन परजीवी संक्रमण के विरूद्ध इमामेक्टिन बेंजोएट की प्रभावकारिता

एशियाई सीबास में *कैलिगस मिनिमस* संक्रमण के विरुद्ध इमामेक्टिन बेंजोएट (ईबी) के साथ एक उपचारात्मक परीक्षण किया गया और उपचार के पांचवें दिन के बाद उत्तरजीविता में 92% सुधार और परजीवीय भार में कमी पाई गई। उपचार के 7वें दिन के बाद कोई परजीवी प्राप्त नहीं किया जा सका जिससे यह सुझाव मिलता है कि पखमीन मछलियों में परजीवीय संक्रमण के नियंत्रण हेतु इमामेक्टिन बेंजोएट दिया जा सकता है।

विभिन्न लवणताओं के तहत ऑक्सीटेट्रासाइक्लिन (ओटीसी) क्षरण पर पीएच का प्रभाव

समुद्री जल में ओटीसी क्षरण पर पीएच और लवणता के प्रभाव पर एक अध्ययन किया गया। लवणता के किसी भी स्तर पर, उच्च पीएच की तुलना में निम्न पीएच स्तर पर ओटीसी का क्षरण तेज गति से होता है।

झींगा मांसपेशियों के ऊतकों से क्लोरमफेनिकॉल की निकासी

पीनियस वन्नामेय में क्लोरमफेनिकॉल की निकासी के अध्ययन हेतु वाणिज्यिक रूप से उपलब्ध आहार पर 500 मि.ग्रा./कि.ग्रा. आहार की दर से क्लोरैम्फेनिकॉल लेपित करके 7 दिनों तक आहार दिया गया। क्लोरमफेनिकॉल खिलाना बंद करने के बाद दो दिन के भीतर ही मांसपेशियों के ऊतकों में सांद्रता तेजी से कम (0.64±0.08 ppm) हो गई तथा 20 दिनों में अवशेष पूर्ण रूप से समाप्त हो गए।

जलीय रोगों के लिए नैदानिक, रोगनिरोधी और चिकित्सकीय प्रौद्योगिकी का विमोचन

सीबा के जलीय जीव स्वास्थ्य प्रभाग ने नैदानिकी (उन्नत डब्लूएसएसवी रियल टाइम पीसीआर किट और ईएचपी रियल टाइम पीसीआर किट), रोगनिरोधी (सिबामॉक्स - वाटर प्रोबायोटिक) और चिकित्सकीय (लुमिपेज - वाइब्रोस के नियंत्रण के लिए) संबंधी कई तकनीक जारी किया है। उन्नत डब्लूएसएसवी रियल टाइम पीसीआर किट और ईएचपी रियल टाइम पीसीआर किट का कोस्ट्रा बायोसोल्यूशन प्रा. लि., चेन्नई से और सीबामॉक्स का टाटा रैलिस

(इंडिया) लिमिटेड, मुम्बई के साथ वाणिज्यीकरण किया गया। इसके अतिरिक्त, लुमिफेज प्रौद्योगिकी में सुधार के लिए आईआईटी-एम और टाटा रैलिस इंडिया लिमिटेड के साथ एक समझौता ज्ञापन पर हस्ताक्षर किया गया।

खारा जलीय जीवों के रोगों के लिए राष्ट्रीय रेफरल प्रयोगशाला

सीबा का जलीय जीव स्वास्थ्य और पर्यावरण प्रभाग, खारा जलीय जीवों के रोगों के लिए एक राष्ट्रीय रेफरल प्रयोगशाला के रूप में कार्य कर रहा है। जलीय संगरोधन और प्रमाणन सेवाओं (एक्यूसीएस) के एक भाग के रूप में वर्ष 2018-19 के दौरान ओआईई सूचीबद्ध झींगा और मछली रोगजनकों के लिए कुल 63 नमूनों का परीक्षण किया गया जिनमें आयातित *आर्टीमिया* सिस्ट, फ्रोजन टिशू तथा आहार नमूने सम्मिलित हैं। ओआईई सूचीबद्ध रोगजनकों के संदर्भ में सभी नमूनों में नकारात्मकता पायी गयी।

मछली के अपशिष्ट को प्लवक बूस्टर में परिवर्तित करने की एक अनूठी विधि, प्लैंकटन*प्लस*

स्वच्छता समस्याओं को कम करने की दृष्टि से सीबा ने 47-49**%** प्रोटीन तथा 20-30**%** लिपिड वाले प्लैंकटन*प्लस* मत्स्य उत्पाद की तैयारी के माध्यम से मछली बाजार के अपरद्द की सफाई हेतु प्रयास किया जिसे जलकृषि तालाबों में प्लवकों की वृद्धि करने या आहार सूत्रण में घटक के रूप में उपयोग करने तथा कृषि/बागवानी में खाद के रूप में उपयोग किया जा सकता है।

प्लवकों के स्तर और झींगा/मछली के वृद्धि निष्पादन पर प्लैंकटन*प्लस* के अनुप्रयोग का प्रभाव

प्लैंकटन*प्लस* पूरक आहार को 20 पीपीएम की दर के भागों में बांटकर देने पर *पी. वन्नामेय की* उल्लेखनीय रूप से (पी <0.01) दैनिक औसत भार में वृद्धि, विशिष्ट वृद्धि दर, कुल बायोमास प्राप्ति और उत्तरजीविता में वृद्धि हुई जबकि 30% कम आहार दिया गया। यद्यपि, प्लैंकटन*प्लस* पूरक की इसी खुराक से *चनोस चनोस* के वृद्धि निष्पादन और उत्तरजीविता को प्रभावित किए बिना 50% आहार की बचत की जा सकती है। प्लैंकटन*प्लस* पूरक से बेसिलिरियोफाइसे, प्रसिनोफाइसे और डिनोफाइसे आदि लाभदायक सूक्ष्म शैवालों के घनत्व को बढ़ाने में सहायता मिली है।

जीवंत आहार का समृद्धिकरण

प्लैंकटन*प्लस* पूरक पोषण से आर्टीमिया बायोमास उत्पादन में सुधार हो सकता है और आर्टेमिया पालन में शैवाल का उपयोग 50% तक कम किया जा सकता है। पख मीन और कवच मीन मछलियों के लार्वा पालन में उपयोग हेतु आर्टेमिया के लिए पीयूएफए से समृद्ध

थ्रॉस्टोचाइट्रिड्स, यूनीसेल्यूलर मोनोसेंट्रिक कवक जैसे प्रोटिस्ट का उपयोग किया जा सकता है।

जलजीव आहार में उपयोग के लिए नए आहार घटकों और आहार योगजों का मूल्यांकन

झींगा और मछली के आहार में घुन से संक्रमित शकरकंद, खमीर किण्वित मूंगफली खली, *लीउकेना ल्यूकोसेफला* पत्ती आहार को में 5 से 10% तक समावेश किया जा सकता है। समुद्री शैवाल, *ग्रेसिलारिया टेनुइस्टिपिटाटा* को झींगा आहार में एक प्राकृतिक योजक के रूप में उपयोग करने की क्षमता पाई गई। अध्ययन से पता चला है कि वृद्धि और प्रतिरक्षा बढ़ाने के लिए स्पिरुलिना से निकाले गए सी-फाइकोसाइनिन को झींगा आहार सूत्रण में 750 से 1000 पीपीएम तक समावेश किया जा सकता है। अध्ययन में यह भी ज्ञात होता है कि बेहतर विकास और उत्तरजीविता प्राप्त करने के लिए *पीनियस वन्नामेय* के तरूण झींगों के आहार में 0.4% क्रिल ऑयल का समावेश किया जा सकता है।

सीबा द्वारा विकसित आहार और नवीन उत्पादों का निरूपण

तालाब में सामान्य की तुलना में प्लैंकटन$^{प्लस}$ पूरक पोषण से *पी. वन्नामेय* की उत्तरजीविता में उल्लेखनीय वृद्धि (12.31%) और 1.71 टन/हे. उपज वृद्धि हुई। प्लैंकटन$^{प्लस}$ पूरक पोषण दिए गए तालाबों में संवर्धित घनत्व और पादप प्लवक (बेसिलारियोफिसे, प्रोसिनोफिसे और डाइनोफिसे आदि) और जंतु प्लवक की विविधता *पीनियस वन्नामेय* में बढ़े हुए वृद्धि निष्पादन का कारण हो सकता है। खुले जल के पिंजरों में केकड़ा (*स्काइला सेराटा*) पालन निरूपण से पता चला कि तलहटी पिंजरों में गुटिका आहार से कुल बायोमास की प्राप्ति अधिक (7.27 कि.ग्रा.) थी। कम लागत वाली मछली की तुलना में सूत्रबद्ध आहार दिए गए बॉक्स में पालित केकड़ों (*स्काइला सेराटा*) में इसी प्रकार की अंडाशय भार प्राप्ति तथा गोनाडोमेस्टिक इंडेक्स प्राप्त हुआ।

कैप्टिव *पीनियस इंडिकस* ब्रूडस्टॉक की कार्यिकीय विशेषताओं पर विभिन्न आहार पद्धतियों का प्रभाव

यह अध्ययन परिपक्वता आहार के विभिन्न स्तरों (शारीरिक भार का 5%, 15% और 25% प्रति दिन) तथा बंद स्थितियों में पालन से कैप्टिव *पीनियस इंडिकस* ब्रूडस्टॉक में कार्यिकीय बदलाव जैसे वृद्धि, मोल्टिंग रिथम, परिपक्वता हार्मोन स्तर पर पड़ने वाले प्रभाव के मूल्यांकन के लिए किया गया था। शारीरिक भार के 15% की दर से आहार दिए गए समूह में मोल्टिंग आवृत्ति अधिक पाई गई। इसके अलावा, बंद स्थितियों पालन के 45 दिनों के बाद, इस समूह में न्यूनतम GIH mRNA स्तर पाया गया।

पोषक तत्वों की आवश्यकताओं का अनुकूलन और आहार विकास

मिल्कफिश लार्वा के आहार विकास के लिए टॉरिन और विटामिन ई (α-टॉकोफेरल एसीटेट) की आवश्यकता को अनुकूलित किया गया और यह क्रमशः आहार का 1% और 196-218 पीपीएम पाये गये। सीबास के लार्वा पालन के लिए उपलब्ध वाणिज्यिक फीड की तुलना में एशियन सीबास के लिए विकसित लार्वा आहार (सीबास लार्वी$^{प्लस}$) से उच्च वृद्धि निष्पादन दर्ज किया गया।

हिल्सा के ब्रूडस्टॉक आहार के विकास के लिए परिपक्वता के विभिन्न चरणों के दौरान हिल्सा के फैटी एसिड के जमाव पर अध्ययन किया गया। अध्ययन में यह पाया गया कि भले ही मांसपेशी में कम से कम जमा हुआ फैटी एसिड एराकिडोनिक एसिड (सी 20:4) है परंतु यह अंडाशय में सबसे अधिक (96%) है, जबकि पामिटोलेनिक एसिड (सी 16: 1) सबसे अधिक जमा हुआ फैटी एसिड है लेकिन अंडाशय में इसकी मौजूदगी सबसे कम (22.7%) है।

आहार प्रबंधन विकल्प

मिल्कफिश, *चनोस चनोस* लार्वा की वृद्धि और उत्तरजीविता पर विलंबित प्रारंभिक आहार के प्रभाव से ज्ञात होता है कि बेहतर विकास और उत्तरजीविता प्राप्त करने के लिए मिल्कफिश के लार्वा को आहार देने की प्रक्रिया निषेचन के 24 घंटे के बाद शुरू की जानी चाहिए। एक्वा मिमिक्री सिस्टम में झींगा पालन पर किए गए अध्ययन से पता चला है कि सिस्टम में उपलब्ध प्राकृतिक आहार सांद्रता केवल कम संग्रहण घनत्वों में अच्छे वृद्धि निष्पादन में मदद कर सकती है। जैविक कार्बन स्रोत के रूप में ग्राउंड राइस ब्रान के उपयोग से बनाए गए बायोफ्लाक का ही सेवन करने वाले झींगों (4.19 ग्रा.) की अपेक्षा बायोफ्लॉक और आहार का सेवन करने वाले झींगों में अधिकतम अंतिम भार (19.58 ग्रा.) तथा उत्तरजीविता (> 90%) देखी गई।

डब्ल्यूआरएनएवी संक्रमण के दौरान miRNAs की अभिव्यक्ति प्रोफाइलिंग

हाल के वर्षों में विषाणु पुनरावर्ति तथा मेजबान कोशिकीय तंत्र की सम्बद्धता में विषाणु तथा होस्ट (मेजबान) माइक्रो आरएनए (miRNA) के महत्व का पता चला है तथा संक्रमण के दौरान मेजबान और रोगजनक से miRNAs के सहसंबंध को समझने के लिए प्रयास तेज किए गए हैं।

डब्ल्यूएसएसवी संक्रमण की स्थिति में झींगा (*पीनियस वन्नामेयी*) की प्रतिरक्षात्मक प्रतिक्रियाओं में सम्मिलित miRNAs की पहचान करने के लिए छोटे आरएनए अनुक्रमण किये गये। प्रक्षेत्र की दो विपरीत परिस्थितियों अर्थात प्रकोप और नियंत्रित प्रायोगिक स्थितियों के अंतर्गत डब्ल्यूएसएसवी से संक्रमित झींगा के miRNAs की अभिव्यक्ति प्रोफाइल की तुलना की गई और इसके परिणामस्वरूप 23365 ज्ञात miRNAs और 481

नवीन miRNAs की पहचान की गई। इसलिए, हमारा अध्ययन दो अलग-अलग स्थितियों में डब्ल्यूएसएसवी संक्रमण के दौरान झींगा के miRNA अभिव्यक्ति का तुलनात्मक विश्लेषण प्रदान करता है।

लांग-रीड्स वाले *पीनियस इंडिकस* का कांटिग-लेवल एसेम्बली

पेसिफिक बायोसाइंसेस सीक्वल प्लेटफॉर्म पर PacBio सीक्वेंस डाटा का सृजन किया गया। सीक्वेंसिंग के लिए 20 केबी सीक्वेंसिंग लाइब्रेरी का इस्तेमाल किया गया था, जहां ब्लूपीपिन साइज सेलेक्शन के आधार पर 17 केबी साइज से अधिक इंसर्ट्स रखे गए थे। सीक्वेंस डाटा के 176,539,267,324 आधार की लंबाई के लगभग 20,857,430 रीड्स, जो जीनोम के 71X कवरेज के बराबर हैं, का उपयोग फाल्कन, कैनु और डब्ल्यूटीडीबीजी 2 असेम्बलर्स के साथ कांटेग-लेवल जीनोम के निर्माण के लिए किया गया था। आप्टिकल मैप तथा HiC डाटा का सृजन, स्कैफफोल्डिंग और क्रोमोजोम लिंकिंग कार्य प्रगति पर है।

dbVAST: झींगा ट्रांसक्रिप्टों के साथ जुड़ी विविधताओं का डाटाबेस

पालन पद्धति के उत्पादन में वृद्धि के लिए संभावित जीनोमिक संसाधनों की खोज और उनके उपयोग को बढ़ावा देने के लिए, झींगा ट्रांसक्रिप्टों से जुड़ी विविधताओं का एक डाटाबेस बनाया गया। तीन झींगा प्रजातियों *पीनियस वन्नामेय*, *पीनियस इंडिकस* और *पीनियस एजटेकस* के कोडिंग अनुक्रमों में सिंगल न्यूक्लियोटाइड बहुरूपता (एसएनपी) का प्रलेखन किया गया और ब्राउज़ करने के लिए उपयोगकर्ता के अनुकूल ऑन-लाइन टूल प्रस्तुत किया गया।

एमआरएफ : मिसिंग रीजन फाइंडर

किसी भी अन्य रोगज़नक़ के साथ समानता प्रदर्शित न करने वाले व्हाइट स्पॉट सिंड्रोम वायरस (डब्ल्यूएसएसवी) जीनोम की विशिष्टता है कि इसके एन्नोटेशन सीमित है। डब्ल्यूएसएसवी जीनोम पर सम्पूर्ण ज्ञान प्राप्त करने के लिए मिसिंग रीजन फाइंडर नाम से एक वेब टूल विकसित किया गया। क्वेरी में डिलीट किए गए जीनोम रीजन को ढूंढने के लिए एमआरएफ, क्वेरी जीनोम की तुलना संदर्भ जीनोम से करता है तथा संदर्भ जीनोमों की व्याख्या के अनुसार डिलीट किए गए इन रीजंस की सीडीएस को सारणीबद्ध करता है। इससे एकल संदर्भ की व्याख्या नामकरण में तुलनात्मक जीनोम विश्लेषण के निष्कर्ष आसानी से समझ में आ जाएंगे। डब्ल्यूएसएसवी जीनोमों से संबंधित नामकरण वर्गीकरण के मुद्दे में इस प्रकार का टूल क्षमतावान है क्योंकि इसमें उपयोगकर्ता एकल संदर्भ जीनोम की तुलना कई जिनोम से कर सकते हैं।

उपसमूह, डेंड्रोब्रानचियाटा में झींगा के फाइलोजीनोमिक्स

जीनस *पीनियस सेंसु लेटो* में टैक्सोनोमिक संशोधन पर शोधकर्ताओं के बीच मतभेद और भ्रम मौजूद है। संपूर्ण माइटोकॉन्ड्रियल डीएनए जीनोम अनुक्रमों पर किए गए अध्यन में अधिकतम संभाव्यता और बेसियन फाइलोजेनेटिक निष्कर्ष से *पीनियस सेंसु लेटो* में मोनोफाइली सूचित हुआ। इसके अतिरिक्त, औसत अमीनो एसिड पहचान (एएआई) के अनुमान में भी *पीनियस सेंसु लेटो* के मोनोफाइली की सूचना मिली है।

मछली में लिंग विभेद

एंटी-मुलेरियन हार्मोन (*एएमएच*) की अभिव्यक्ति से *ग्रे* मुलेट, *मुगिल सेफालस* और *रेड स्नैपर लुटजानुस अरजेंटिमैकुलैटस* में एक नर विशिष्ट अभिव्यक्ति का संकेत मिला कि मछली में सेक्स विभेद मार्कर के रूप में *एएमएच* के उपयोग की संभावना है।

पर्लस्पॉट, ऑरेंज क्रोमाइड और ग्रे मुलेट के समष्टि आनुवंशिक स्टॉक

वाणिज्यिक रूप से महत्वपूर्ण खारा जल पखमीन में माइटोकॉन्ड्रियल एटीफेज 6/8 के उपयोग से विश्लेषण के आधार पर समष्टि विविधता की जांच की गई। परीक्षित *इट्रोप्लस सुराटेंसेस* के लगभग सभी स्टॉकों में उल्लेखनीय आनुवंशिक विविधता देखी गई परंतु दूरी से अलगाव गैर-उल्लेखनीय था। *इट्रोप्लस मैकुलाटस* के वेंबानाड और पुलिकेट सम्पदाओं के बीच महत्वपूर्ण आनुवंशिक विचलन देखा गया। *मुगिल सेफालस* में, परिणामों ने भारतीय तट में दो अलग-अलग आनुवंशिक सम्पदाओं अर्थात एक ओडिशा और केरल के बीच और दूसरा (गोवा और गुजरात) के बीच मौजूद होने का संकेत दिया है।

पर्लस्पॉट फुल-सिब फैमिली का वृद्धि निष्पादन

दर्ज किए गए दो पर्लस्पॉट (*इट्रोप्लस सुराटेंसेस*) फुल-सिब कुलों के वृद्धि निष्पादन में दोनों कुलों की मछलियों में शरीर की कुल लंबाई की तुलना में शारीरिक भार में विविधता के उच्च गुणांक (सीवी) हैं।

भारतीय तटीय क्षेत्र में माइक्रोसेटेलाइट मार्करों के उपयोग से भारतीय सफेद झींगों के संपूर्ण समष्टि की आनुवंशिक संरचना

भारतीय तटीय क्षेत्र में *पी. इंडिकस* में **7** लोसी माइक्रोसैटेलाइट डाटा की तुलना से ज्ञात हुआ है कि चेन्नई और क्विलोन की सम्पदा में अन्य सम्पदाओं से काफी भिन्नता है। यह जानकारी संरक्षण और स्टॉक विशिष्ट चयनित प्रजनन कार्यक्रमों में सहायक होगी।

भारतीय प्राकृतिक जल में जावानीस राइसफ़िश, *ओरीज़ियास जवानिकस* (ब्लीकर, 1854) (बेलोनिफ़ॉर्मस: एड्रियनिचथइडे) की पहली सूचना

भारतीय प्रायद्वीप के प्राकृतिक जल में *ओ. जवानिकस* के पहली बार फैलाव से भारत में *ओरिज़ियास* प्रजातियों की संख्या पांच होने की पुष्टि हुई है। पृष्ठीय और पुच्छीय पख के उदरीय भाग के किनारों पर पीले उप-सीमांत बैंड की मौजूदगी, इसे अन्य भारतीय प्रजातियों अलग पहचान देती है। भारत और इंडोनेशिया में मौजूद समष्टि के बीच न्यूक्लियोटाइड आनुवंशिक दूरी अविवेच्य (इनडिस्टिंकगिशेबल) पाई गई।

इट्रोप्लस सुराटेंसिस की वृद्धि में सुधार के लिए CRISPR-Cas9 मध्यस्तता वाले जिनोम इंजीनियरिंग

लक्षित जिनोम एडिटिंग के लिए एक सशक्त टूल **CRISPR-Cas9** के उपयोग से इट्रोप्लस सुराटेंसिस में मयोस्टेटिन जीन को भंग करने हेतु प्रयोग किए गए। निषेचित अंडों में CRISPR/Cas9 प्रोटीन का मैक्रो इनजेक्शन लगाया गया और भ्रूण विकास को प्रलेखित किया गया।

Executive summary

The current year, 2018-19 was an important and productive year for CIBA. The institute has been pursuing research and development for the development of sustainable brackishwater aquaculture. With twenty-nine in-house and external funded research grants, and with several out-reach activities, CIBA has contributed remarkably towards the development of science of brackishwater aquaculture. As a research and development organization, the success and effectiveness of the organization have been measured by the outputs of scientists/researchers. The current year, the scientists from CIBA has published 39 peer –reviewed research articles in the various reputed national and international journals. Further, thirty-one commercial agreement has been signed with the stakeholders during the current year. The institute maintained the quality of the research and it is evidenced by winning the most prestigious ICAR team award, Nanaji Deshmukh ICAR Award for outstanding interdisciplinary team by the Fish nutrition division of CIBA. Further, Dr M. Kumaran, Principal Scientist of CIBA obtained Swami Sahajanand Saraswati Outstanding Extension Scientist Award. Some of the highlights of research and development accomplished by the institute during the last year are presented below.

Development of pond reared Indian white shrimp stock

Shrimp farming in India, which is almost exclusively based on exotic *Penaeus vannamei*, is at a cross road due to the emerging disease, reduced survival, increase in the cost of production and recent falls in the prices. At this context, development of a native species is a viable option to ensure sustainability of shrimp farming. Indian white shrimp, *P. indicus*, has been identified as suitable candidate species for domestication and genetic improvement. Experimental trials have been carried out to develop captive/pond reared broodstock of *P. indicus*, which is the primary requirement of any selection program. Hatchery reared post larvae of *P. indicus* were grown to broodstock size (25-35 g) in earthen pond, These F0 generation were successfully bred under captivity, and F1 generation offspring were are being further reared.

Polyculture of Indian white shrimp (*Penaeus indicus*) and milkfish (*Chanos chanos*)

Polyculture of shrimp has been proved to be viable alternative to reduce the nutrient waste from the aquaculture facilities and to optimize the economy shrimp farming. In order to evaluate the production performance of polyculture of *P. indicus* (stocking density: 25 PL/m^2) and *C. chanos* (0.25 no/m^2 and 0.5 no/m^2), a 75 day culture experiment was carried

out. Highest survival (79.33± 1.88 %) and production (1451.28± 22.15 kg/ha) of shrimp was recorded in the pond which *P. indicus* reared with milkfish at a stocking density of 0.5 ind. /m^2, although significantly higher average body weight obtained at the pond stocked with milkfish at a stocking density of 0.25 m^2.

Bio-floc based nursery rearing technology for *Penaeus vannamei*

Bio-floc technology has been an emerging alternative towards the environmental friendly aquaculture. This technology is characterized by reduced water exchange, reduced feed use and improved biosecurity. *Penaeus vannamei* PL were reared at a stocking density3500 PL/m2 in 350 mt capacity nursery tank designed by the institute for a period of 28 days. Nursery reared animals were grown up to 0.92 ± 0.15 g with a survival of 94.20± 2.86 %)

Evaluation of Aqua-mimicry technology on growth performances, water quality and immune responses in RAS environment

A RAS based nursery rearing was carried out with addition of carbon source and rotifer as feed supplement. The survival and growth was monitored every 15 days in each treatment. The treatments included as C: control, T1: only Biofloc, T2: Biofloc and rotifer, T3: only Rotifer. At the end of Experiment the rotifer with biofloc condition showed better growth (3.89±0.25) and survival (91%) which is significantly different from control animals (3.24±0.29, 85%).

Growth performance, osmolarity of Indian white shrimp juveniles reared at different salinity

A 50-day experiment was carried out to study the growth performance, water quality, osmolarity and serum mineral profiles of P. *indicus* juveniles (0.4-0.5g) reared at different salinity. Osmolarity study reveals serum osmolarity changes proportionately with ambient water salinity

Nursery rearing of *Penaeus indicus* in the estuarine ecosystem as a livelihood activity: A nursery rearing model for Indian white shrimp, Penaeus indicus, has been demonstrated for self-help groups at Uyallikuppam village (Palar backwaters) near Kalpakkam (Tamil Nadu). Penaeus indicus (n= 400) of 1.5g size were separately stocked in 4 hapas (2 m x 1m size) and reared for sixty days. On an average of 8.50 g size of P. indicus were obtained with 90 % survival

Development of submersible cage system for mud crab grow out production: Mud crabs are benthic organisms, and therefore, pelagic/floating cages adversely affect the physiology of these animals owing to the relatively higher surface and sub surface temperature. In order to circumvent the issues of subsurface/floating cages, easy-to-manage submersible cages have been developed, and evaluated the culture performance with reference to the floating cages. Average weight gain was >100 g in submersible system whereas it is significantly less in floating system (<15 g) indicating that submersible system outperforms traditional floating system. It could be concluded that implementation of submersible cum floating crab culture system provide higher growth compared to conventional one for crab fattening.

Open water cage aquaculture in mangrove regions of Maharashtra

In collaboration with Mangrove cell, Maharashtra CIBA initiated three-tier seabass farming involving in and around of mangrove coastal waters in Sindhudurg, Maharashtra with participation of self-help groups. (SHGs). Around six nurseries, a pre-grow-out and 33 grow-out cage cultures with the participation of SHGs have been formed. The SHGs have generated a total revenue of Rs. 3.16 lakhs through seabass nursery and pre grow out rearing work. From the grow out farming it is expected to grow 400-500g with an estimated total revenue generation of 10-12 lakhs.

Integrated Multi-trophic Aquaculture (IMTA) of Seabass and Green Mussels

To develop and propagate family farming models of candidate finfish and shellfish species in the west coast of India, initiated IMTA cage culture in Gad creek of Malvan, Sindhudurg. At present seabass have grown to size 400 g from the stocking size of 60 g with survival ranging from 79.30-90.03%. Harvest of 400-500g seabass is expected in mid-June 2019 with estimated total revenue generation of 2-2.5 lakhs.

Juvenile milkfish as ornamental “Silverfish”

Milky white glittering, shining body, agility, semi-transparent V-shaped caudal fin, swifte movement pattern, wide salinity tolerance, voracious gracing on tank algae and disease resistance qualifies milkfish juveniles as a potential ornamental fish called “Silverfish”. Being a highly compatible fish with other ornamental tankmates, were sold @Rs. 50/- /10 pair.

Milkfish farming in West Bengal as Decan Hilsa

Considering demand and preference of milkfish by local Bengalis, CIBA took efforts to popularize milkfish as 'Decan Hilsa' in West Bengal. By farming in four different culture systems, 1.3 ton of milkfish was harvested and well accepted by the Bengalis by the name Decan Hilsa.

Farm inputs usage pattern in Indian shrimp culture

A survey was conducted during 2017 to understand the input usage pattern in the shrimp producing states, Andhra Pradesh, Tamil Nadu, Gujarat and Maharashtra. The study showed use of environmental modifiers being used highest quantity to improve soil and water quality, followed by probiotics (water, soil and gut probiotics) and disinfectants. No record of use of anti-microbial product was observed during the study.

Growout farming of Hilsa in ponds

Hilsa has good market potential in West Bengal, and there is a huge demand for table size hilsa. Two months old fingerlings were further reared in two different system viz. earthen pond and RAS using pelleted feed. After 11- months fishes reached around 80 g size, and the performance was better in ponds.

Wide salinity tolerance of streaked rabbit fish, *Siganus javus*

Streaked spine foot Rabbit fish, *Siganus javus* considered as important food fishes because of their fast growth rates, herbivorous food habits, and economic value. An experiment was carried out for 30 days to know their salinity tolerance levels. This experiment for the first time documented the wide salinity tolerance of *Siganus javus*, a potential herbivorous food fish for brackishwater farming

Male reproductive quality of *Penaeus indicus*

Spermatophore and sperm quality of penaeid shrimp often determine the success of seed production, particularly under captive condition. It is reported that reproductive tract development and spermatophores generation are generally compromised under captive condition. In order to evaluate the underlying principle of the process of reproductive development male shrimp reared in tanks and ponds were evaluated, and compared with wild caught shrimp. Sperm count was found to be significantly lower at the pond reared and tank reared animals compared to the wild caught shrimps.

Effect of short term chilled storage on the spermatophores quality of *Penaeus indicus*

Storage of male gametes would eliminate the need to keep breeders for artificial fertilization. In order to evaluate the effect of chilled storage on quality of male gamets, spermatophores were refrigerated at 4°C and sperm quality was evaluated at different intervals. Number of normal sperms was significantly higher in the first day of sampling than the fifth day of sampling. Acrosome reaction was also observed in the stored spermatophores at five days of preservation. Beyond five days, the sperm cells were disintegrating and viability was also not observed. This study proves the applicability of chilled storage as a preservation method for spermatophores

In-vitro fertilization and hybridization potential of Indian white shrimp, *Penaeus indicus*

Procedure for *in vitro*-fertilization of penaeid shrimp was successfully developed. Successful intra specific fertilization of *P. indicus* was achieved with a hatching rate of 4.8%, and 29% of nauplii developed into post larvae.

Effect of various feeding regimes on the physiological characteristics of captive *Penaeus indicus* broodstock

This study was carried out to evaluate the effect of different levels of maturation diet (5%, 15% and 25% of body weight per day) and captive rearing on physiological changes such as growth, molting rhythms and maturation hormone levels of captive *P. indicus* broodstock. Molting frequency was found to be higher at treatment group fed at 15% of body weight. Further, after 45 days of captive rearing, this treatment group had the minimum GIH mRNA level.

Seabass seed production accomplished newer heights

CIBA being a pioneer in captive breeding and seed production of seabass, recently standardised the protocols for natural spawning in captive condition. Out of 5.53 million eggs spawned in the last year, 2.66 million eggs spawned spontaneously and 2.87 million from induced spawning. An all-time high of 0.59 million fry seeds were sold in the year 2018-19 and a revenue of Rs. 1.72 million was realized. Additionally, 1.20 lakhs seeds were completely weaned for artificial feed and sent to Maharashtra.

Breeding performance of two different geographical stocks of milkfish (*Chanos chanos*)

While comparing the reproductive performance of milkfish from different geographically isolated stocks of east coast, Chennai stocks showed better performance with extended period of spawning. Both the stocks showed multiple spawning, and exposed the scope for year-round breeding of milkfish in captivity.

A good progress in captive breeding of grey mullet using farm reared parental stocks

In 2017 mullet spawned and eggs got fertilized for the first time, but the larvae survived only for eight days. In 2018, due to intensive efforts lead to resulted in mass larval production 0.75 million. The larvae survived up to 28 days. Further optimizations on larval rearing is in progress.

Maturation of *Liza parsia* reared in pond conditions

A study attempted with 300 number of *Liza parsia* (Goldspot mullet) for the reproductive maturation evidenced the ease of captive maturation with optimum water conditions and feed. Oocytes having less than 100 µm in diameter are non-vitellogenic in nature and, attained the maximum GSI and oocytes diameter of 606.55±17.02 and 18.31±2.0, respectively in captive condition. This observation evident that broodstocks of *Liza parsia* could be easily developed in pond conditions.

A good progress in captive maturation of mangrove snapper

Targeting the technology on captive breeding of mangrove snapper, a total of 90 adult fishes are being maintained in broodstock holding systems. Oozing males were observed in during June to October 2018 and February to March 2019, indicating 8-21% male stocks were attained maturity. However, female maturation has not been achieved and indications are there for oocyte development.

Induced maturation and spawning of spotted scat in RAS based homestead fish breeding model

For simplification breeding in spotted scat, a RAS of 3000 L capacity and 12.9 m^3/day flow rate with central drainage was fabricated and experimented. Adult scats were induced with varying level of and combinations of hormones. Female fishes were induced successfully with LHRHa 25 µg/kg/month, whereas combined dose of LHRHa + 17-αMT @ 25 + 25

µg/kg/ month was helpful to increase sperm density in males. These optimized doses would be useful for attaining spawning and larval production under RAS based homestead models.

Captive breeding of Silver moony, *Monodactylus argenteus*

Captive breeding and seed production of this potential brackishwater ornamental fish was achieved using hormonal induction. The diameter of the egg was 860 ± 14.11 µm, hatched out in 18 h, and the hatching percentage was 90%. Newly hatched larvae were 1.60-1.67 mm. This will pave way for mass production and transition in use of wild caught to captive bred fish for export.

WSSV, EHP and IMNV are major threats to Indian shrimp farming

Active disease surveillance of shrimp farms during 2015-19 suggests that white spot syndrome virus (WSSV) and *Enterocytozoon hepatopenaei* (EHP) are the predominant pathogens affecting two major shrimp farming states AP and TN. The prevalence of WSSV ranged between 11-40% and EHP between 21-43%. The infectious myonecrosis virus (IMNV) has emerged as another major challenge with prevalence rate of 15% during 2018-19.

Polychaete worms can transmit *Enterocytozoon hepatopeanei* to shrimp

CIBA studies revealed that the polychaete worms (*Marphysa* spp.) serve as carrier for shrimp pathogens such as WSSV and EHP. The EHP is horizontally transmitted from infected shrimp to polychaetes and *vice versa.* However, no evidence of vertical transmission was recorded in different developmental stages of polychaetes.

EHP spores remain infectious for more than a year in seawater at room temperature

The EHP spores were found to retain infectivity for a period of over 1 year in seawater at room temperature. The activity at such storage condition was lost only after 1 ½ years. However, spores stored at 4^{o}C, -20°C and -80^{o}C showed dramatic decrease with complete loss of spore viability and infectivity after one month.

Germination of EHP spores could be experimentally induced

Germination of EHP spores was induced by using dyes such as potassium hydroxide and phloxine. The entire event of germination takes place in fewer than two seconds. The germinating spores infect the nearby potential host cell by striking the cell and piercing its membrane.

Vertical transmission of WSSV in shrimp

In the experimentally infected *Penaeus indicus*, intranuclear inclusion bodies reactive to the VP28 probe were observed in WSSV infectied ovarian cells, suggesting that even a lower dose of WSSV infection has the possibility of vertical transmission.

Mass mortality of farmed mud crab, *Scylla serrata* in Andhra Pradesh

Mass mortality of mud crab *Scylla serrata* culture was observed in Nagayalanka, Krishna district, Andhra Pradesh in 2018. Diseased crab samples were positive for white spot syndrome virus (WSSV). They were also heavily infested with metazoan crustacean parasite, stalked barnacle, *Octolasmis* spp. The haemolymph of infected crab showed increased total plate count and total *Vibrio* count compared to that of healthy ponds.

Tilapia lake virus (TiLV) can be transmitted to sea bass

During disease Surveillance of sea bass farms co-cultured with tilapia, sea bass experienced chronic mortalities associated with haemorrhagic encephalitis were found to be affected with TiLV. Challenge experiment conducted to test the inter species transmission of TiLV from infected tilapia to seabass showed successful transmission of TiLV to sea bass with high cumulative mortalities.

Prevalence of parasitic infections in brackishwater finfishes

Profiling of parasitic diseases during 2016-19 in brackishwater candidate fish species and crab suggested the presence of six major parasites such as *Argulus*, *Caligus*, *Lernanthropus*, *Zeylanicobdella*, *Anisakis* and *Octolasmis*. However, no parasitic infections were recorded in in mullets and milk fish.

Microbial profiling of Zoea syndrome

Metagenomic study was conducted to figure out the etiology of the zoea-2 syndrome. Overall a total of 46 genera were seen specific to healthy, 328 specific to diseased and 371 genera common in both. Some of the genera were more abundant in zoea-2 syndrome affted samples are Devosia, Unclassified Rhodobacteraceae, Nonlabens, Muricauda, Unclassified Flavobacteriales, and Pseudoalteromonas.

Microbial profiling of CIBAMOX

The 16s rDNA based metagenomic microbial profiling revealed several novel bacteria involved in nitrogen metabolism. Bacterial group belonging to Caldilineaceae family were also dominant in ammonia oxidation besides *Nitrosomonas* and *Nitrobacter*. A large

percentage of microbes identified in the AOB and NOB enrichments belonged to the phylum *Proteobacteria.*

Characterization of quorum sensing system in *Vibrio harveyi* clade

To understand the virulence, quorum sensing system was characterised in sixty genomes of *Vibrio harveyi* clade. The autoinducer 2 synthesizing *luxS* gene was present in all the isolates of *V. harveyi* clade. However, autoinducer 1 synthesizing gene *luxM* was present in *V. harveyi, V. campbellii, V. jasicida* and *V. ovensiii* but absent in *V. natriegens* and *V. rotiferianus.*

Rapid detection technique to differentiate viable and dead EHP spore

A staining technique to assess the viability of EHP spores was developed. The viable spores stained by Calcofluor White appeared as turquoise-blue through the violet filter (395-415 nm). The dead spores stained by Sytox Green appeared as yellow-green oval bodies through the blue excitation filter (470-490 nm) and white-yellow through violet filter (395-415 nm).

Development of real time PCR assay for detection of iridovirus infection in fish

SYBR Green based real time PCR assay was developed for detection of Iridovirus with detection limit of 10 viral particles. A membrane cofactor protein gene based PCR was also standardised for detection of iridovirus.

Maternal transmission of WSSV in wild *Penaeus indicus* spawners: Vertical transmission of WSSV, directly through gametes, has yet to be proved. In order to test this hypothesis, reproductive tissues of WSSV infected females were diagnosed for WSSV through qRT PCR, and found that reproductive tissues had only 50 to 60 copies of WSSV, and only 36% of reproductive tissues of infected females showed the presence of WSSV. However, in situ hybridization studies did not reveal positive signal for WSSV.

Isolation and characterization of gut microbes: The Biofloc system is found to be advantageous and allows colonizing beneficial bacterial population in the gut region. Out of 94 strains screened, 36 strains were found to produce amylase enzyme, 20 strains protease, 27 strains lipase and 6 strains cellulase and 8 strains xylanase. Totally 21 isolates selected for further identification and different species of *Cobetia, Exiguobacterium, Bacillus, Marinilactibacillus, Staphyllococcus* and *Novosphingobium* genera from biofloc treatments were identified. In control strains of Bacillus and Exiguobacterium only observed. Among all, the genus Exiguobacterium identified in all treatments and control.

Commercialization of water analysis kit

A multi-parameter portable water analysis kit for dissolved oxygen, ammonia (0.1 to 2 ppm), nitrite (0.05 to 1 ppm), calcium & magnesium minerals, total hardness, carbonate, bicarbonate and total alkalinity in different source and pond waters of varying salinity has been developed and commercialised to New Bio Science Company, Mysore.

Aquaculture planning web tool

CarryCap – An online aquaculture planning web tool for the estimation of carrying capacity of water bodies was developed and being used for the aqua zonation work by AP State Govt. for optimization of aquaculture development and to avoid conflicts among resource users.

Soil water health cards and Location Specific BMPs

About 55 Soil water and water health cards were distributed to aqua farmers of Chidambaram and Nagapattinam Districts, TN. The SWHCs database has been analysed to capture the geographical variation which helps in framing Location Specific BMPs.

Nutrient dynamics under different culture practices

Study on *P. vannamei* culture under simulated earthen and lined tanks under 25 ppt salinity with zero water exchange showed that water quality is comparatively better in lined ponds especially redox potential and metabolites were low in the lined ponds. However, the growth rate was 21% high in earthen ponds.

Adaptation of *P.vannamei* under a sudden change in climate

Study on the adaptability of *P. vannamei* under the sudden decrease of salinity from 25 to 5 ppt revealed that although the water osmolality varied drastically, serum osmolality varied within a short range of 510-687 mOsmol/kg at 5 hrs and still the range reduced and stabilized (639-665 mOsmol/kg) at 24 hrs. It shows that *P. vannamei* is able to adapt quickly to changes in salinity due to its osmoregulatory capacity

Effect of clay polymer adsorbent on growth and nitrogen metabolite concentration in *P.vannamei* culture

Application of clay polymer composite @ 2.5g/ 100 litre at weekly interval to *P.vannamei* culture reduced the TAN by 88.3 and 78.9 percent during the first week and it reduced to 45.1

and 43.2 percent in the last week at lower (60 and 90 no/m^2) and higher stocking density (90 no/m^2), respectively.

Effect of oxygen releasing compound on water quality

Application of developed oxygen releasing product at 3, 4 and 5 kg/ha enhanced the dissolved oxygen level to 7.5, 9.2 and 12.1 ppm, respectively and reduced the total ammonia nitrogen to 0.025 from 0.125 ppm after 2 hrs of application. Based on the DO levels and other water quality products, the optimum dose was found to be 3 kg/ha.

Assessment of suitable sites for inland saline aquaculture in Punjab and Haryana

The salinity, pH, hardness and alkalinity of inland saline waters from selected districts of Punjab and Haryana ranged from 2-20 ppt, 7.2 to 8.3, 540-6570 ppm and 126-601 ppm respectively. The source waters are rich in calcium but deficient in magnesium and potassium warranted for mineral supplementation. The water-soluble and exchangeable potassium of inland saline soils of Rajasthan varied between 15 to 223 kg/ha and 27 to 814 kg/ha.

Mycotic bioremediation of total ammonia nitrogen in varying water salinity

In vitro studies were conducted on mycotic bioremediation of total ammonia nitrogen (1 and 2 mg $^{l-1}$) using the *Pleurotus species* in different salinities of 1, 15, 30 and 45 ppt. Total ammonia nitrogen showed a reduction of more than 80% in 1, 15 and 30 ppt and less than 80% in 45 ppt within 72 hrs.

Carbon dynamics in relation to other nutrients in shrimp aquaculture

The variation in carbon concentration along with other nutrients like nitrogen and phosphorus in pond sediments under varying in salinities were studied. The organic carbon and available nitrogen content were found to decrease with salinity, whereas available phosphorus content was observed to follow the reverse trend. The water-soluble carbon was found to increase with salinity, varying from 1.4 mg/kg to 2.5 mg/kg: WSC 45> WSC 25> WSC11> WSC 6

Role of rearing temperature on WSSV outbreak in shrimp

Shrimp in room temperature of 30^0C and 32°C experienced 100% mortality within 6 days post challenge and the dead/moribund shrimps tested 1st step positive by PCR. The shrimps reared at 34 and 35°C experienced 0% and 7% mortality respectively and both were 2nd step positive. The study confirms the role of temperature on WSSV infectivity and mass mortality.

GHG emission in aquaculture ponds

P.vannamei culture pond soils during the fallow period after the first and second months of harvest exhibited more GHGs emission, particularly CO_2. Drying practice followed by liming contributed more to global warming potential. During the culture, the inclusion of 40% Fermented soybean meal and Bacillus strains at the dose of 10^6 CFU/ml as dietary and microbial interventions mitigated the emission of N_2O compared to CO_2 and CH_4.

Application of brown seaweed extract as growth promotor for shrimp

Brown seaweed (*Ascophyllum nodosum*) extract was used as growth promoter for shrimp juvenile. The shrimp fed with the micro algal preparation registered 20% higher growth at three-fold dilution. However, higher concentration of seaweed extract had negative effect on growth and survival.

Feed supplemented with lactic acid bacteria improve growth and survival of *P. vannamei*

A feeding trial was conducted on *P. vannamei* with feed supplemented with two isolates of lactic acid bacteria (LAB) viz., *Lactococcus lactis* subsp. *lactis* SDKRC-5 and *Lactobacillus* isolate (SDKRC-6). After 63 days of feeding trial, the LAB supplemented group recorded 14% higher growth and 10% enhanced survival over the control.

Emamectin benzoate effective against crustacean parasitic infestation in Asian Seabass

A therapeutic trial with emamectin benzoate (EB) against *Caligus minimus* infestation in Asian seabass provided 92% improvement in survival and reduction in parasitic load after fifth day of treatment. No parasite could be recovered after 7^{th} day of treatment, suggesting that EB could be employed in controlling parasitic infestations in finfish.

Influence of pH on oxytetracycline (OTC) degradation under varying salinities

A study on influence of pH and salinity on OTC degradation in seawater was carried out. The degradation of OTC was faster at lower pH compared to higher pH irrespective of the salinity.

Withdrawal of chloramphenicol in shrimp muscle tissue

Withdrawal period of chloramphenicol in *Penaeus vannamei* was studied by feeding commercially available feed coated with chloramphenicol at 500 mg kg^{-1} feed for 7 days.

Post cessation of chloramphenicol feeding, the concentration in the muscle tissues dropped drastically within two days (0.64±0.08 ppm) with complete elimination of residue by 20 days.

Release of diagnostic, preventive and therapeutic technology for aquatic diseases

Aquatic Animal Health division of CIBA released several technologies related to diagnostics (Improved WSSV real time PCR kit and EHP real time PCR kit), preventive (CIBAMOX – water probiotic) and therapeutic (Lumiphage – for control of Vibrios). The Improved WSSV real time PCR kit and EHP real time PCR kit was commercialized to Coastra Biosolutions Pvt. Ltd., Chennai and CIBAMOX to Tata Rallis (India) Ltd, Mumbai. For further, improvement of Lumiphage technology, an MOU was signed in association with IIT-M and TATA Rallies India Ltd.

National Referral Laboratory for Brackishwater Aquatic Animal Diseases

Aquatic Animal Health and Environment Division of CIBA is serving as National Referral Laboratory for brackishwater aquatic animal diseases. As part of Aquatic Quarantine and Certification Services (AQCS), a total of 63 samples including imported *Artemia* cyst, frozen tissue and feed samples were tested during 2018-19 for OIE listed shrimp and fish pathogens. All the samples were tested negative for OIE listed pathogens.

A novel method of converting fish waste to plankton booster, Plankton^{Plus}

An effort was put by CIBA for cleaning the fish market to diminish sanitary problems due to fish waste through its transformation into products, branded as Plankton^{Plus} having protein content of 47-49% and lipid of 20-22%, which can be used for boosting plankton in aquaculture pond or as ingredients for feed formulation and also as manure for agriculture/horticulture.

Effect of Plankton^{Plus} application on plankton status and growth performance of *shrimp/fish*

Plankton^{Plus} supplementation @20 ppm with split application significantly ($P<0.01$) increased the average daily gain, specific growth rate, total biomass gain and survival of *P. vannamei* even when 30 % less feed was offered. Whereas, Plankton^{Plus} supplementation at the same dose can save 50 % of feed without affecting growth performance and survival of *Chanos*

chanos. Plankton^{Plus} supplementation helped to increase the density of beneficial microalgae like Bacillariophyceae, Prasinophyceae, and Dinophyceae, etc. and zooplankton.

Live feed enrichment

Plankton ^{Plus} supplementation can improve artemia biomass production and reduce the usage of algae by 50 % for artemia culture. Thraustochytrids, unicellular monocentric fungi-like protists, rich in PUFA can be used for enriching artemia being used for larval rearing of finfish and shellfish.

Evaluation of newer feed ingredients and feed additives for use in aquafeeds

Weevil infested sweet potato, yeast fermented groundnut cake, *Leucaena leucocephala* leaf meal can be incorporated 5 to 10% in shrimp and fish diet. Seaweed, *Gracilaria tenuistipitata* was found to have the potential to be used as a natural binder in shrimp diet.The study revealed that C-Phycocyanin extracted from spirulina can be incorporated @750 to 1000 ppm in the shrimp feed formulations for boosting growth and immunity. Study also revealed that 0.4 % of krill oil might be incorporated in the diet of *Penaeus vannamei* juveniles for getting better growth and survival.

Demonstration of feed and novel products developed by CIBA

There was a significant increase (12.31%) in survival, and enhancement of *P. vannamei* yield to the tune of 1.71 t/ha in pond supplemented with Plankton ^{Plus} compared to control. Enhanced growth performance of *Penaeus vannamei* might be due to the augmented density and diversity of phytoplankton (Bacillariophyceae, Prasinophyceae, and Dinophyceae, etc.) and zooplankton in the Plankton^{Plus} supplemented ponds. Demonstration of crab (*Scylla serrata)* culture in open water cages revealed that total biomass harvested was higher (7.27 kg) in bottom cages fed pellet feed. Crab (*Scylla olivacea)* culture in box with formulated feed showed similar ovary weight gain and gonadosomatic index when compared with low-cost fish.

Effect of various feeding regimes on the physiological characteristics of captive *Penaeus indicus* broodstock: This study was carried out to evaluate the effect of different levels of maturation diet (5%, 15% and 25% of body weight per day) and captive rearing on physiological changes such as growth, molting rhythms and maturation hormone levels of captive *P. indicus* broodstock. Molting frequency was found to be higher at treatment group

fed at 15% of body weight. Further, after 45 days of captive rearing, this treatment group had the minimum GIH mRNA level.

Optimization of nutrient requirements and feed development

For the development of milkfish larval feed, the requirement of taurine and Vit E (α-tocopheryl acetate) were optimized and were found to be 1 % and 196–218 ppm of feed, respectively. Larval feed developed for Asian seabass (Seebass Larvi ^{plus}) showed higher growth performance while compared with commercial feed available for larval rearing of seabass.

For the development of broodstock diet of hilsa, mobilization of fatty acids in hilsa during different stages of maturity has been studied. It was found that even though arachidonic acid (C20:4) is the least mobilized fatty acid from the muscle, it is the highest retained (96%) in the ovary whereas the palmitoleic acid (C16:1) is the highest mobilized fatty acid, but its retention in the ovary is the lowest (22.7%).

Feed management options

Effect of delayed initial feeding on growth and survival of milkfish, *Chanos chanos* larvae has revealed that the feeding of milkfish larvae must be initiated at 24 h post-hatching for getting better growth and survival. Study on shrimp culture in Aqua mimicry system revealed that natural feeds concentration available in the system could help only to realize a good growth performance in lower stocking densities. The shrimp which had access to biofloc & feed had a maximum final weight (19.58g) and survival (>90%) compared to the shrimp (4.19g) which had access to the only biofloc generated by using ground rice bran as organic carbon source.

miRNAs expression profiling during WSSV infection

In recent years, the importance of viral and host microRNAs (miRNA) in mediating viral replication and control of host cellular machinery, has been realized and increasing efforts have been taken in order to understand the interactions of miRNAs from host and pathogen during infection. small RNA sequencing was performed to identify the miRNAs involved in shrimp (Penaeus vannamei) immune responses under WSSV infection condition. The expression profiles of miRNAs of shrimp infected with WSSV under two contrasting conditions of field outbreak and controlled experimental conditions were compared and as a result, 23365 known miRNAs and 481 novel miRNAs were identified. Our study, therefore,

provides the comparative analysis of miRNA expression from shrimp during WSSV infection in two different conditions.

Contig-level assembly of *Penaeus indicus* genome with long-reads

PacBio sequence data was generated on pacific biosciences sequel platform. The 20 Kb sequencing libraries were used for sequencing where inserts over 17 Kb size were retained based on BluePippin size selection. About 20,857,430 reads of 176,539,267,324 bases length of sequence data which is equivalent to 71X coverage of genome was used for building contig-level genome with assemblers Falcon, Canu and WTDBG2. Generation of optical map and HiC data, scaffolding and chromosome linking are in progress.

dbVAST: database of variations associated with shrimp transcripts

In order to promote the search and use of potential genomic resources that could augment culture production, a database of variations associated with shrimp transcripts was created. The single nucleotide polymorphisms (SNPs) in coding sequences of three shrimp species, *Penaeus vannamei*, *Penaeus indicus* and *Penaeus aztecus* were documented and presented for browsing as a user-friendly on-line tool.

MRF: Missing Region Finder

The uniqueness of white spot syndrome virus (WSSV) genome, not exhibiting similarity to any other pathogen, has severely limited its annotation. A web tool named Missing Region Finder (MRF) was developed to gain insights in to WSSV genome. MRF compares the query genome against a reference genome to find deleted genome regions in query and tabulate the CDS in these deleted regions as per the annotations of reference genome. Thus, findings of comparative genome analysis in the annotation nomenclature of a single reference would be easily comprehensible. Such a tool has potential to sort the nomenclature issue concerning WSSV genomes, as users can compare several genomes against a single reference genome.

Phylogenomics of shrimp in suborder, Dendrobranchiata

Controversy and confusion exists among researchers on the taxonomic revision in Genus *Penaeus* sensu lato. The maximum likelihood and Bayesian phylogenetic inferences conducted on complete mitochondrial DNA genome sequences indicated monophyly of

Penaeus sensu lato. Further, the average amino acid identity (AAI) estimates also suggested monophyly of *Penaeus* sensu lato.

Sex discrimination in fish

The expression of anti-mullerian hormone (*amh*) indicated a male specific expression in grey mullet, *Mugil cephalus* and red snapper, *Lutjanus argentimaculatus* suggesting the possibility of using *amh* as sex discrimination marker in fish.

Population genetic stocks of pearlspot, orange chromide and grey mullet

The population diversity in commercially important brackishwater finfish were examined based on the analysis using mitochondrial ATPase 6/8. Significant genetic difference was observed among all the stocks of *Etroplus suratensis* examined, but isolation by distance was non-significant. Significant genetic divergence was observed between the Vembanad and Pulicat stocks of *Etroplus maculatus*. In *Mugil cephalus*, the results indicated the presence of two distinct genetic stocks along the Indian coast, one between Odisha and Kerala and the other between (Goa and Gujarat).

Growth performance of Pearlspot full-sib families

Growth performance of two pearlspot (*Etroplus suratensis)* full-sib families recorded indicated higher coefficient of variation (CV) for body weight than the total body length in both the families.

Population genetic structure of Indian white shrimp across Indian coast using microsatellite markers

Comparison of 7 loci microsatellite data in *P. indicus* along Indian coast revealed that the Chennai and Quilon stocks differed significantly from other stocks. This information would be helpful in conservation and stock specific selective breeding programmes.

First record of the Javanese ricefish, *Oryzias javanicus* (Bleeker, 1854) (Beloniformes: Adrianichthyidae) in the natural waters of India

The distribution of *O. javanicus* in the natural waters of the Indian peninsula was confirmed for the first time bringing the number of *Oryzias* species recorded from India to five. The presence of yellowish sub-marginal bands on the dorsal and ventral sides of the caudal fin makes it easily distinguishable from other Indian species. The nucleotide genetic distance between the populations occurring in India and Indonesia was found to be indistinguishable.

CRISPR-Cas9 mediated genome engineering for growth improvement of *Etroplus suratensis*

Experiments were conducted to disrupt the myostatin gene in *Etroplus suratensis* using CRISPR/Cas9, a powerful tool for targeted genome editing. Fertilized eggs were microinjected with CRISPR/Cas9 protein and the embryonic development was documented.

Introduction

As the global demand for seafood is increasing every year against the plateauing wild fishery catches, aquaculture is looked up to with a lot of hope and responsibilities. Aquaculture is the fastest growing food-producing sector across the world currently produces 47 percent of food fish for the world, and it supplies over 60 percent of food fish to the Asian population. India is the second largest producer of farmed fish and offers a vast potential for aquaculture development and doubling the farmer's income. Though aquaculture is possible in all types of water resources (freshwater, brackishwater and seawater), the pressure on freshwater resources due to multi-user demands and climate change-related impacts constraint its expansion in the freshwater sector, hence the future aquaculture development is expected to occur mostly in salty brackishwater.

Out of a total 3.9 million ha of the brackishwater area estimated, 1.2 million hectares of coastal saline lands have been identified to be potentially suitable for brackish water farming. Also, about 9 million hectares of salt-affected inland soils in the hot semi-arid and arid ecoregion of northern plains and central highlands in the states of Haryana, Rajasthan, Punjab, Uttar Pradesh, Maharashtra and Gujarat are found suitable. Estimates show that only 11% of the potential coastal area available is utilized for farming. Hence this resource assessment was done long back, CIBA targeted to re-estimate the potential brackishwater resources with the advent of advanced satellite mapping and GIS tools. This mapping will help in planning for future expansion and management of brackishwater farming.

It is inspiring to witness the spectacular growth of this industry in India, spearheaded by shrimp farming with an export of about 7 billion US$ plus in 2017-18, which was only a nascent industry during the early 1990s. The aquaculture sector is also confronting severe challenges, such as the impact of climate change and variability, disease outbreaks, environmental degradation, increasing input costs, anthropogenic activities, and related social and economic changes, increasing intra-regional trade and public health concern over food safety. Therefore, addressing these issues through research and development, and policy formulation is of utmost necessity.

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

Established in the year 1987, ICAR-CIBA headquartered at Chennai has its experimental station at Muttukkadu (MES), Tamil Nadu and research centres at Kakdwip (KRC), West Bengal in east coast and Navsari, Gujarat (NGRC) in the west coast. Established on 7th June 2018, research center in Navsari Gujarat (NGRC) is a CIBA's first aquaculture research center on the west coast of India. The main objective of the center is catering to the needs of aquaculture development along the west coast of India.

This annual report is a comprehensive combined report on ICAR-CIBA's research progress and administrative activities throughout the year 2018-19. Expectantly this report will provide adequate information about events, performance, and contribution to the brackishwater farming sector.





Vision

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

Mission

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

Mandates

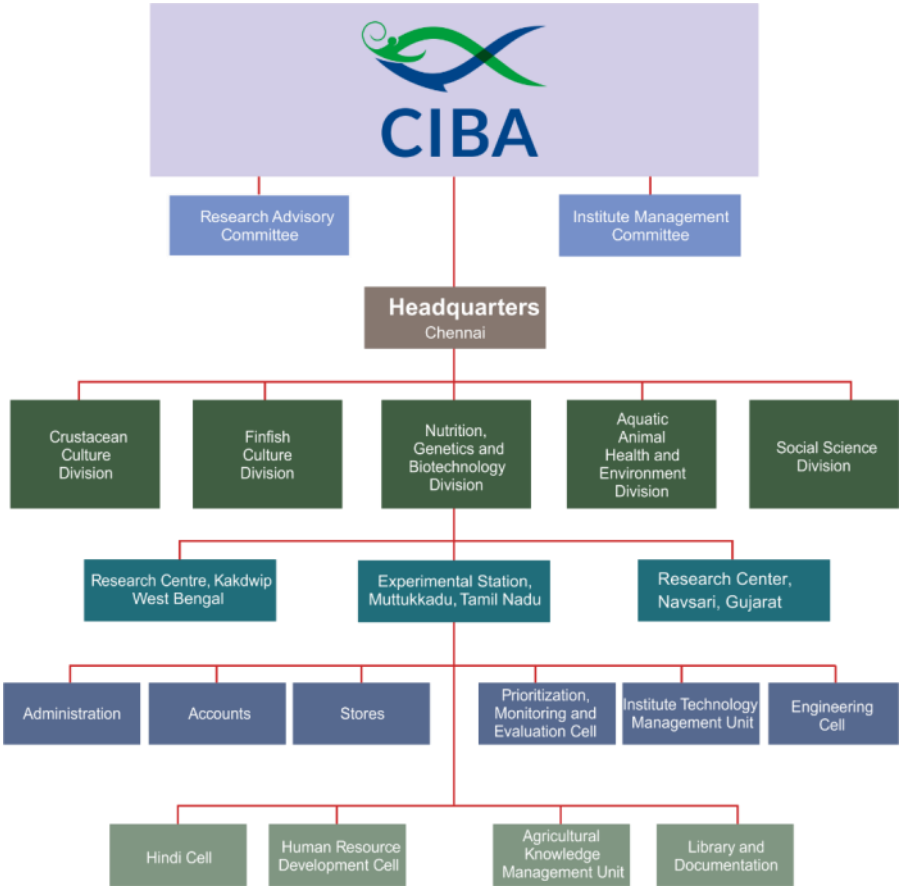
Basic, strategic and applied research for techno-economically viable and sustainable culture systems for finfish and shellfish in brackishwater.

Species and systems diversification in Brackishwater aquaculture

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

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

Organizaton chart



Unified Budget of CIBA for the year 2018-19

Rs. in lakhs

S.No.	Sub-Head	BE 2018-19	RE 2018-19	Actual expenditure during 2018-19
	Grants for creation of CAPITAL ASSETS (Capital)			
1	Works - Office building	220.00	139.00	139.00
2	Equipments	68.00	72.86	72.85
3	Information Technology	15.00	15.00	15.00
4	Library Books and Journals	10.00	10.00	10.00
5	Furniture & Fixtures	7.00	6.99	6.99
	Sub-total (A)	**320.00**	**243.85**	**243.84**
	Grants in Aid - SALARIES (Revenue)			
1	Establishment Expenses - Salaries	1797.00	2390.00	2389.96
	Sub-total (B)	**1797.00**	**2390.00**	**2389.96**
	Grants in Aid - GENERAL (Revenue)			
1	Pension & Other Retirement Benefits	1550.00	2071.00	2070.99
2	Traveling Allowances	30.00	35.00	35.00
3	Research & Operational Expenses	216.00	216.00	216.00
4	Administrative Expenses	1061.00	770.73	770.73
5	Miscellaneous Expenses (HRD & Others)	18.00	19.00	19.00
	Sub-total (C)	**2875.00**	**3111.73**	**3111.72**
	TSP			
1	Capital	36.00	17.00	17.00
2	Revenue	26.00	32.00	32.00
	Sub-total (D)	**62.00**	**49.00**	**49.00**
	SCSP			
1	Capital	0.00	26.15	26.11
2	Revenue	0.00	94.27	94.27
	Sub-total (E)	**0.00**	**120.42**	**120.38**
	GRAND TOTAL (A+B+C+D+E)	**5054.00**	**5915.00**	**5914.90**

Staff Position

(as on 31.03.2019)

Category	Sanctioned	Filled	Vacant
Director	1	1	0
Head of Divisions/Principal Scientist	5	1	4
Senior scientists	10	6	4
Scientists	52	59	(+) 7
Technical Officers / Technical Assistants	25	22	3
Administrative Officer	1	0	1
Finance & Accounts Officer	1	1	0
Deputy Director (OL)	1	0	1
Assistant & Administrative Officer	3	3	0
Junior Accounts Officer	1	1	0
Private Secretary	1	1	0
Personal Assistants	2	2	0
Stenographers Gr. III	1	1	0
Assistants	7	6	1
Upper Division Clerks (UDC)	3	3	0
Lower Division Clerks (LDC)	5	2	3
Skilled Support Staff	55	25	30
Grand total	174	134	47

On-Going Research Projects

Crustacean Culture Division

Institute Funded Projects

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

Externally Funded Projects

	Project Title	Funding	Project team
	Upgradation of breeding P. *indicus* through stock evaluation and culture demonstrations	NFDB	PI: Dr. A. Panigrahi Co-PIs: Dr. G. Gopikrishna, Dr. S. Kannappan, Dr. P. Mahalakshmi, Dr. K.P. Kumaraguru vasagam, Dr. K. Vinaya Kumar, Dr. P. Shyne Anand, Ms. L. Christina
	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

	Evaluation and refinement of indigenous automatic feeder for shrimp farming	NFDB	**PI: Dr. P. Nila Rekha** **Co-PIs:** Dr. K. Ambasankar
	Healthy shrimp and 'GIFT' tilapia production through bio-floc based farming system: Development of technology and standard operating procedure	DBT	**PI: Dr. A. Panigrahi** **PI: Dr. S. Felix, VC, TNJFU** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. P. Nila Rekha, Dr. K.P. Kumaraguru Vasagam Dr. Antony Cheryl, TNJFU Dr. A. Gopalakannan, TNJFU
	Optimization of aerators use to reduce production cost of shrimps under different brackishwater farming conditions	NFDB	**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. T. Ravisankar, Dr. M. Muralidhar, Dr. R. Saraswati, Dr. Aritra Bera
	Mapping of coastal resources and identifying suitable areas for expanding Integrated Multi-Trophic Aquaculture (IMTA) in Maharashtra	IMTA Maharashtra	**PI: Dr. M. Jayanthi** **Co-PIs:** Dr. C.P. Balasubramanian Dr. M. Muralidhar, Dr.C.V. Sairam, Dr. K.P. Kumaraguru Vasagam, Dr. P. Kumararaja, Shri Pankaj Amrut Patil

Finfish Culture Division

Institute Funded Projects

Project Title		Project Team
10	Application of improved techniques for captive maturation, assessment of reproductive biology, system development of induced breeding larval rearing and seed production of brackishwater candidate finfish species	**PI: Dr. M. Kailasam** **Co-PIs:** Dr. M. Makesh, Dr. Satyanarayan Sethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Pankaj Amrut Patil, Shri Tanveer Hussain, Shri T. Sivaramakrishnan, Shri Dani Thomas, Dr. K.C.. Neethu, Shri R. Subburaj
11	Development and evaluation novel culture technologies for candidate brackishwater finfishes for sustainable aquaculture.	**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Kailasam, Dr. Satyanarayan Sethi, Dr. Krishna Sukumaran, Dr. G. Biswas, Dr. Prem Kumar, Dr. Aritra Bera, Smt. Babita Mandal, Smt. M.U. Rekha, Shri Tanveer Hussain, Shri Dani Thomas, Shri Pankaj Amrut Patil , Shri T. Sivaramakrishnan, Shri R. Subburaj

Aquatic Animal Health and Environmental Division

Institute Funded Projects

Project Title		Project Team
12	Prevention and management strategies for viral, microbial and parasitic diseases of	**PI: Dr. S. V. Alavandi**

	candidate species in brackishwater ecosystem	**Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. P.K. Patil, Dr. S. K. Otta, Dr. Sanjoy Das, Dr. P. Ezhil Praveena, Dr. R. Ananda Raja, Dr. Sujeet Kumar, Dr. T. Bhuvaneswari, Dr. Vidya Rajendran, Shri T. Sathish Kumar, Shri Mary Lini, Shri Joseph Sahaya R ajan **Associates from other division** Dr. M. Makesh, Dr. N. Lalitha, Dr. Prem Kumar, Ms. Leesa Priyadarshini, Dr. Satheesha Avunje
13	Abiotic stress management for enhanced productivity and environmentally sustainable shrimp farming	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Satheesha Avunje, Dr. Suvana Sukumaran , Dr. A. Nagavel

Externally Funded Projects

Project Title		Funding	Project team
14	National surveillance programme for aquatic animal diseases	NFDB	**PI: Dr. S. V. Alavandi** **Co-PIs:** Dr. K.K. Vijayan, Dr. K.P. Jithendran, Dr. M. Poornima, Dr. Sanjoy Das, Dr. Sujeet Kumar, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. R. Ananda Raja, Shri T. Sathish Kumar, Dr. Vidya Rajendran Dr. Joseph Sahayarajan
15	All India network on fish health	ICAR	**National Coordinator: Dr. K.K. Vijayan** **PI: Dr. P.K. Patil** **Co-PIs:** Dr. S.V. Alavandi, Dr. S.K. Otta, Dr. R. Ananda Raja, Dr. T. Bhuvaneswari, Dr. Satheesha Avunje, Dr. M. Makesh, Dr. R. Saraswathy, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. C.V. Sairam, Dr. T. Ravisankar, Dr. R. Geetha
	Consortium research platform on vaccines and diagnostics	ICAR	**Project Coordinator:** **Dr. M. Makesh**

	a. Development of RNAi –mediated prophylaxis and therapy of white spot syndrome virus (WSSV)		**PI: Dr. S.K. Otta** **Co-PIs:** Dr. S.V. Alavandi, Dr. M. Makesh
	b. Development of vaccine for betanoda virus infecting seabass, *Lates calcarifer*		**PI: Dr. M. Makesh** **Co-PIs:** Dr. M. Poornima, Dr. K.P. Jithendran, Dr. P.K. Patil, Dr. Sujeet Kumar
	c. Biocontrol of vibrios in shrimp hatcheries using bacteriophages		**PI: Dr. S.V. Alavandi** **Co-PIs:** Dr. Satheesha Avunje, Dr. Vidya Rajendran Dr. Sujeet Kumar Dr. Joseph Sahaya Rajan
	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 T. Sathish Kumar, Dr. Vidya Rajendran Dr. Joseph Sahaya Rajan
	Network project on antimicrobial resistance	ICAR	**PI: Dr. S.K. Otta** **Co-PIs:** Dr. Satheesha Avunje, Dr. Vidya Rajendran
	National Innovations in Climate Resilient Agriculture (NICRA)- Impact of climate change on aquaculture and mitigation options for minimizing green house gases from aquaculture sector	ICAR	**PI: Dr. M. Muralidhar** **Co-PIs:** Dr. M. Jayanthi , Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Dr. S.K. Otta, Shri J. Ashok Kumar, Dr. N. Lalitha, Dr. P. Kumararaja, Dr. Aritra Bera, Dr. Satheesha Avunje, Dr. Suvana Sukumaran , Dr. A. Nagavel

Nutrition, Genetics & Biotechnology Division

Institute Funded Projects

Project Title		Project Team
	Application of advanced molecular and bioinformatic tools for improvement of brackishwater fish and shell fish	**PI: Dr. G. Gopikrishna** **Co-PIs:** Dr.K.K. Vijayan Dr. M. Shashi Shekhar, Dr. Sherly Tomy, Dr. K. Vinaya Kumar,

		Dr. B. Sivamani, Dr. J. Raymond Jani Angel , Ms. Misha Soman Dr. M.U. Rekha
	Novel approaches for development and improvement of sustainable shrimp and fish feeds	**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, Ms. Leesa Priyadarsani Shri T. Sivaramakrishnan

Externally Funded Projects

Project title		Funding	Project team
	Outreach activity on fish feeds and nutrient profiling of brackishwater fish and shrimp	ICAR	**PI: Dr. K. Ambasankar** **Co-PIs:** Dr. J. Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K.P. Kumaraguru Vasagam, Ms. Leesa Priyadarshini Shri T. Sivaramakrishnan
	Outreach activity on fish genetic stocks (Lead Centre: NBFGR, Lucknow)	ICAR	**PI: Dr. G. Gopikrishna** **Co-PIs:** Dr. M. Shashi Shekhar, Dr. B. Sivamani, Dr. C.P. Balasubramanian, Dr. Sherly Tomy, Dr. J. Raymond Jani Angel , Dr. T.N. Vinay, Ms. Misha Soman
	Whole genome sequencing of Indian white shrimp *Penaeus indicus*	ICAR	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. G. Gopikrishna, Dr. C. P. Balasubramanian, Shri J. Ashok Kumar, Dr. K. Vinaya Kumar, Dr. S.K. Otta
	Poverty alleviation through prevention and future control of the two major socio economically important diseases in Asian aquaculture	DBT	**PI: Dr. M. Shashi Shekhar** **Co-PIs:** Dr. K.K. Vijayan, Dr. G. Gopikrishna, Dr. K. Vinaya Kumar, Mr. T. Sathish Kumar
	Investigations on pathogenic microorganisms of shrimp aquaculture using metagenomic and other bioinformatics approaches	ICAR	**PI: Shri J. Ashok Kumar** **Co-PIs:** Dr. S.V. Alavandi Dr. K. Vinaya Kumar Dr. Satheesha Avunje Dr. Joseph Sahayarajan

Social Sciences Division

Institute Funded Projects

Project Title		Project Team
19.	Research on socio-economics, frontline extension and information technology for	ICAR **PI: Dr. C.V. Sairam**

	sustainable brackishwater aquaculture sector	**Co-PIs:** Dr. T. Ravisankar Dr. B. Shanthi Dr. D. Deboral Vimala Dr. M. Kumaran Dr. P. Mahalakshmi Shri J. Ashok Kumar Dr. R. Geetha Dr. K.C. Neethu

Externally Funded Projects

Project title		Funding	Project team
20.	Brackishwater cage culture with multi-trophic candidate species diverse rearing systems for alternate livelihood and societal development in Maharashtra	Mangrove cell Maharashtra	**PI: Dr. C.V. Sairam** **Co-PIs:** Dr. M. Kailasam Dr. C.P. Balasubramanian Dr. Pankaj Patil Shri Tanveer Hussain Shri T. Sivaramakrishnan Shri K.P. Sandeep
21.	Cage culture in brackishwaters of Puducherry and karaikal regions of Puducherry Union Territory A – feasibility study	FIMSUL	**PI: Dr. M. Kumaran** **Co-PIs:** Dr.M. Jayanthi Dr. D. Deboral Vimala Dr. C.V. Sairam Dr. M. Muralidhar Dr. K.P. Kumaraguru Vasagam Smt. Babita Shri R. Subburaj

Kakdwip Research Centre

Institute Funded Projects

Project Title		Project Team
22.	Development and dissemination of economically viable and sustainable brackishwater aquaculture technologies for livelihood improvement of small and marginal farmers of Indian Sundarban	**PI: Dr. T. K. Ghoshal** **Co-PIs:** Dr. Sanjoy Das, Dr. G. Biswas, Dr. Prem Kumar, Ms. L. Christina, Smt. Leesa Priyadarsani

Externally Funded Projects

Project Title		Funding	Project team
23.	Elucidation of molecular mechanism of dopamine action on final oocyte maturation of Goldspot mullet (*Lisa parzia*, Hamilton, 1822)	DBT	**PI: Dr. Prem Kumar** **Co-PIs:** Dr. G. Biswas, Dr.T.K. Ghoshal

Other Projects

24.	Agri-Business Incubation centre (ABI) at CIBA, Chennai	NAIF - ICAR	**PI: Dr. T. Ravisankar** **Co-PI :** Dr. P.K.Patil
25.	Intellectual property Management and Transfer/ Commercialization of Agricultural Technology Scheme (Up-scaling of existing components i.e. Intellectual property Right (IPR)	NAIF - ICAR	**Dr. T. Ravisankar, OIC** Dr.P.K. Patil, Coordinator Divisional Members Dr. R. Geetha, SSD Dr. T.N.Vinay, CCD Dr. Raymond Jani Angel, NGBD (Genetics) Dr. K.P. Sandeep, NGBD (Nutrition) Shri Dani Thomas, FCD

RESEARCH HIGHLIGHTS

BRACKISHWATER PRODUCTION SYSTEM RESEARCH



CRUSTACEAN FARMING

Shrimp aquaculture has been mainstay of Indian aquaculture sector that accounted for almost 70% of Rs 45000 crore seafood export revenue last year. Although shrimp farming sector has witnessed spectacular growth during recent decades, it has reached almost 0.6 million ton last year, this valuable industry is currently constrained due to multiple reasons. The institute continues to conduct research efforts to improve and refine this production system.

PENAEUS VANNAMEI

Exotic Pacific white shrimp was introduced to India in 2009, and thereafter this specific pathogen free and genetically improved stock dominated shrimp farming sector in India. Although growth of industry has been spectacular during this decade, currently *P.vannamei* production systems have been facing severe challenges due to multiple reasons ranging from emergent disease to fallen market prices. During this period we have been addressing several issues in vannamei production system.



GROWTH PERFORMANCE PENAEUS VANNAMEI IN SIMULATED EXPERIMENTAL SYSTEM THAT MIMICS THE NATURAL ESTUARINE WATER CONDITION (AQUA MIMICRY)

Farming methods of shrimp is rapidly evolving by adopting advancements in the aquaculture and allied sectors. Biofloc based farming is widely practiced in intensive shrimp farming. Although biofloc technology has been successful in many cases, the operating cost of the biofloc system is exorbitantly high, and further many misconceptions exist about the biofloc technology. A potentially more balanced approach is the use of biofloc and natural biota together, aquamimicry. To evaluate the potential of aquamimcry in shrimp production system a 90-day feeding trial with vannamei shrimp juveniles (70 shrimps/m^3) in outdoor microcosm was conducted. There were four treatments with different feeding regime; control

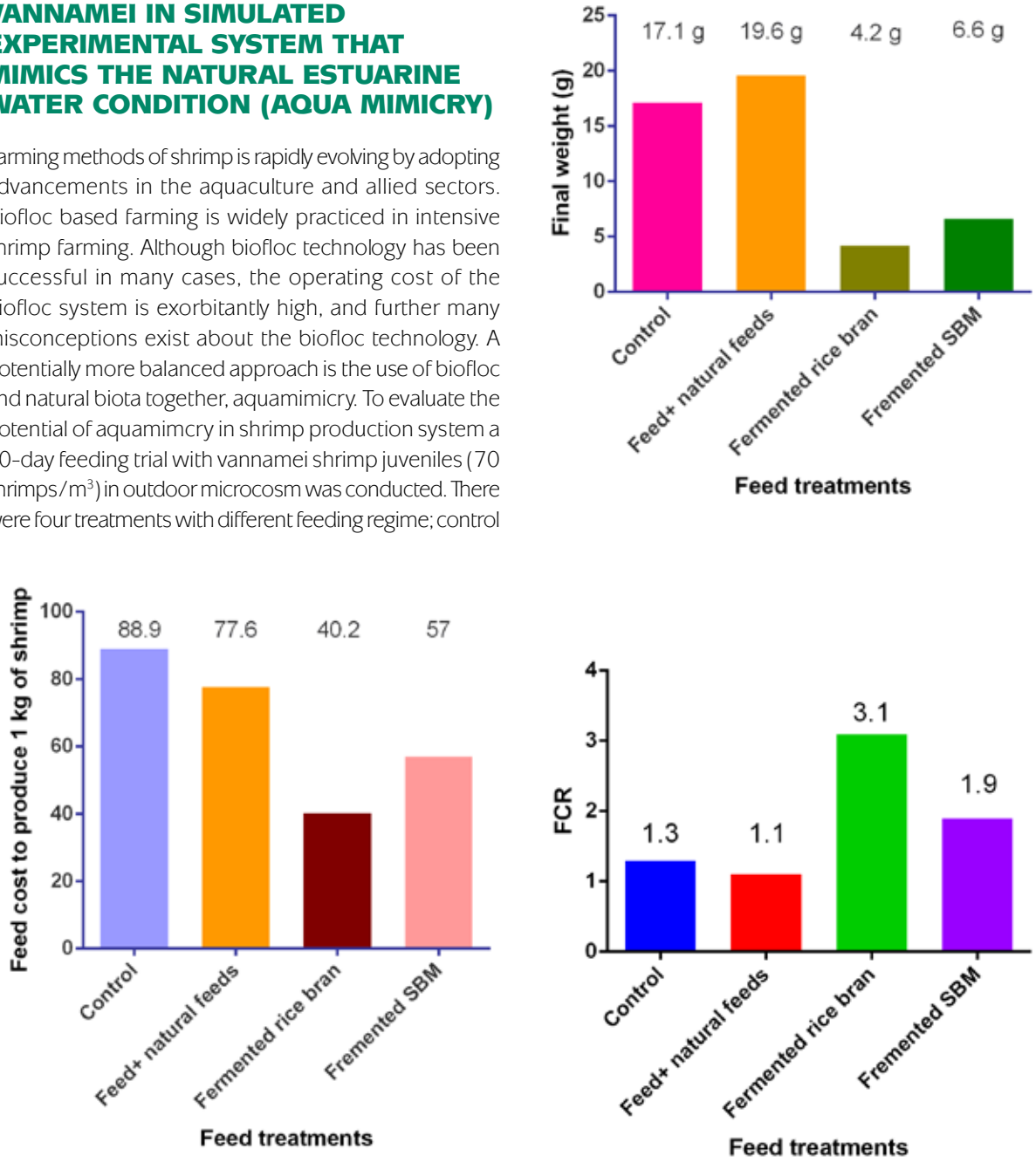


Fig 1 Key growth performance indicators of shrimp under different feeding regimes

(Clear water only with formulated feed), natural feed with formulated feed, fermented rice bran and fermented soybean meal. Rice bran and fermented soybean meal were used as carbon source for biofloc formation. Self-cleaning microcosm tanks served as rearing system. **The shrimp which had access to biofloc & feed had a maximum final weight (19.58g) and survival (>90%) compared to the shrimp (4.19g) which had access to only biofloc generated by using ground rice bran as organic carbon source**. The results of this study will be useful in further fine tuning the nutritional elements in the practical shrimp feed, and cost can be further reduced without compromising the growth performance of the shrimp.

AQUAMIMICRY: EFFECT OF DIFFERENT SHRIMP STOCKING DENSITY

Shrimp stocking density is known to have much impact on the utilization of feed and growth performance of the shrimp. Farmers do shrimp farming in varying densities ranging from 30 to 90 shrimps per square meter. In this experiment we evaluated the influence of stocking density in the absence of feed in the system which is rich in natural feeds. A 72 day feeding trial was conducted with shrimps post larvae of 18 days age. Stocking densities such as 10, 20, 30, 40 and 50 shrimps per meter square were evaluated. To have uniform natural feeds in the form of biofloc, mixture of SBM+ RB fermented for 24 hours was used as carbon source. Self-cleaning microcosm tanks served as rearing system. This study concludes that there is an apparent direct correlation between stocking density in the absence of feed. It indicates that **natural feeds concentration available in the system could help only to realize a good growth performance in lower densities and not higher densities**. Therefore, this study establishes that biofloc based natural feed not only play role in maintaining water quality in zero water exchange-based system, but also contribute to the nutrition of the shrimps reared. Planning of feed ration for this kind of systems should be adjusted considering the natural feeds to have cost saving.

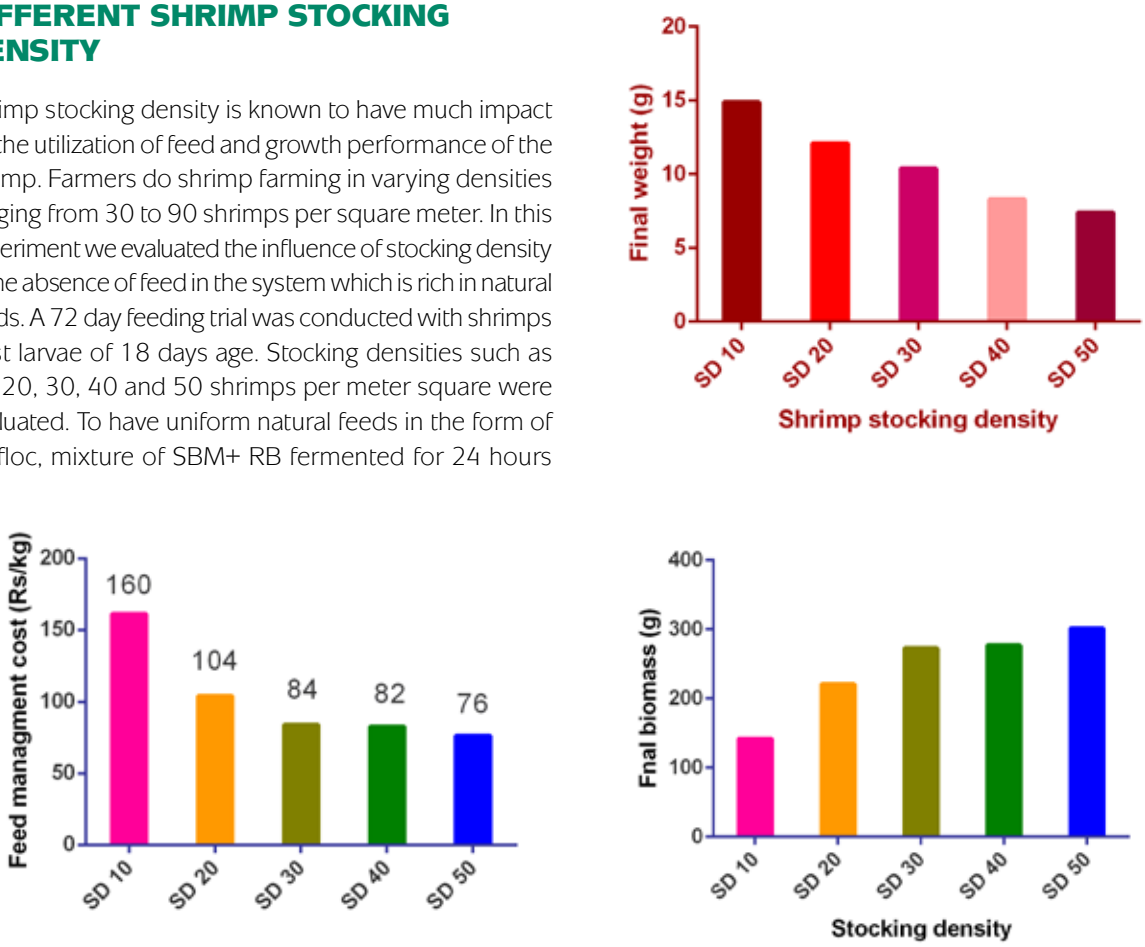


Fig 2 Growth performance of the shrimp at different stocking densities

COMPENSATORY GROWTH IN SHRIMP VANNAMEI

Compensatory growth is already proved in fishes. However, the reports on such a compensatory growth in shrimp are clashing. In fact, this kind of compensatory growth is beneficial for the farmers in management point of view. Therefore, to confirm the presence or absence of compensatory growth this study was conducted with stunted shrimp from the aqua mimicry feeding trials. Here the shrimps were brought to normal feeding regime as our standard shrimp feeding chart. The growth performance was observed for another 55 days. Self-cleaning microcosm tanks served as rearing system. The stunted shrimps were found to have faster growth compared to the normal shrimps. **The weekly weight gain in the stunted shrimps was more than 3 g per week, while it was only around 1.6 g per week in the normal shrimps**. Compensatory growth in shrimp is evidenced from the results of this study.

PLANKTON PLUS: A COST EFFECTIVE PLANKTON BOOSTER IN VANNAMEI FARMING:

The recycling of the waste in the fish market and landing centres into useful product is one of the efficient management measures to improve the

ecosystem health and diversification of livelihood of coastal fishers. Almost 25 to 50% of fish in the fish markets becomes waste; the institute has made an efficient method to transform these wastes into a useful commercial product, a plankton booster ('Plankton Plus') in aquaculture ponds

A 77 days trial was conducted in *Penaeus vannamei* ponds at Bapatla, Andhra Pradesh, India to study the effect of Plankton Plus on augmenting plankton in shrimp culture pond. Plankton Plus was supplemented @ 10 ppm in split doses. Control ponds were supplemented with rice bran-yeast-mollases juice and dolomite as and when required to maintain the bloom and water quality. At the end of the culture period, average weight of shrimp was higher (11.82 g) in pond supplemented with Plankton Plus compared to control (9. 93 g). There was a significant increase (12.31%) in survival, and enhancement of yield to the tune of 1.71 t/ha in pond supplemented with Plankton Plus compared to control. Plankton Plus supplemented ponds were dominated by beneficial microalgae (Bacillariophyceae, Prasinophyceae and Dinophyceae etc.) and zooplankton. Enhanced growth performance of Penaeus vannamei might be due to the augmented density and diversity of phytoplankton and zooplankton in the Plankton Plus supplemented ponds.

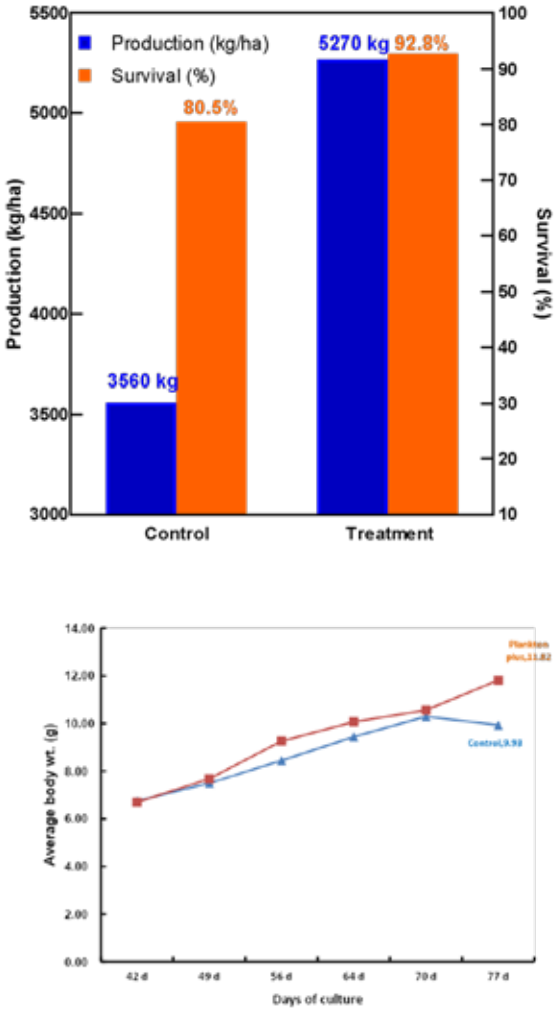


Fig 3 Production performance in control and Plankton plus treated ponds



Fig 4 Sampling of Experimental ponds



Fig 5

BIOFLOC BASED NURSERY REARING TECHNOLOGY FOR *PENAEUS VANNAMEI*

Biofloc technology has been an emerging alternative towards the environmental friendly aquaculture. This technology is characterized by reduced water exchange, reduced feed use and improved biosecurity. In order to develop a cost effective nursery system, the institute has conducted two demonstration trials at farmers' field in Odisha. *Penaeus vannamei* PL were reared at a stocking density3500 PL/m2 in 350 mt capacity nursery tank designed by the institute for a period of 28 days. Nursery reared animals were grown up to 0.92 ± 0.15 g with a survival of 94.20± 2.86 %)



Fig 6 Biofloc based nursery tanks

In an another demonstration trials at Andhra Pradesh, two stage nursery system were demonstrated with first phase (N1) for 10days with high stocking (20000 to 30000nos per cum) followed by second phase (N2) for 15 to 20 days with stocking of up to 7000 individuals and finally harvested at ABW 250 – 350 mg within 4 weeks. The CN ratio manipulation with addition of carbon sources customized with biofloc consortium could induce bacterial flora to reduce the nitrogenous metabolites like TAN, Nitrite and Nitrate

ISOLATION AND CHARACTERIZATION OF GUT MICROBES: THEIR EFFECT ON GROWTH, WATER QUALITY, MICROBIAL DYNAMICS AND ENZYME ACTIVITIES:

Experiment conducted with four different treatments: carbon sources with probiotic consortium, probiotic consortium without biofloc, sugar and probiotic consortium, mixed carbon sources without probiotic consortium and a set of control tanks were reserved without biofloc treatments. The result revealed that the survival rate of mixed carbon sources treated tanks were elevated (80%) contrasting other treatments (76%), while, control showing relatively low survival (67%). The ABW were relatively higher in biofloc treated tanks compared to control. The Biofloc treated shrimps were found to be colonized with beneficial bacteria in the gut region. Among the enzymatic microflora, amylase producer is common in all the treatments and control. Likewise, other enzyme such as protease, lipase, cellulase and xylanase producers were found high in biofloc treated tanks specifically higher in mixed carbon sources treatment. The gene expression study showed relative expression levels of potential immune genes were significantly up-

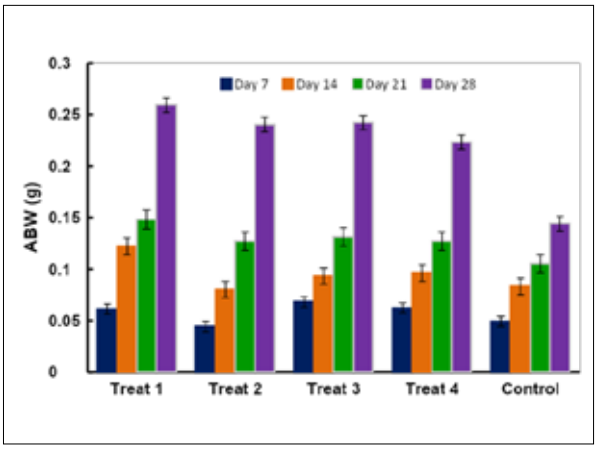


Fig 7. Average body weight of Penaeus vannamei post larvae reared in different treatments

regulated in shrimps grown in biofloc system, particularly with mixed carbon sources, than the control. The Biofloc system is advantageous and allows to colonized beneficial bacterial population in the gut region. Out of 94 strains screened, 36 strains were found to produce amylase enzyme, 20 strains protease, 27 strains lipase and 6 strains cellulase and 8 strains xylanase. Totally 21 isolates selected for further identification and different species of *Cobetia, Exiguobacterium, Bacillus, Marinilactibacillus, Staphyllococcus* and *Novosphingobium* genera from biofloc treatments were identified. In control strains of *Bacillus* and *Exiguobacterium* only observed. Among all, the genus *Exiguobacterium* identified in all treatments and control.

EVALUATION OF AQUA-MIMICRY TECHNOLOGY ON GROWTH PERFORMANCES, WATER QUALITY AND IMMUNE RESPONSES IN RAS ENVIRONMENT

A RAS based nursery rearing was carried out with addition of carbon source and rotifer as feed supplement. The survival and growth was monitored every 15 days in each treatment. The treatments included as C: control, T1 : only Biofloc, T2: Biofloc and rotifer , T3: only Rotifer. At the end of Experiment the rotifer with biofloc condition showed better growth (3.89±0.25) and survival (91%) which is

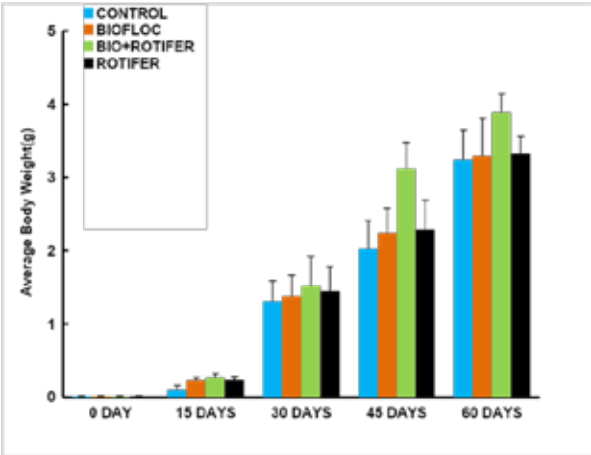


Fig 8 Growth performance of Penaeus vannamei in Aqua mimicry experiment

significantly different from control animals(3.24±0.29, 85%). The rotifers culture added @ 2 litre/tank in two split dose, one at morning and other at afternoon. The rotifers were cultured with standard procedure by giving chlorella as feed. The rotifers collected by scooping with 200um mesh hand net from cultured tanks.

NUTRIENT DYNAMICS UNDER DIFFERENT CULTURE PRACTICES

Shrimp aquaculture is generally practiced in the coastal zone owing to the availability of the brackishwater. However, some of aquaculture ponds constructed in these areas are swampy or sandy, that type of soils do not hold sufficient water level. Further some of these soils are acid sulphate, which is characterized by low pH level Use of plastic pond liners are reported to be effective management scheme to separate the pond and soil. This study was aimed to evaluate the water quality and production performance of *P. vannamei* in a plastic lined system. *Penaeus vannamei* (~4 g) post larvae were stocked in 500 L simulated earthen and lined tanks (40 shrimps per tank) at 25 ppt salinity. The treatments were replicated thrice and no water exchange was carried out during the experimental period. After 50 days of rearing the growth rate was 21% high in earthen ponds. Dissolved oxygen was higher in lined tanks than earthen. In both the practices, the negative value of redox was recorded after 10 DOC and the values were comparatively high towards the positive side in lined ponds whereas, there was no trend in temperature. There was a significant decrease in total alkalinity (282-175 ppm as $CaCO_3$) as culture progressed in lined ponds. Total hardness varied from 5170-5610 and 5133 to 6673 ppm as $CaCO_3$ in lined and earthen ponds respectively. Increase in metabolites with DOC is comparatively lower in lined ponds.

Comparison of metabolites and nutrients under lined and earthen ponds

Characteristics	Lined pond	Earthen pond
DO (ppm)	5.3-6.4	4.9-5.9
TAN (ppm)	0.065-0.941	0.06-1.202
NO2 (ppm)	0.068-0.714	0.077-0.895
NO3(ppm)	0.7-1.5	0.7-1.8
PO4(ppm)	0.2-2.9	0.2-1.9

ADAPTATION MECHANISM OF *P. VANNAMEI* UNDER VARIOUS SALINITIES

In continuation of the last year's work to evaluate adaptability of *P.vannamei* from fresh water to high salinity of 50 ppt, animal samples were collected from field at periodical intervals and osmolality was analysed in both water and serum. The mean water osmolality was

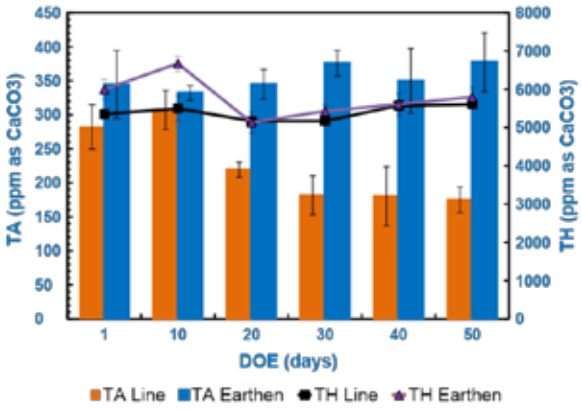


Fig 9 Total alkalinity and total hardness in the lined and earthen ponds

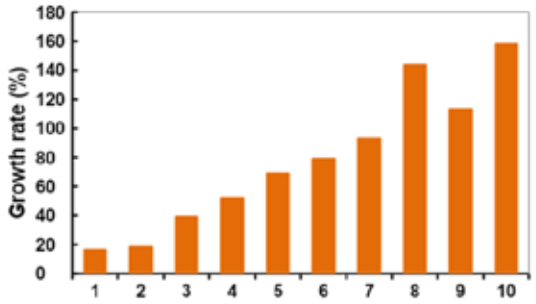


Fig 10 Growth rate of Penaeus vannamei in simulated lined and earthen experimental system

21, 90, 534 and 1587 mOsmol/kg under 0, 4, 18 and 50 ppt salinity respectively. However, serum osmolality variation was lower and it was 614, 678, 714 and 1155 mOsmol/kg at 4, 18 and 50 ppt salinity respectively. Due to the osmoregulatory capacity of *P. vannamei*, it adapts and grows under varying salinities without much stress. The iso-osmotic point is 858 and it fits under polynomial 2nd order regression equation (R^2: 0.9794).

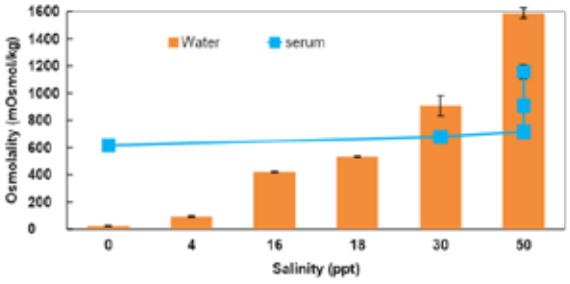


Fig 11 Influence of salinity on water and serum osmolality

PENAEUS INDICUS



POLYCULTURE OF INDIAN WHITE SHRIMP (*PENAEUS INDICUS*) AND MILKFISH (*CHANOS CHANOS*)

Polyculture of shrimp has been proved to be viable alternative to reduce the nutrient waste from the aquaculture facilities and to optimize the economy shrimp farming. In order to evaluate the production performance of polyculture of *P. indicus* and *C. chanos*, a 75 day culture experiment was carried out at the earthen ponds in Kakdwip Research Centre of CIBA (KRC of CIBA). *Penaeus indicus* was stocked (25 PL/ m^2) along with milk fish at two stocking densities (0.25 ind/m^2 and 0.50 ind/m^2), and reared for 75 days. The production performance was compared with monoculture *P. indicus* at the same density. Highest survival (79.33± 1.88 %) and production (1451.28± 22.15 kg/ha) of shrimp was recorded in the pond which *P. indicus* reared with milkfish at a stocking density of 0.5 ind. /m^2, although significantly higher average body weight obtained at the pond stocked with milkfish at a stocking density of 0.25 m^2. No significant ($p < 0.05$) difference in the load of total heterotrophic aerobic bacteria (THAB) and total Vibrio (TV) was observed between polycultured and monocultured ponds. However, significantly higher TAN and NO_2-N were recorded in the control monoculture pond. This study indicates the potential of system diversification for optimizing economics of pond culture and to keep the environmental wellbeing of the pond system.

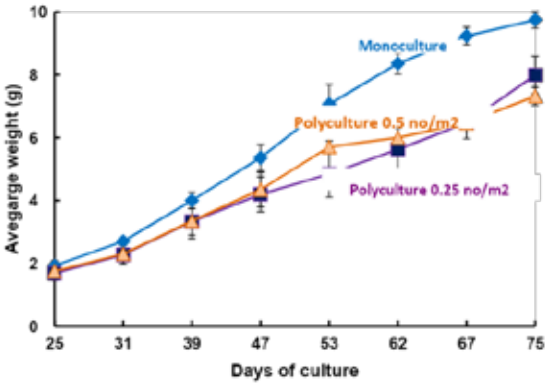


Fig 12 Penaeus indicus: Production trials at different salinities.

In order to evaluate the production performance of *Penaeus indicus* at different salinities, field levels trials were carried out at different coastal regions, where salinity ranges from 1 to 60 ppt. Production performance was almost similar at lower and higher salinities. Further, average daily growth rate (ADG) was found to be similar at all the salinities except 60 ppt, where adg was almost half compare to other salinities irrespective of lower and higher.

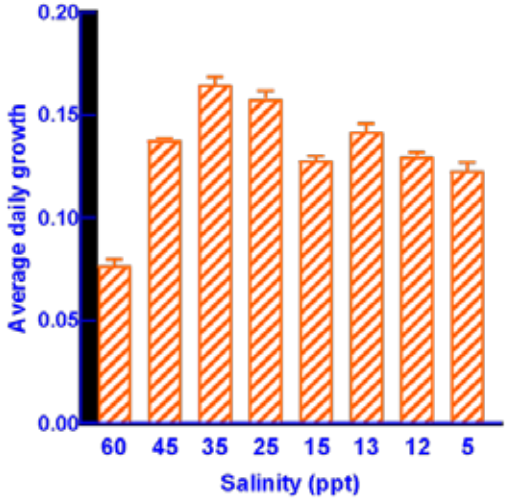


Fig 13: Average Daily growth observed during culture of P.indicus in different salinities.

DEMONSTRATION OF INDIAN WHITE SHRIMP CULTURE ACROSS DIFFERENT LOCATIONS

To further refine the performance of Indian White Shrimp *Penaeus indicus* with indigenous technology using 'indicus *plus*' (35% CP) feed, high density culture carried out in farmers' ponds ha in Andhra Pradesh. At the end of 100 -110 days of culture period, a final body weight of 17-19g with a survival up to 85--98 % and a production ranging from 3 to 4.5 tons/ ha was obtained in moderately high stocking density (30 to 35 pc/sq m) ponds, which was sold at a farm gate price of Rs 300/-.

GROWTH PERFORMANCE, OSMOLARITY OF INDIAN WHITE SHRIMP JUVENILES REARED AT DIFFERENT SALINITY IN C:N RATIO MANIPULATED SYSTEM

Osmoregulatory capacity of penaeid shrimp and serum mineral profile aid in understanding about the physiological adaptation of Indian white shrimps related to ambient salinity that indirectly regulate growth performance of shrimps at different salinity. Keeping this in view, a 50 day experiment was carried out to study the growth performance, water quality , serum mineral profiles of *P. indicus* juveniles (0.4-0.5g) reared at different salinity in 100 L FRP tanks at 12 individual/tank using low protein feed (CIBA feed-30%) and fermented carbohydrate supplementation (CN 10 and CN 20). Osmolarity study reveals serum osmolarity changes proportionately with ambient water salinity- shows strong hyper-hypo osmoregulatory pattern (Osmolarity capacity-at low salinity-hyper OC and high salinity hypo OC). Minerals play an important role in osmoregulation. Among major minerals, calcium (Ca) and magnesium (Mg) are considered important for molting and new shell formation. The ratio of Na (Sodium) to K (Potassium) and Mg (Magnesium) to Ca (Calcium) in should be preferably 28:1 and 3:1 and Ca:K should be 1:1.Serum mineral profile ratio revealed that at low salinity 3 and 25 ppt shrimp had Ca/K ratio were 1.3-1.5 whereas at 48 ppt ,it was only 0.5.

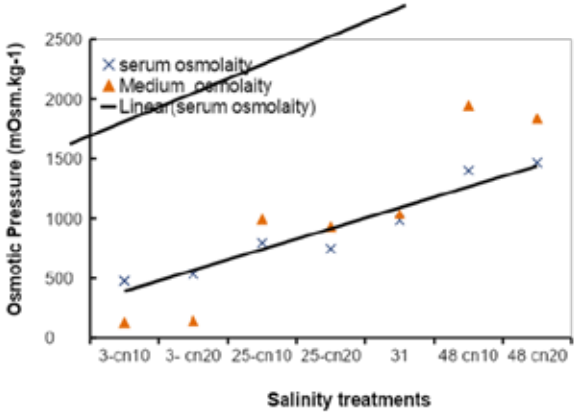


Fig 14. Serum Osmolality (mOsm.kg-1) and osmolality constant of P.indicus reared at different salinity

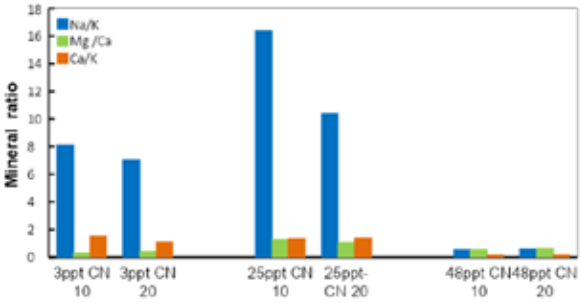


Fig15 Serum mineral profile ratio, Na:k, Ca:Mg and Ca:K ratio of P.indicus reared at different salinity

STOCKING DENSITY DOES NOT AFFECT COMPENSATORY GROWTH OF NURSERY REARED SHRIMPS

In continuation of previous experiment on nursery rearing of *P.indicus* high density nursery rearing of *P. indicus* at higher densities; 1666, 3333, 8333 nos./m^3 with and without soil base was carried out in a 45 days trial to understand the compensatory growth effect. The study revealed significantly higher survival and growth in post larvae reared without soil bases system (98- 47%)

compared to soil base system (70-40%) indicate the potential of high density culture in tank based sytem than pond based nursery system. Density does not found to significantly affect the growth of shrimp after 14 days trail in pond base indicate compensatory growth gain of shrimp after nursery rearing is independent of density of shrimps in nursery phase.

NURSERY REARING OF *PENAEUS INDICUS* IN THE ESTUARINE ECOSYSTEM AS A LIVELIHOOD ACTIVITY

A nursery rearing model for Indian white shrimp, *Penaeus indicus*, has been demonstrated for self-help groups at Uyallikuppam village (Palar backwaters) near Kalpakkam (Tamil Nadu). *Penaeus indicus* (n= 400) of 1.5g size were separately stocked in 4 hapas (2 m x 1m size) and reared for sixty days. The salinity, pH and temperature were observed from 21-28 ppt, 7.10 to 8.0 and 25- 28°C respectively. On an average of 8.50 g size of *P. indicus* were obtained with 90 % survival and a biomass 3.24 Kg

PEN CULTURE OF *SCYLLA SERRATA* IN MANGROVE ECOSYSTEM

Integrating pen culture of mud crab in mangrove habitats provide alternate livelihood opportunities for coastal communities through economic benefits of aquaculture and ensure participatory conservation of these vulnerable resources. The present study was therefore carried out to gather scientific data on production and economic feasibility of mud crab rearing in a mangrove based pen culture system. The culture site was located at Assolna village mangrove creek, Goa, India (Lat 15° 10' 39.29" N, Long73° 58' 06.23" E). Pen culture system was constructed in an intertidal area surrounded by mangrove trees and associated vegetation. The pen was constructed using 10 mm high density polyethylene netting (HDPE, twine size 2.0mm) stretched using casuarina poles driven to the creek bed. Lower margin of nets was buried 35 cm in to the lake bed and upper margin was stretched using a 10 mm polypropylene rope. A poly vinyl chloride sheet (PVC, width-20 cm) was tied to the free board area of netting to prevent escape of mud crabs. Dimensions of the pen were 50 m × 20 m, thus enclosing an area of 1000 m^2. Mud crabs, S. serrata with an average weight of 10.6 g were stocked in pen and reared for a period of 207 days.

Mud crab harvest has been started from the system since 5 months from the stocking using scoop nets and baited circular traps. Only half of the stocked crabs were harvested in the first harvest due to the differential growth in the mud crab species. The harvested mud crabs were weighed and a representative sample of 100 individuals of both male and females were collected to determine the carapace width and body weight distribution. A total of 426 numbers (123.3 kg) of mud crab, 10 kg of penaeid shrimps, 10 kg pearl spot, 15 kg milkfish, 10 kg mullets, 10 kg red snapper, 3 kg silver biddies, 2 kg sea bass, 13 kg crescent perches and 4.5 kg other fish species were harvested. The total returns obtained from pen pond including various species of fish and penaeid shrimp was Rs. 85,705. The total operational cost incurred for the culture system including labour was Rs. 45,825. The benefit-cost ratio was estimated at 1.87 for the current year.



Fig 16 Pen constructed for mud crab culture

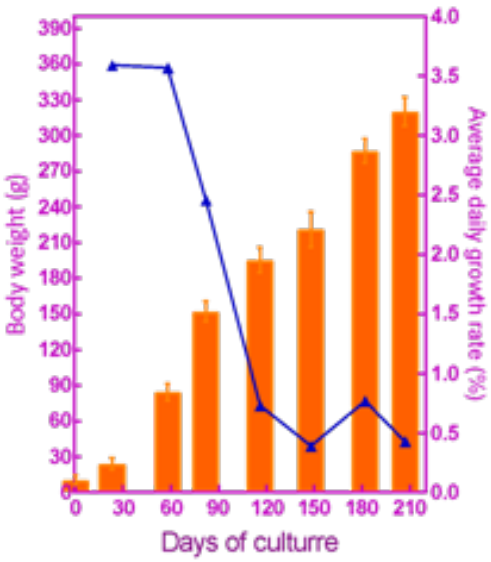


Fig 17 Growth of mud crab in pen culture system

EVALUATION OF FORMULATED FEED IN BOX CULTURE OF *SCYLLA OLIVACEA*

Mud crab (*Scylla olivacea*) is a native species of Sundarban, West Bengal and is known for its delicacy. Owiing to the h high export demand of this species particularly, gravid females, many farmers started culturing this species in pond and fiber boxes. Conventionally crabs are fed with low cost fish but major constraints are uncertainty in supply, price fluctuation and poor quality of raw fish. Pellet feed was prepared and offered to crabs maintained individually in 10 fiber boxes for a period of 28 days to observe its effect on growth and maturation. As a control, conventional low cost fish was offered in another 10 fiber boxes having individual crab. **The increase in ovary wt. and gonadosomatic index of crab fed pellet feed was at par with low cost fish**.

Performance of mud crab with conventional feed vs. formulated feed

Pellet feed	Control (low cost fish)	Formulated feed
Initial body wt., g	106.76±6.04	118.97±3.27
Final body wt., g	120.13±6.7	134.84±3.29
Survival %	70±00	80±00
Initial ovary wt., g	5.80±0.41	5.24±0.26
Final ovary wt., g	22.75±0.83	24.40±0.06
Initial GSI	4.51±0.39	4.12±0.23
Final GSI	15.51±0.85	16.59±0.44

DEVELOPMENT OF SUBMERSIBLE CAGE SYSTEM FOR MUD CRAB GROW OUT PRODUCTION

Mud crabs are benthic organisms, and therefore, pelagic/ floating cages adversely affect the physiology of these animals owing to the relatively higher surface and sub surface temperature. In order to circumvent the issues of subsurface/floating cages, easy-to-manage submersible cages have been developed, and evaluated the culture performance with reference to the floating cages. In the submersible cage system, a rectangular PVC frame with a facility to fill-in and drain-out the water was constructed, and cages are installed on this frame. When animals are fed, the water in the PVC frame is pumped out, and after feeding and cleaning the cages, the water is pumped into the frame again and the entire system becomes submersible. Growth performance



Fig18 Box culture of crab



Fig19 With trash fish



Fig20 With pellet feed

of crabs was compared between two systems after two months of rearing. Surface water temperature was observed as 34 – 35°C whereas bottom temperature was 4°C lower than surface at morning. Initial body weight of crabs for both systems was not significant ($p > 0.05$, independent samples t-test). Specific growth rate and average weight gain found significantly higher in submersible cages compared to floating system after

two months of cultivation ($p < 0.05$, independent samples t-test). Average weight gain was >100 g in submersible system whereas it is significantly less in floating system (<15 g) indicating that submersible system outperforms traditional floating system. It could be concluded that implementation of submersible cum floating crab culture system provide higher growth compared to conventional one for crab fattening.



Fig 21 Sub merged mud crab cages

OPEN WATER CAGE AQUACULTURE AS ALTERNATE LIVELIHOOD AND SOCIETAL DEVELOPMENT IN AND AROUND MANGROVE REGIONS OF MAHARASHTRA

Sindhudurg accounts for 3% of Maharashtra's total mangrove cover but houses more of its coastal biodiversity than any other district in the state. Deforestation of mangroves timber for boat fabrication, firewood for human settlements, illegal aquaculture activities has also impacted on the nursery and breeding grounds of marine fishes, mammals, birds, etc. Hence to provide employment opportunities for improving income/ livelihood generation, nutritional security, etc., ICAR-CIBA, Chennai in collaboration of Mangrove cell, Maharashtra have initiated three-tier seabass farming technologies such as nursery rearing, pre-grow out and grow out culture in and around of mangrove coastal waters in Sindhudurg district of Maharashtra with participation of self-help groups (SHGs). In such initiative, around six nurseries, a pre-grow-out and 33 grow-out cage cultures with the participation of SHGs comprising of male and female beneficiaries have been formed.

ASIAN SEABASS NURSERY AND PRE-GROW OUT REARING IN HAPPAS

For nursery rearing, happas (2 x 1 x1 m, 2 mm mesh size) were installed in a pond (0.8 ha) with a water depth of 1.5 m and salinity 25 ppt. Seabass seeds (1.2-2.0 cm) from CIBA fish hatchery were provided to SHGs in the range of 7200-10000 fishes and stocked at a density of 500 per happa-1. The fry was fed with CIBA formulated Seabass larval feed (0.2 mm-1.2 mm) @ 8-10% body weight two times a day. Regular grading was done at an interval of four days to separate shooters and to maintain uniform size. After 65-75 days, seed reached to fingerlings size of 6-12 cm and 10-14 g with an average survival of 52.16 %. The harvested fingerlings were sold @ Rs. 20 per fingerlings. In pre-grow out trial, a total of 2500 seabass (6-10 cm) fingerlings from nursery growers are stocked @ 400 fishes/net cage (6m^2). Farm made slow sinking pellet feed supplied @ 6-8% daily in two rations. After rearing of 60 days, fish reached to stockable fingerlings size of 14-18 cm and 20-25 g with the survival of 60.52 %. The harvested stockable fingerlings were sold @ Rs. 33 per fingerlings. The SHGs have generated a total revenue of Rs. 3.16 lakhs through Seabass nursery and pre grow out rearing work.

Details of seabass nursery rearing & pre-grow out culture trials, and SHGs income generation in Sindhudurg, Maharashtra

SHG Name	Seed Supplied	Feed	Period	Fingerling production	Survival (%)	Income (Rs.)
Jai Ganesh Nivati, (6 W +2 M)	7600 (1.2-2.0 cm)	CIBA seabass feed (0.2 -1.2 mm)	65-75 days	5394 (10-12 cm)	71.0	Rs.1,07,880
Dolphin, Redi (6 W +2 M)	10000 (1.2-2.0 cm)		65-75 days	4394 (8-10cm)	44.0	Rs. 64,971
Jay Gajanan, Redi (6 W +2 M)	7200 (1.2-2.0 cm)		65-75 days	2179 (6-10cm)	30.2	Rs. 27,447
Samrudhi, Redi (6 W +2 M)	10000 (1.2-2.0 cm)		65-75 days	5513 (6-10cm)	55.13	Rs. 65,470
Chanak, Redi (6 W +2 M)	2500 (1.2-2.0 cm)		65-75 days	1513 (16-20 cm)	60.5	Rs. 50,656







Fig 22a ICAR CIBA, Chennai Mangrove Foundation and SHGs Success News in Maharashtra Media and Distribution of revenue generation cheque to different CIBA seabass nursery SHGs of Sindhudurg towards the production of seabass fingerlings by delegates of BRAOCON Farmers Conclave Programme on 22 January 2019 at CIBA, Chennai

GROW-OUT FARMING IN LOW VOLUME CAGES

A total number of 33 cages of 4 x 4 x 2 m (32m^2) dimensions were fabricated using Galvanized Iron (GI) pipes (1.5" and 1.25") and were allotted to 8 SHGs units comprising of 90 men and 9 women of Sindhudurg. HDPE knotless cage nets were used for culture and to avoid cannibalism net is modified with an internal partition to make two internal compartments of 2 x 2 x 2 m inside the cage nets to facilitate re-stocking of two size graded seabass fishes in each compartment. The whole cage structure was floated with six HDPE barrels each of 210 L capacity and anchored in creeks with 85 kg of mild stainless-steel anchors. From October 2018-February 2019, seabass fingerlings (6-18 cm & 4-14 g) procured from Seabass Nursery fish farmers of Andhra Pradesh and CIBA Nursery units, Sindhudurg were stocked in total 20 cages @1000 fishes/cage. The fishes were fed with CIBA seabass slow sinking grow-out feed of size 2-6 mm @ 8% body weight two times a day. The cage culture is in progress with the seabass have grown to the size of

40-200 g with an average survival of 42.5% and the harvest of 400-500g seabass is expected in mid-June 2019 with estimated total revenue generation of 10-12 Lakhs. In Maharashtra, this is one of the first kinds of activity which motivated the SHG's especially to women fishermen's to participate in seabass production and to generate the additional income through conservation of the ecosystem.



Fig 23 One unit–Four - Cages Talashil Village



Fig 24 Two unit –Four Cages - Kothewada Village



Fig 25 On-site Fish Grading by Farmers

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) OF SEABASS AND GREEN MUSSELS IN CAGES INSTALLED IN CREEKS

To develop and propagate family farming models of candidate finfish and shellfish species in the west coast of India, initiated IMTA cage culture in Gad creek of Malvan, Sindhudurg. Three families comprising of two men and one woman having a background of brackishwtaer fishing in creeks were selected from villages of Tondavali, Talashil, and Pan-Khol Juva, Taluka-Malvan, District-Maharashtra for IMTA culture of Seabass and Green Mussels in cages installed in creeks. Three pre-fabricated GI Pipes frame cages (8 x 4x 1.2 m), on 27 October 2018 two cages were stocked with seabass fingerlings (8-10 cm and 10-12 g). The fishes were fed with CIBA seabass slow sinking grow-out feed of size 2-6 mm @ 8% body weight two times a day. On 8 January 2019 Green mussel, *Perna viridis* (2-2.5 cm) attached to nylon ropes consisting of 200-250 green mussels (total weight of rope 650-950 g) were procured from fish farmers of Kumta, Karnataka and stocked to the outer periphery of each IMTA Cages at a density of 80 ropes/ cage. To achieve good fish growth, survival and to avoid cannibalism, regular fish grading at the interval of 15 days was carried out at each IMTA cage sites. During the culture, regularly visited to each site for inspection of the cages, performance of the IMTA beneficiaries, scientific and technical inputs to the beneficiaries, monitoring, and sampling of the fishes to assess the growth and health status of seabass. The IMTA cage culture is in progress and mainly due to good cage culture management practices implemented by the IMTA families, the seabass have grown to size of 60-400 g with survival ranging from 79.30-90.03% and the harvest of 400-500g seabass is expected in mid-June 2019 with estimated total revenue generation of 2-2.5 lakhs to three IMTA families within

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) CULTURE IN CAGES INSTALLED IN CREEKS OF SINDHUDURG, MAHARASHTRA



Fig 26 IMTA Cage-1 at Talashil



Fig 27 IMTA Cage-2 at Tondavali



Fig 28 IMTA Cage-3 at Pan-Khol Juva



Fig 29Cultured Green Mussels Ropes

SEABASS AND MILKFISH FARMING IN A POND ON A POLYCULTURE APPROACH

To propagate the polyculture of prominent candidate brackishwater aquaculture finfishes, conducted a trial of polyculture of Asian seabass, *Lates calcarifer* fingerlings and milkfish, *Chanos chanos* seed in Pond with the participation of local fish farmers (8 number) of Mayane village, Taluka-Vengurla, Sindhudurg, Maharashtra. The polyculture was conducted in the same pond where seabass nursery was functioning and an artificial partition by using crab fencing net was created to make one acre of the pond in 0.8 ha pond with a depth of 1.5 m. The milkfish after reaching to the fingerling size, a total of 550 number of stockable seabass fingerlings (18-25 cm, 150-300 g) procured from previous year IMTA farmers were stocked in a partitioned area of a pond and fed slow sinking pellet feed@3-6% bodyweight twice a day. A total of 166.5 kg seabass fish along with 750 kg of milkfish (300-1000 g) was harvested. The harvested medium and big sized seabass and milkfish realized a farm gate price of Rs. 150/Kg, 400/kg, and 100/Kg thus resulting in total revenue of Rs. 1,31,400 lakhs to the group of 8 farmers even after the escape of fishes during monsoon flood.



Fig 30 Harvested seabass and milkfish and from polyculture

MONOCULTURE OF MILKFISH IN A POND IN COLLABORATION OF FISHERIES DEPARTMENT, GOA

To promote species diversification and sustainable aquaculture practices of important candidate brackishwtaer species in the west coast of India, conducted a trial of milkfish, *Chanos chanos* monoculture in collaboration with Fisheries Department of Goa. About 4000 milkfish seed (ABW 0.1-0.3g) were stocked in the departmental pond located at Ela-Dhauji, old Goa, Goa. Without nursery rearing, the seed were directly stocked in the 1.2 ha pond with water depth of 1.5 m and salinity 30 ppt. During the culture, the milkfish seed were fed with Indian Major Carp feed (28-30% protein) @ 3-5% body weight two times a day and salinity ranged from 5-40 ppt. After the culture of 11 months, a total production of 1.4 tonnes milkfish (ABW 400-750g) with survival of 80% was obtained. The harvested fishes were sold at the rate of Rs. 180-200/-kg in the retail market of Goa.



Fig 31 Harvested size and biomass of Milkfish at Goa Fisheries Departmental Pond

JUVENILE MILKFISH COULD BE A POTENTIAL ORNAMENTAL FISH: SILVERFISH

Characters of juvenile milkfish such as milky white glittering, shining body, agility, semi-transparent V-shaped caudal fin, swift movement pattern, wide salinity tolerance, voracious gracing on tank algae and disease resistance qualifies milkfish juveniles as a potential ornamental fish called "Silverfish". Freshwater acclimatized milkfish Juveniles handed over to private aqua shop owners at Chennai to understand the acceptance by aquarium hobbyist in the sector. The initial response was positive and 10 pair of milkfish juvenile sold @ Rs. 50/-. Further initiatives are taken to popularize this fish as an alternative revenue generative species in the paradigm of ornamental fishes. Small experiments were conducted to know its compatible tankmates.







Fig 32 Milk fish as an ornamental fish

Table Compatibility of milkfish with other common aquarium fish

ISH	COMPATIBILITY	REASON
Tinfoil Barb	Compatible	Swims like milkfish
Red tailed shark/ Rainbow shark	Compatible	Bottom dweller; no competition
Black Shark	Compatible	Bottom dweller no competition
Tiger Barb	Incompatible	Caudal fin nibbling behaviour

POPULARIZATION OF MILKFISH FARMING IN COASTAL DISTRICTS OF WEST BENGAL AND ITS ACCEPTANCE AS *DECAN HILSA*

Milkfish is fast growing herbivorous fish which has a similar outlook and culinary properties like hilsa. Considering demand and preference of milkfish by local Bengalis, CIBA took efforts to popularize milkfish as '*Decan Hilsa*' in West Bengal. About 8000 hatchery produced milkfish fry were distributed among four beneficiaries in Haldia block of East Midnapur district. For the first time seeds were distributed to beneficiaries through state fisheries machinery to achieve maximum visibility. Four different culture system was followed such as monoculture (Salinity 7-8 ppt), polyculture with *P. monodon* & *M. rosenbergii* (4 ppt), Nylon net cage culture (10-12 ppt) and polyculture with IMC (0 ppt).



Fig 33 Stocking of milk fish seed

Approximately 1.3 ton of milkfish was harvested. This culture demonstration was successful and created mass awareness among local communities and also in Bangladesh (Dhaka Times) as print media covered these trails extensively. It was very well accepted by the Bengalis by the name *Decan Hilsa* .

MULTIPLE STOCKING AND MULTIPLE HARVESTING (MSMH) TECHNIQUE OF MILKFISH CULTURE

Milkfish is a suitable species for low input-based culture system easily adoptable by small and traditional farmers. For small farmers return from farming at regular intervals is most desirable to meet up their day to day needs. In this context, MSMH technique of milkfish culture could be suitable to these farmers. Moreover, this method could augment the productivity of a small pond by many folds. Therefore, to evaluate the performance of this technique in brackishwater ponds, a trial was conducted with two stocking densities (7500 and 15000/ha) as treatments. Milkfish fingerlings (6-8 g) were stocked and reared in fertilized ponds (500 m^2) provided with CIBA formulated feed (CP 30%; Price: Rs. 35/ kg) @5-3% of body weight daily. After 100 days, harvesting was started when the fish attained at least 150 g and ponds were restocked with the same quantity of advanced fingerlings (25-40 g) at 15 days intervals keeping the total number of fishes same to that of the initial stocking. This system exhibited higher production of 3.6 ton/ ha in the high density compared to 2.8 ton/ ha in the low density culture in 160 days suggesting the suitability of the former density.

DEMONSTRATION OF LOW INPUT-



ইলিশের বদলি মিল্ক ফিশ

Fig 34 Multiple stocking and multiple harvesting

BASED MILKFISH CULTURE IN SUNDARBAN

To promote milkfish farming scientifically, CIBA has developed seed production technology of milkfish by achieving the first breakthrough on captive breeding



Fig 35 Milkfish harvest from demonstration pond

in June 2015. As an activity to popularize this species in traditional farming systems of Sundarban, a low input-based culture demonstration was conducted in a collaborative research mode. CIBA provided hatchery-bred 2800 number milkfish fingerlings (8 g) after conducting a nursery rearing phase at its Kakdwip Research Centre to an enterprising fish farmer, Mr. Animesh Das from Debichak, Ramganga. Milkfish fingerlings stocked in a 0.14-ha brackishwater pond provided with nylon net fixed vertically at epilimnion as a substrate for periphyton growth. Additionally, fish were fed with a floating feed (CP: 28%) at 2-3% of biomass daily. This culture yielded 600 kg (4.2 ton/ha) in 6 months with a production cost of Rs. 90/ kg and selling price of Rs. 160-180/ kg, and was economically viable.

HILSA : GROWOUT PRODUCTION

Hilsa has good market potential in West Bengal, and there is a huge demand for table size hilsa. However, the demand needs to be fulfilled by the wild catch, and there is no farming attempt so far in a commercial scale. In this backdrop, two months old nursery-reared fingerlings of 34 numbers (4.8 to 5 cm; 2.2 to 2.4 g) were equally stocked in two different system viz. earthen pond (1000 m^2) and RAS (8 m3) in the month of May. In both the systems, fishes were fed with pelleted feed (38% protein and 8% lipid) @ 5% of biomass. At 15 days interval, lime and GNOC was applied @ 150 and 50 Kg ha-1, respectively. At fort night interval regular water quality such as dissolved oxygen (6.5 ppm), pH (8.2) and salinity (6 to 8 ppt) were measured. After 11- months of culture, the growth performance of hilsa was visible good in pond system than RAS.

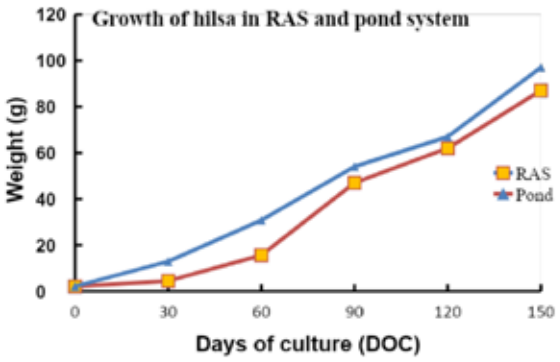




Fig 36 Production performance of Hilsa ilisha

EFFECT OF FEEDING FREQUENCY IN NURSERY REARING OF *MYSTUS GULIO* IN NET CAGES

Brackishwater catfish, *Mystus gulio* has good market demand as a high-value species in Eastern India. Standardized homestead hatchery technology of this species has been popularized among farmers. The hatchery produced 10-15 day old fry are further reared in the nursery to produce fingerlings suitable for stocking in grow-out system. To refine the nursery rearing method in hapa system, a trial was conducted to find out suitable feeding frequency. Among different feed management strategies, feeding frequency plays an important role in regulating the feed intake, growth, survival and waste outputs of fish. Twelve-day old fry (0.01-0.02 g/ 9-12 mm) were stocked in net cages (hapa: 2×1×1 m) at 250 no./ hapa. The fry were fed @ 10 to 4% of body weight with CIBA formulated diet (CP 30%, CF 6%; Price: Rs. 35/ kg) at four feeding frequencies (1, 2, 3 and 4 times/ day) as treatments. After 50 days, fry attained significantly higher growth of 1.29±0.41 g at 4 times feeding a day compared to other groups (P<0.05). Moreover, higher survival in 2, 3 and 4 times feeding differed significantly from that of 1 time feeding a day (P<0.05). Therefore, a feeding frequency of 4 times daily is suggested for nursery rearing of *M. gulio* in hapa system.



Fig 37 Harvested Mystus gulio fingerlings from hapa rearing system

Effect of feeding frequency on growth and survival of Mystus gulio during nursery rearing in hapa.

Feeding frequency (FF)	Final length (mm)	Final wt. (g)	Survival (%)
1	46.8±2.15	0.95±0.18b	79.2±1.2b
2	48.02±2.70	1.05±0.27b	92.8±1.6a
3	48.01±2.26	1.02±0.36b	89.6±2.5a
4	49.44±2.96	1.29±0.41a	90.4±2.4a

Means with different superscripts in a column differ significantly (P<0.05); values are mean ± SD of two replicates.

WIDE SALINITY TOLERANCE OF STREAKED RABBIT FISH, *SIGANUS JAVUS* THE IMPACT OF SALINITY ON GROWTH, SURVIVAL AND SERUM OSMOLALITY

Streaked spine foot Rabbit fish, *Siganus javus* , is considered as important food fishes because of their fast growth rates, herbivorous food habits, and economic value. The study was carried out to determine salinity tolerance of streaked spine foot rabbitfish, *Siganus javus* with varying salinity and its impact on growth, survival and serum osmolality. A total of 270 nos *Siganus javus* juveniles (10.45±0.26 cm and 15.15±0.76 g) were

stocked in 300 l tanks containing 30 ppt seawater to have 15 juveniles in each tank. Later the salinity was reduced by 5 ppt at every 12 hrs intervals to have a final salinity of 5, 10, 15, 20, 25 ppt with three replication per salinity treatment. The experiment was carried out for 30 days and the fishes were fed with artificial feed @ 5 % of the biomass. At the end of the trial, the serum osmolality was significantly varied among the salinity levels highest osmolality in 30 ppt (control) and lowest in 5 ppt (380.11±2.72). The mean body weight and the total length of fish also varied significantly among the treatments ($P<0.05$) as presented in the table. Overall, better growth performance was shown by the fishes reared in the higher salinity compared to the lower ones. However, survival was not affected by salinity. This experiment for the first time documented the wide salinity tolerance of *Siganus javus*, a potential herbivorous food fish for brackishwater farming.

Table Serum osmolality of *Siganus Javus* for a period of 30 days

Salinities (ppt)	Water osmolality	Serum osmolality
5	(mmol kg-1)	(mmol kg-1)
10	138.91±1.81	380.11a±2.72
15	281±2.75	390.33b±4.40
20	433.75±2.81	391.67b±2.75
25	565.33±4.88	395.44b±3.21
30	689.58±8.92	402.67c±1.90
	859±3.60	421d±2.23

Mean value with same superscript did not show any significant difference (P>0.05)

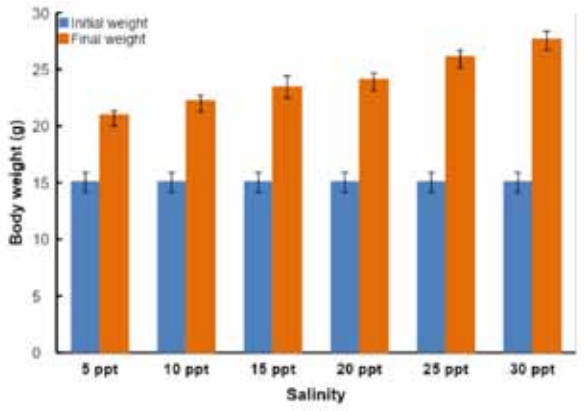


Fig 38 Growth performance of Siganus javus in different salinities for 30 days



Fig 39 Streaked spine foot rabbit fish Siganus javus

OPTIMUM SCAT FRY STOCKING DENSITY FOR IN THEIR NURSERY PHASE FOR SUSTAINABLE JUVENILE PRODUCTION IN THE POND AND OPEN WATER-BASED SYSTEMS

Scat juveniles (2 – 5 cm) have huge demand in ornamental trade due to its spotted rhombic appearance and easy upkeep in aquaria. Being an herbivore fish, its nursery rearing can be popularized as low cost and short-term income generation activity by fisher / tribal groups. Hapa based nursery rearing mode was adopted in the pond and open water systems to optimize the rearing density for enhanced survival. Thirty days post-hatch hatchery-produced larvae with initial T.L. 10 ± 0.2 mm were stocked at three different stocking density (5000, 3000, 2000 nos/m3) in hapa (2 X 1 X 1 m) in a fertilized pond. Feeding was done with 30 % crude protein crumbled floating feed at the rate of 5 % body weight twice a day. Larvae reached marketable size 35.1 ± 1.19 mm with the highest 35 % survival after 60 days of rearing in 3000 nos/m3 density. Highest larval size 38.8 ± 5.1 mm was achieved in density of 2000/m^3.

Another trial was conducted in the open water of village Kuvathur (Kancheepuram district) with tribal fisher folks. Hapas (2 X 1 X 1 m) were tied inside a pen structure and stocked with two stocking densities of 500/m^3 and 200/m^3 60 days post-hatch larvae of T.L. 22.9 ± 2.03 mm. Feeding was done with 30 % crude protein crumbled floating feed at the rate of 4 % body weight twice a day. Hapas were cleaned fortnightly. 100 % survival and 44.1 ± 7.18 mm T.L. was achieved after 45 days of rearing in 300/m3density. These juveniles were sold @ ₹ 15/fish to ornamental traders. Both the nursery rearing models were found to be suitable for rearing scat in cost-effective way.

MASS PRODUCTION OF ORANGE CHROMIDE WITH FARMERS PARTICIPATION

Orange chromide has good demand in the domestic as well as in the international ornamental fish market. Fry produced in our hatchery were presented to the coastal fisher women's Uyyalikuppam near Kalpakkam and Kuvathoor near Kovalam, reared up to market size and sold to the aquarium shops. Initial Average length & Weight of Orange Chromide was 3.87 ± 0.20 cm, 1.085 ± 0.163 g respectively at 32 ppt salinity. After 3 months of rearing the average length & Weight was 5.87 ± 5.21 cm, 4.8 ± 1.0 g respectively at 30 ppt salinity and Survival was 89.1%.

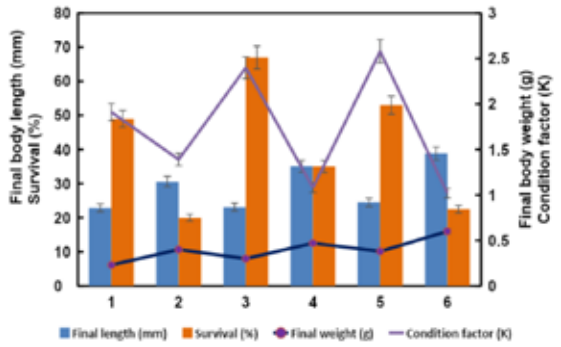


Fig 40 Survival and growth performance of scat juvenile in hapas placed inside ponds

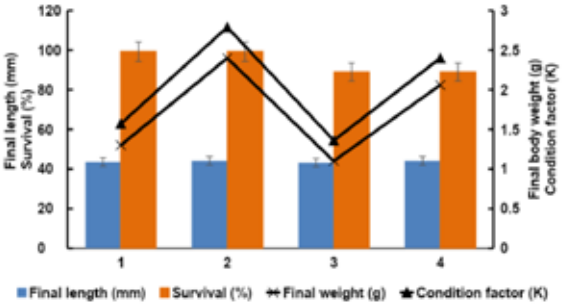


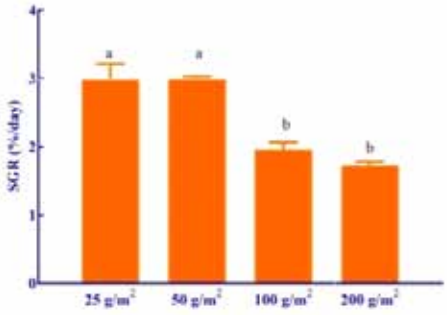
Fig 41 Survival and growth performance of scat juvenile in hapas placed inside pens in open waters at Kuvathur village (Kanchipuram, TN)



Fig 42 Mass production of orange chromide

SEA WEEDS

Cultivation of seaweed has been one of the predominant forms of aquaculture in the world aquaculture scenario. *Gracilaria tenuistipitata* is economically important seaweed, which is extensively cultivated in South East Asian countries. This species survives well below 20 ppt salinity. The present study was therefore carried out at the tide-fed brackishwater pond system of Kakdwip Research Centre of CIBA with the objective of estimating the optimum initial biomass intensity to be stocked. The experimental trial was conducted with four initial stocking intensities: 25, 50, 100 and 200 g/m2 at water depth of 0 – 0.3 m (identified as the most suitable culture depth by the experimental trial 1) in nylon net bags (1 m x 1 m, mesh size 2 mm) in a tide-fed pond of 600 m2 from July 2018 to December 2018 in triplicate. Seaweed biomass was measured once a month Significantly hihger SGR was found at the lower stocking densities (25 and 50 g/m^2) compared to higher stocking densities.





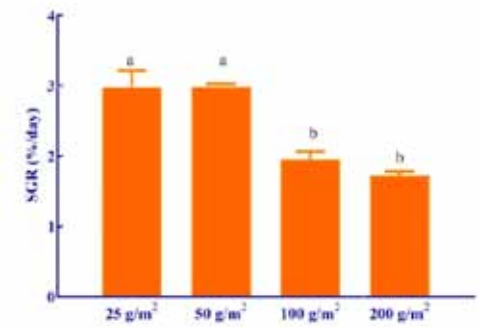




Fig 43 Comparison of aeration requirements in bio floc-based systems and earthen pond shrimp culture

Bio floc shrimp culture systems are gaining importance for cost-effective production where water is limited or land is expensive. Aeration requirement in bio floc-based systems were analysed based on the primary data collected from the biofloc based shrimp culture ponds at Tamil Nadu and Andhra Pradesh and compared with the aeration use in earthen ponds. Air diffuser systems operated using air blowers have been widely used in bio floc systems (Fig. 1), whereas different types of surface aerators are used in earthen ponds. Findings revealed that the aeration requirements in biofloc system vary from 6.2-12 HP/ m3 volume of water. Assessment in the farmers ponds indicated that the aeration requirement per cubic meter water in earthen pond varied from 2.3 to 4.5 HP/ m^3 volume of water. Study indicated that bio floc systems require around 170 % of higher aeration compared to earthen pond culture as aeration is needed continuously to keep solids in suspended in the water column at all times and bio flocs (algae, bacteria, protozoans, and other kinds of particulate organic matter such as feces and uneaten feed) also consumes dissolved oxygen.

EVALUATION OF SOLAR BASED AERATOR SYSTEMS AT MUTTUKADU EXPERIMENTAL STATION OF CIBA

The model solar aerator was developed and installed (Fig. 2) at Muttukadu pond, with four panels supporting 1 HP aerator. Variable frequency drive has been installed for the automatic switchover to electrical current based to run the aerator during a power failure. On-farm trials of the Hybrid system powered aerators indicated that it can run the aerator for six hours. The battery capacity for four hours was incorporated in to system during power failure. Hence the technical feasibility of providing aeration in night hours and economic feasibility has been evaluated considering the dynamic nature of the sector and long-term investment in the solar energy systems.



Fig 44 Solar based aerator

MAPPING OF RESOURCES FOR AQUACULTURE IN MAHARASHTRA

Assessment of coastal resources using remote sensing techniques and the ground truth survey in the coastal districts of Maharashtra was carried out to assess suitable land and water resources for aquaculture and also the seasonal variation of water quality characteristics. The mangrove extent and its spatial spread in the coastal districts of Maharashtra was mapped from the Sentinel data of the year 2018, indicated the mangrove extent of 13.71 ha, 37.58 ha, 141.21 ha 36.80 ha, 46.43 ha in Sindhudurg, Ratnagiri, Raigad, Palgar and Thane districts. The comparison with forest survey of India data indicated the increase in mangrove extent from 238 ha in 2017 to 278.73 ha. in 2018.



Fig 45 Coastal area map of Maharashtra district, India

PULICAT MAPPING -PRIMARY PRODUCTIVITY ASSESSMENT OF PULICAT LAKE USING GIS & REMOTE SENSING

Water Samples have been collected at periodic interval from October 2018 to December 2018 from twenty-five-point locations in Pulicat lake covering a distance of 400 km stretch from mouth of the lake to Jameelabad

at the upstream of the lake. Regression models for chlorophyll-a, turbidity and salinity were developed using remote sensing reflectance extracted from Landsat 8 OLI and observed water quality parameters. Results indicate that the dual band ratio of Rrs483/Rrs865 (R^2=0.7677) was most effective in estimating chlorophyll a whereas for turbidity and salinity single band algorithm was effective with Rrs655 (R^2=0.7938) and Rrs655 (R^2 =0.7669) respectively. The regression models are shown in figure 2. Spatial map of empirically estimated water quality parameters is shown in figure 3.4, 3.5 & 3.6. This model is used for estimating post monsoon water quality parameters and the model differs for other regions. Water depth varies from 92 cm to 320 cm during 2017 and 90 to 210 cm during 2018.

THIRUVALLUR DISTRICT AQUACULTURE FARM MAPPING

Thiruvallur district is located between 13°8′26.16′ North 79°54′21.6′ East and it covers an area of 3423 km2. There are five rivers flowing in Thiruvallur district which are Kosathalaiyar River, Cooum River, Adyar River, Arani River and Nadari. Aquaculture farms in Thiruvallur district has been mapped using Geo eye 1 satellite image in ArcGIS 10.2. Around 1337.62 hectares are under shrimp farming and most of them falls under Ponneri and Gummidipoondi taluk.

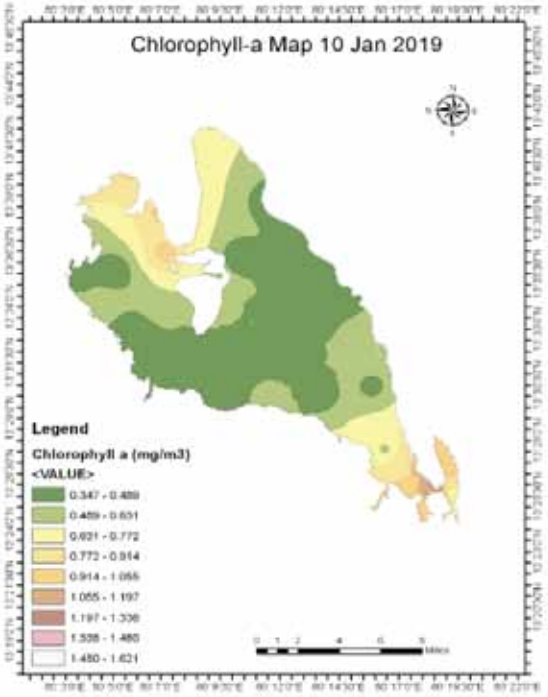


Fig 46 Chlorophyll map of Pulicat

THIRUVALLUR DISTRICT AQUACULTURE FARM MAPPING

Thiruvallur district is located between 13°8′26.16′ North 79°54′21.6′ East and it covers an area of 3423

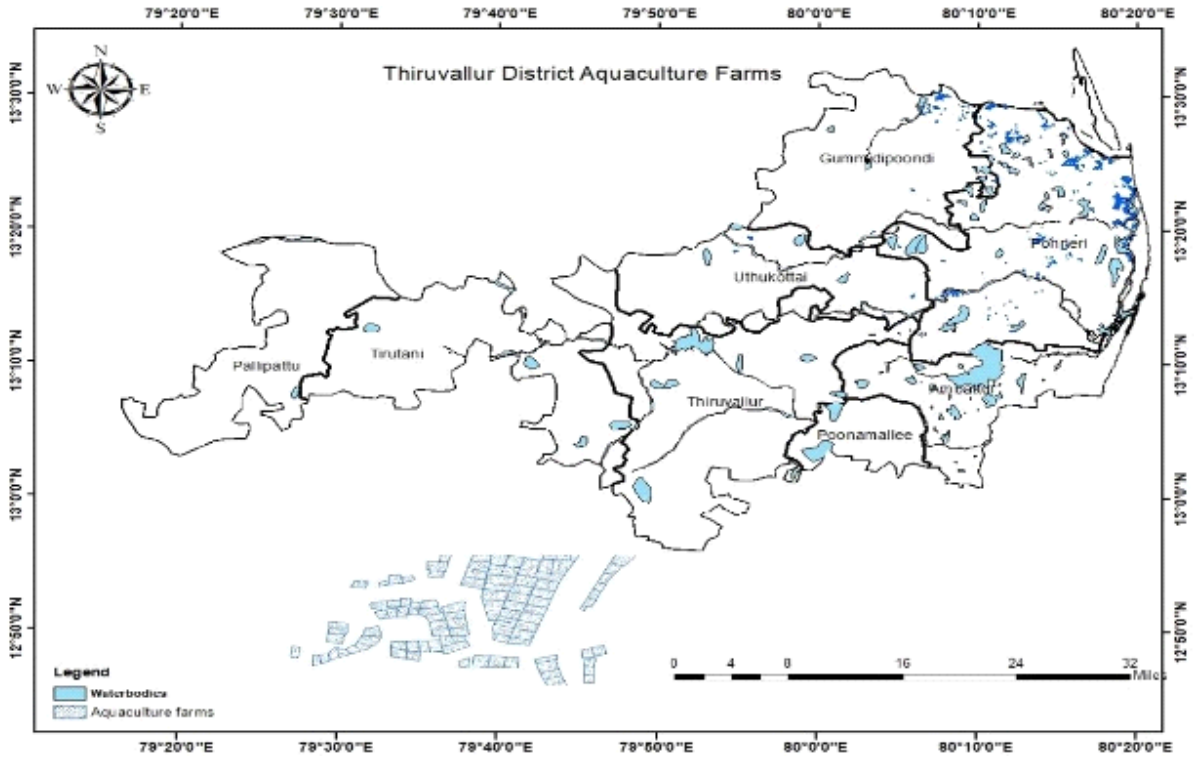


Fig 47 Thiruvallur district aquaculture farms

km2. There are five rivers flowing in Thiruvallur district which are Kosathalaiyar River, Cooum River, Adyar River, Arani River and Nadari . Aquaculture farms in Thiruvallur district has been mapped using Geo eye 1 satellite image in ArcGIS 10.2. Around 1337.62 hectares are under shrimp farming and most of them falls under Ponneri and Gummidipoondi taluk

INDIGENOUS AUTOMATIC FEED DISPENSER FOR SHRIMP FARMING SOLAR POWERED FEEDER – REFINEMENT

Refinement of the existing design by rectifying minor drawbacks and utilization of DC motor for energy efficient direct usage of solar power was done. Three units have been fabricated for on farm trials and on farm demonstration of the refined indigenous automatic feeder was done at *P. Vannamai* farm, Kattur during Feb 2019 as the farming season has started then. Weekly observation is being carried out for soil quality, water quality and feed conversion ratio parameters for refined auto feeder installed pond and a control pond viz., manual feeding pond at the same farm, Feed dispersion distance was 30 m diameter and Quantity of the feed dispensed is 500g in 7 sec. Based on the body weight of the shrimp farmers themselves adjusted the timer and operated the automatic feeder, Solar power was utilised by installing one solar panel along with control unit and 2 nos of 65 AH battery for store solar energy and utilise in the absence of solar energy time.

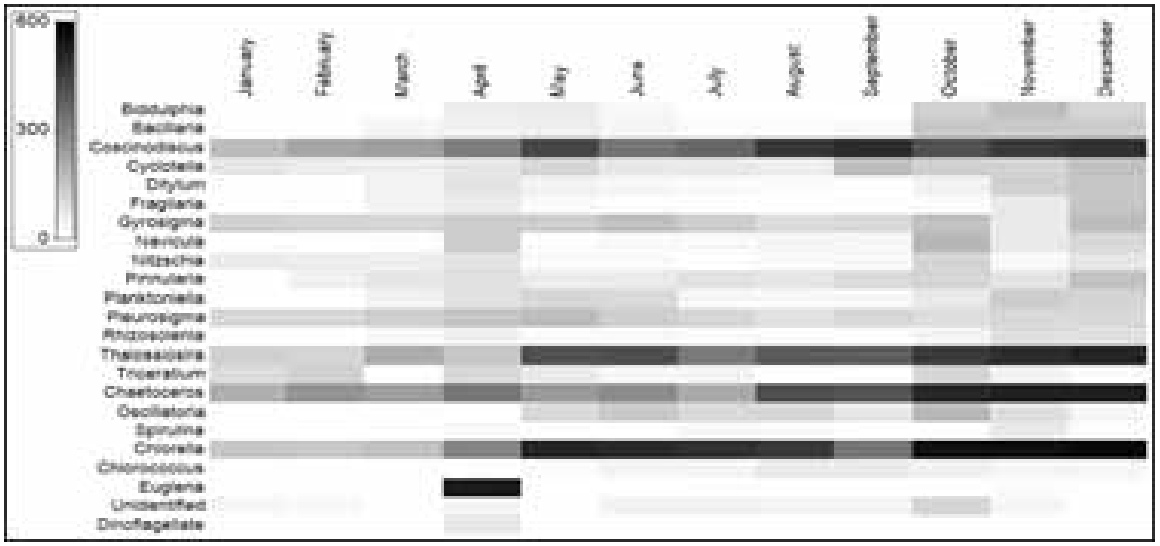
PHYTOPLANKTON AND ZOOPLANKTON DIVERSITY AND SEASONAL DYNAMICS IN ADYAR ESTUARY

Due to the rapid urbanization and human settlement, Adyar creek and estuary, Chennai, has become one of the most polluted riverine ecosystem. Recently, Chennai River Restoration Trust has taken massive effort to restore this important ecosystem. As a first step to optimally utilize this ecosystem for brackishwater aquaculture for diversification of livelihood, ICAR CIBA has taken steps to evaluate the health of ecosystem by studying the dynamics of phytoplankton and zooplankton of this estuary. Knowledge on primary and secondary productivity of any natural ecosystem is fundamental to assess the site selection for cage and pen culture. Plankton sample was collected from 6 stations located in Adyar creek, Srinivasapuram during January to December 2018. Phyto and zooplankton density was counted fortnightly and analyzed using PRIMER 7 software. Overall results conclude that among the phytoplankton, *Chlorella* sp, *Thalassiosira* sp, *Coscinodiscus* sp and *Chaetoceros* sp is dominating in all stations and Rotifers and Copepod was dominating among zooplankton (Fig 11). Maximum density of phytoplankton was observed during Monsoon with an average cell density of 1000 cells/mL and maximum density of zooplankton was found during Monsoon 100 individuals/mL of water sample respectively. Maximum diversity was observed

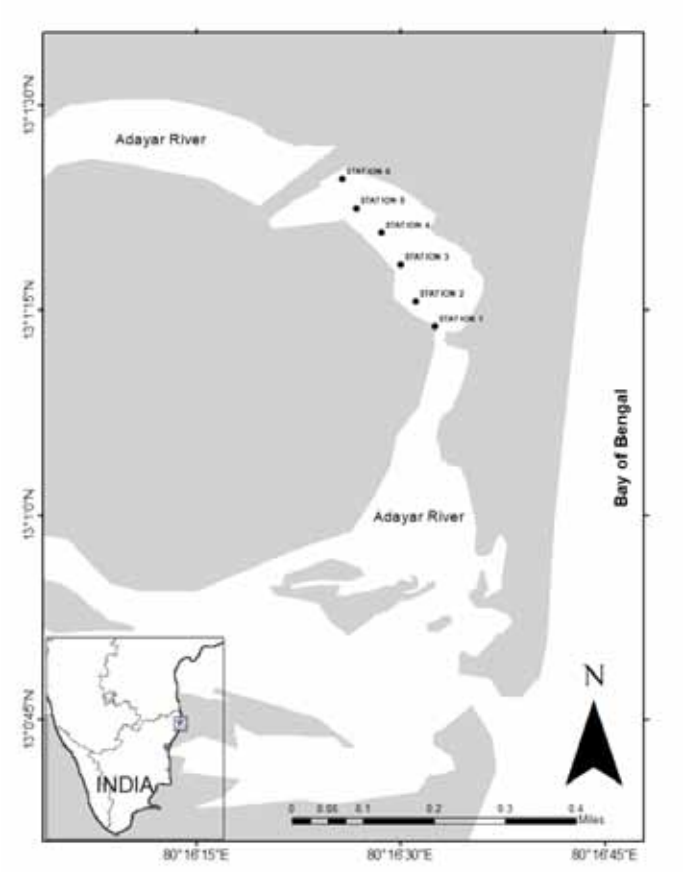


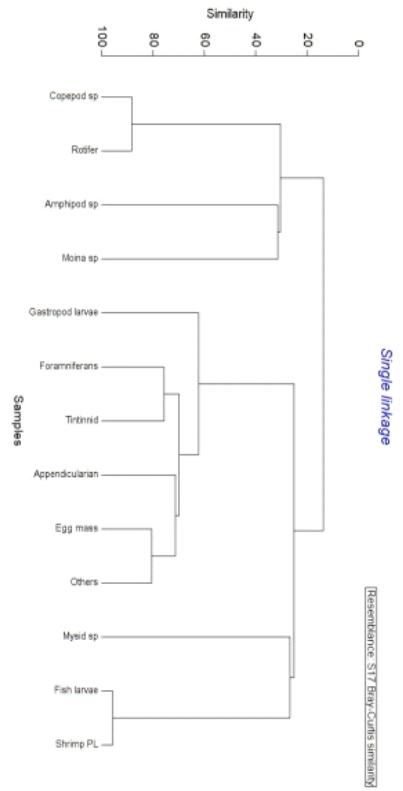
Fig 48 Auto feeder installed in farmers pond

during pre-monsoon period followed by Monsoon > Summer > Winter. Among 6 stations, maximum diversity was observed at Station 3 and Station 2 with optimum water quality parameters though out the study period. Hence it can be conclude that Station 3 and Station 2 can be selected for brackishwater farming practices.



Shade plot showing maximum density of phytoplankton during Jan-Dec 2018





Cluster diagram showing zooplankton density (similarity) during Jan-Dec 2018

Fig 49 Adyar estuary map

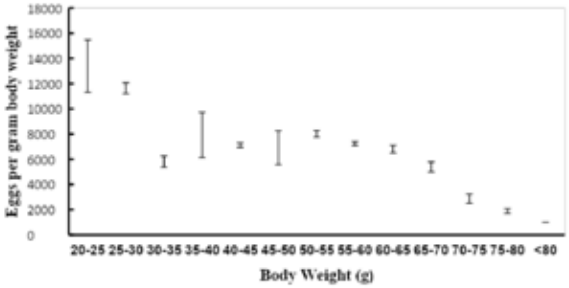
REPRODUCTION, BREEDING AND LARVAL REARING

Complete control over reproduction under captivity has been the most elusive goal of aquaculture since its inception. Further development of aquaculture will ultimately be determined by efficiency of reproductive technologies in par with other livestock production.

Diversification of farmed species has been well acknowledged as a tool for sustainable development of aquaculture. Indian brackishwater aquaculture is almost synonymous to penaeid shrimp aquaculture, particularly farming of exotic *Penaeus vannamei*. An aquaculture industry based on a single non-native species has always been constrained by inherent limitations, for example: limited source of supply, issues of emerging diseases and decline in the quality of broodstock. Development of potential native species is one of the options to resolve the issues related to exotic *P. vannamei* culture. Indian white shrimp, *P. indicus* has been identified as the national priority species for domestication and genetic improvement. With respect to faming of new species, several issues have to be resolved, particularly issues in captive reproduction and hatchery production. For the last five years the institute has been focusing on captive reproduction and domestication of candidate species for brackishwater aquaculture.

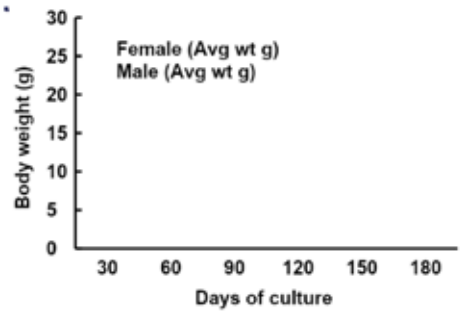
PENAEUS INDICUS

Development of captive reared broodstock of Indian white shrimp, *Penaeus indicus*: This research program was aimed to develop captive reared brood stock for *P. indicus*. More than 700 wild-caught *P. indicus* brooders were screened for WSSV, and seven experimental hatchery cycles were carried out using WSSV negative brooders. Although absolute fecundity was higher in highest size group (> 80 g), relative fecundity, eggs/gram body weight was highest in the lowest size group (20-25 g).



EGGS PER GRAM BODY WEIGHT (MEAN ±SD) OF *PENAEUS INDICUS* BROODERS SPAWNED DURING STUDY PERIOD

Juveniles of *Penaeus indicus* (0.16±0.02 g) were reared in a polythene lined pond of 800 m^2 area at a stocking density of 5 ind./m^2 as well as in indoor cement tanks of 8 tonne capacity in 15, 30 and 60m^2 stocking density for 180 days. Growth characteristics were recorded in an interval of 30 days and sexual differentiation was possible in animals of 6-7 g average body weight by observing the secondary sexual characteristics. In the males, fully joined petasma and presence of spermatophores in terminal ampoule was observed in 11-12 g size class. Superior growth trend was observed for females from 90 days of culture onwards. Towards the end of the 180 days of culture, early maturing females were observed but accounted only 10% of the total female population. The tank reared animals exhibited poor growth and survival, which made sexual dimorphism visible post 140 days of culture. Significant difference was not observed in the final average bodyweight in the three different stocking densities after the completion of 180 days of culture at $P<0.05$. The tank reared females and males did not exhibit any sex related growth pattern, but fully developed spermatophores in the terminal ampoule was observed in males.



AVERAGE BODY WEIGHT OF MALE AND FEMALE *PENAEUS INDICUS* REARED IN POLYTHENE LINED PONDS AT DIFFERENT DAYS OF CULTURE (N=50)

The pond reared females were further reared until reaching 30-45 g size, and noticed 100% mating and impregnation. Seventy percent of the impregnated females from pond reared stock were showed gonad development between advanced second stages to 3 rd stage of ovary development after 7 month pond rearing at 1 no/sq.m. The matured female had an average weight 36.11±5.5 g , 15.38±0.48 cm, 3.61±0.34 CL. Female were subjected to unilateral eyestalk ablation and 16% female showed advanced gonad development after 3rd day of eye stalk ablation with 8% had spawning. Further to standardize the role of reproductive hormone in P. indicus brooders, 17β-estradiol was administered at a dose of 200 µL/female. Seventy percent of female at 2+ stage of ovary development stage spawned (fecundity: 75,000) with 80% hatchability.

COMPARATIVE EVALUATION OF THE SPERMATOPHORE QUALITY OF *PENAEUS INDICUS* IN WILD CAUGHT AND REARED IN CAPTIVITY (POND AND CEMENT TANKS)

A comparative evaluation of the spermatophore quality was done in 180 days old cement tank reared and pond reared *Penaeus indicus*. The spermatophores were collected from both the groups and sperm count, spermatophore weight, viability etc. was analyzed.

Both the experimental groups had the same age group but the body weight of the pond-reared animals were significantly higher. Additionally spermatophores qualities of wild caught males were also studied. Although spermatophores weight of the wild and pond reared males are similar, number of sperms in the wild male was significantly higher than the pond reared animals. The sperm count was significantly lower in the cement tank reared animals but significant difference was not observed in the normal morphology of the sperm. The no of dead sperms was significantly higher in the tank reared animals (Table 1).



MALE REPRODUCTIVE TRACT OF *PENAEUS INDICUS*

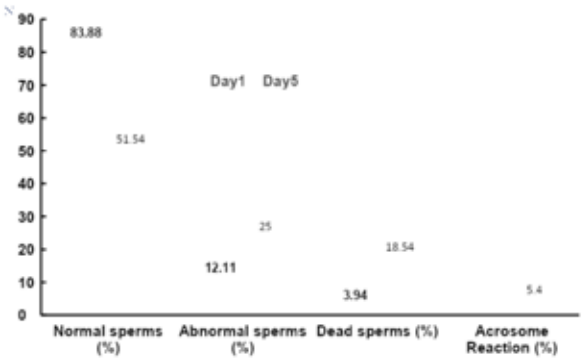
Comparative spermatophore quality parameters of *Penaeus indicus*

Variable	Tank	Pond	Wild
Body weight (g)	11.17±0.38[a]	20.63±1.34[b]	30.18±1.76 [c]
Spermatophores without sperm (%)	10	Nil	Nil
Spermatophore weight (mg)	79±0.3[a]	142±0.01[b]	144±0.02 [b]
Sperm count (106 Cells)	0.94±0.17[a]	19.87±3.22[b]	43.05±8.04 [c]
Data expressed as Mean ± S.E. Observations having different alphabet in the same row are significantly different at P<0.05.			

EFFECT OF SHORT TERM CHILLED STORAGE ON THE SPERMATOPHORES QUALITY OF *PENAEUS INDICUS*

To study the effect of short term chilled storage, spermatophores were collected in calcium free saline from inter-molt stage male *Penaeus indicus*. The collected spermatophores were stored at 4 °C and spermatophore quality characteristics such as viability, normal morphology and acrosome reaction was analysed. Number of normal sperms was significantly higher in the first day of sampling than the fifth day of sampling at P<0.05. Acrosome reaction was also observed in the stored spermatophores at five days of preservation. Beyond five days, the sperm cells were disintegrating and viability was also not observed. This study proves the applicability of chilled storage as a preservation method for spermatophores.

Male spermatophores of Penaeus indicus can be preserved at 4 ° C without losing the viability



Percentage no of normal sperms, dead sperms, abnormal sperms and acrosome reaction in the chilled stored spermatophore after day1 and day 5 in chilled storage.

EFFECT OF VARIOUS FEEDING REGIMES ON THE PHYSIOLOGICAL CHARACTERISTICS OF CAPTIVE *PENAEUS INDICUS* BROODSTOCK:

This study was carried out to evaluate the effect of different levels of maturation diet and captive rearing on physiological changes such as growth, molting rhythms and maturation hormone levels of captive *P. indicus* broodstock. Wild caught *P. indicus* brood stocks (TL-155±5 mm; BW-32.0±3g) were reared for 45 days

In adult shrimp molting does not lead to the weight gain. Profile of the GIH mRNA level depends on the nutritional status of the animal.

at stocking density of 1:1 male and female ratio under standard hatchery conditions. The feeding regime of each treatments were maintained as 5%, 15% and 25% of body weight in triplicate with clam meat and formulated feed two times a day. After 30 days of rearing, the weight gain and specific growth rate of the each animal was measured. Mean weight gain of animals feed with 5%, 15%, and 25% were 0.45±0.12g, 1.11±0.9g, 0.72±0.35g respectively which indicate that the adult stage animals would not grow, and the moulting may not for the growth of the animal. The moulting frequency of both male and

IN-VITRO FERTILIZATION AND HYBRIDIZATION POTENTIAL OF INDIAN WHITE SHRIMP, *PENAEUS INDICUS*

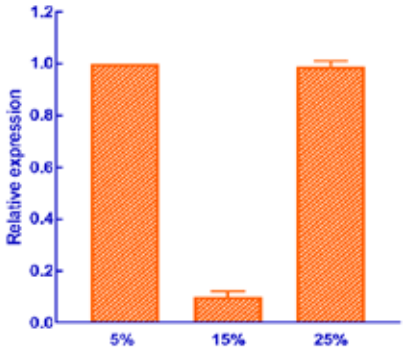


Management of reproduction of farmed shrimps under captive condition is the essential tool for developing selective breeding programs as well as for the interspecies hybridization procedure. Although reproductive biology of the shrimp has been studied in considerable details since the inception of commercial shrimp farming, mechanism of fertilization in penaeid shrimp has not been addressed in detail. The objectives of this study were: 1) to evaluate the feasibility of fertilizing capacity of preovulatory oocyte in vitro and trace the events of fertilization in Penaeus indicus, and 2) to examine the potential of hybridization of P. indicus with P. monodon. In the first experimental trial, females with ripe ovaries were dissected out, and ~1 million oocytes were mixed with 1 ml of sperm suspension. Fertilization and embryonic development were evaluated at every 15 minutes. The study shows that pre ovulatory eggs are capable for egg activation and fertilization. Hatching rate was calculated as 4.8% from the total number of egg fertilized, and 29% of nauplii developed up to PL stage. In the second trial, hybridization potential of P. indicus with P. monodon was evaluated using the procedure developed in the first trial.

VARIOUS STEPS OF EMBRYONIC AND LARVAL DEVELOPMENT

Successful intra specific fertilization was obtained, although percent of fertilization was low (10%). The results suggest that the in vitro fertilization has been an effective tool in selective breeding and hybridization in penaeid shrimps. Further the study demonstrates that hybridization between interspecific species is possible even with evolutionary distant species, and that could be effective non transgenic tool for producing hybrids with improved aquaculture traits

female varied significantly from each feed group where the 15% BW showed higher moulting frequency 2 times in 30 per animal. Further, the feeding regime showed indirect relationship to the moulting stage and positively correlated with the moulting frequency. After the 45 days rearing GIH mRNA reduced to the minimum level at the treatment group where animals fed at the rate of 15% of body weight.



Relative expression levels of GIH mRNA in the eyestalk of female Penaeus indicus reared under captivity

MODIFICATION OF BROODSTOCK REARING SYSTEM WITH SOIL BASE INCREASES IMPREGNATION IN CLOSED THELYCUM *PENAEUS INDICUS*

Captive rearing of *P. indicus* broodstock to close the life cycle is one of the major thrust areas of research to develop breeding program. Successful mating in confined indoor is a one of the challenge in breeding cycle of closed thelycum shrimps as impregnation is important for gonad development After 8-9 month indoor tank reared female reached average body weight 15.4±0.89g (14-16 g) carapace length, 2.82±0.15cm, and male 13.13±1.18 g (12-14 g) with carapace length 2.71±0.12. The male and females were restocked for maturation in soil based tanks system at 1:0.75 ratio and maintained photoperiod (18D:6L).The shrimps were fed with maturation feed (60%) and 40% live feed (mussels and Artemia). After 30 days , 57.14% male had milky white developed spermatophore and 60% of female were impregnated.

ADMINISTRATION OF SEX STEROID, E2 (17B-ESTRADIOL) TO INDUCE MATURATION AND SPAWNING OF *PENAEUS INDICUS*

Artificial reduction of gonad inhibiting hormone (GIH) titre by unilateral eyestalk ablation has been the most widely used inducement method for spawning in commercial shrimp hatcheries. The success of this procedure largely depends on the physiological status of the animals. In order to optimize the induced maturation procedure, we have refined this technique by using downstream reproductive hormones such as 17β-Estradiol in addition to the eyestalk ablation. Administration of 17β-Estradiol (200µL/female) in ablated spawners triggered spawning with 75,000 fecundity and above 80% hatchability.

MUD CRAB, *SCYLLA SERRATA*

Mud crab, *Scylla serrata* has been the focus of diversification of brackishwater aquaculture in India. Salient observations of the research work carried out during this year are: A total of four hatchery runs were carried (and three were successful) out with a production of 2600 to 3200 megalopa per one unit of production system with a capacity of 4 mt with an average survival of 3. 2%.

HATCHERY PERFORMANCE OF MUD CRAB SCYLLA SERRATA

Stage	Batch 1	Batch 2	Batch 3
Hatched	500000	1800000	4400000
Larvae reared	120000	156000	158000
Megalopa	2693	3200	2660
Megalopa/ larvae X 100	2.2	2.1	2



Larval survival of in a representative hatchery run of Scylla serrata (Z1 to Z5 Zoea 1 to 5 stages; M: Megalopa)

MATERNAL TRANSMISSION OF WSSV IN WILD *PENAEUS INDICUS* SPAWNERS

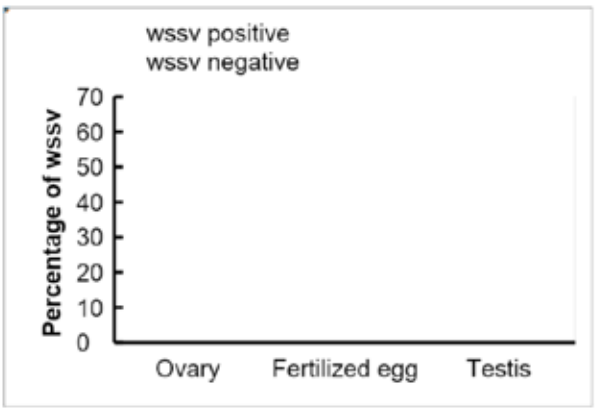
Indian white shrimp, *Penaeus indicus,* has been identified as the species of national priority for domestication and genetic improvement program in India. The viral pathogen, white spot syndrome virus (WSSV) is the most economically important virus that has been challenging the shrimp industry for the last two and half decades. WSSV prevalence were recorded during 2018-19 in different season revealed an average WSSV prevalence 45% and above 90% of the wssv positive brooders were only second step positive. Fertilized eggs and gonad tissue of the infected brooder were analysed further to quantify and tissue localization through real time PCR, *insitu* hybridisation and H&E stain. The preliminary WSSV quantification revealed low level infection with WSSV DNA copies below 50-70 copies /µL. Only 36% of gonad tissue, ovary and testis found to be infected whereas fertilized eggs recorded 60% WSSV positive while *insitu* hybridisation study of the fertilized infected egg and ovarian tissue did not give WSSV positive localization.



Infected Ovary: ISH



wssv fertilized egg: ISH stain



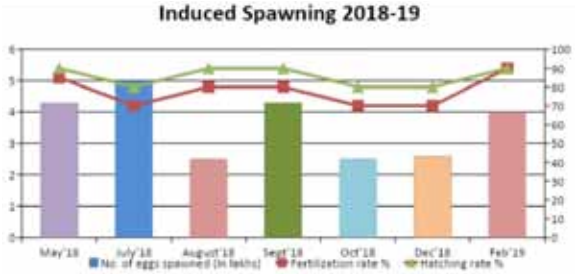
Percentage of WSSV infection in ovary, testis and fertilized eggs of P.indicus wild spawner

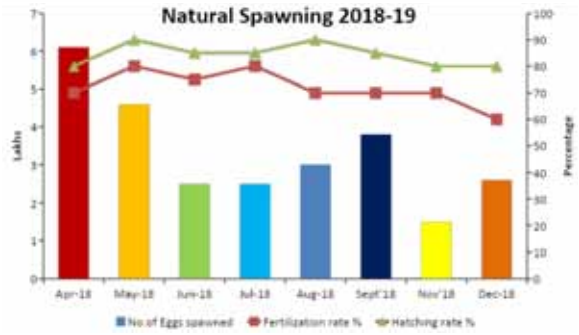
SEA BASS, *LATES CALCARIFER*

CIBA'S CAPACITY IN SEABASS SEED PRODUCTION ACCOMPLISHED NEWER HEIGHTS WITH THE INCREASING DEMAND FOR SEEDS FROM THE FARMING SECTOR

After the breakthrough in captive breeding and seed production of seabass by CIBA in the early '90s, farming seabass went through several stages of success and failures due to several technical and non-technical reasons. CIBA continue to support seabass as a diversified potential candidate for farming in brackishwater. In recent years, there is good progress in expansion seabass farming in both ponds and open water cages, using indigenous formulated feed. Realizing feed and seed are the two key drivers in the expansion of seabass farming, CIBA is putting enormous effort with advanced science to back up these two areas. A total of 43 numbers of seabass broodstock is being maintained in different systems, viz. 20 numbers in open 100-ton RCC tanks, 18 numbers in two maturation units under RAS and five numbers in earthen pond. Eight broodstock procured from Machilipattinam, Andhra Pradesh were added to the existing stock during the year 2018-19. Further, CIBA is preparing to add broodstocks of diverse genetic make-up to the existing stock and to maintain them in open water cages as back up for the future. In breeding seabass under captivity, CIBA had succeeded in both natural spawning without hormonal induction and induced breeding with hormones. Nearly half of the spawning occurred in the last year was natural ones, in the optimum rearing conditions, almost throughout the year. A total of 5.53 million eggs were spawned, 2.66 million eggs spawned from spontaneous spawning and 2.87 million from induced spawning. We observed that the number of eggs spawned and the fertilization rate was higher in spontaneous spawning compared to the induced one using hormones.

To ensure the supply of disease-free seeds to the farmers, hatchlings were screened for VNN by nested PCR, and negative hatchlings only were further reared and sold to farmers.





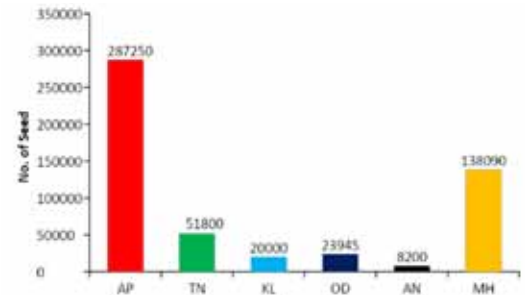
HIGHLIGHTS IN THE SEED PRODUCTION AND SALE LAST YEAR

An all-time high of 0.59 million fry seeds were sold in the year 2018-19 and a revenue of Rs. 1.72 million was realized from the sale.

For the first time, more than 1.20 lakhs seeds were completely weaned for artificial feed in the tank-based nursery, reared to more than 2 cm size and were supplied to Mangrove cell project being operated in Sindhudurg, Maharashtra.

A total of 32 farmers were supplied with seabass seeds during the year with about

54.27% seeds sold to Andhra Pradesh farmers followed by Mangrove cell Project, Maharashtra (23.5%).



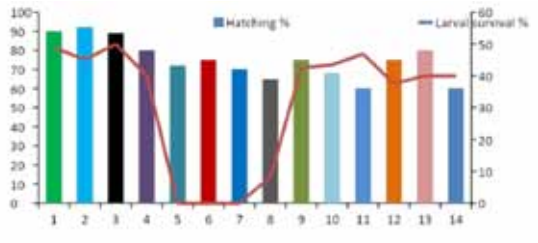
MILK FISH, *CHANOS CHANOS*

CAPTIVE BREEDING OF TWO DIFFERENT GEOGRAPHICAL STOCKS OF MILKFISH (CHANOS CHANOS)

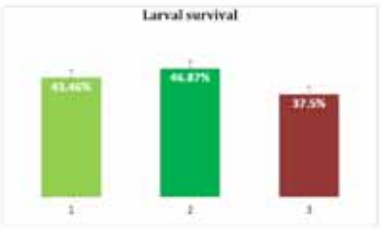
CIBA continue to do further fine-tuning and optimization of the captive breeding of milkfish after the first-time breeding of milkfish under captive conditions achieved on 8th June 2015, at our Muttukkadu fish hatchery. To evaluate the difference in reproductive performance of broodstock from two geographical locations in the east coast (Chennai (Avg. body weight 5.47 kg) and Kakinada (Avg. body weight 4.36 kg)), experiments were conducted simultaneously with the regular seed production process. Chennai stocks showed an extended breeding horizon for eight months (Feb-September) in 2017, compared to the broodfish sourced from Kakinada. Five does of combined hormone pellet were administered in both the stocks following similar breeding protocol and resulted in 14 total spawnings for six months (March-August) out of which two spawnings was from Kakinada population during month of July. It appears that the lunar cycle positively influences the milkfish spawning in Chennai population compared to Kakinada and the highest numbers of spawning occurred around 3.16 days around the new moon or full moon. Total 5.68 lakh hatchlings produced from 7.41 lakh fertilized eggs collected from both the population and under improved larval rearing protocol maximum larval survival achieved till 45 %. The milkfish fry were distributed among farmers and state fisheries departments of Kerala, West Bengal, Goa, Maharashtra, Gujarat, and Tamil Nadu. Total of Rs. 3, 74,084 revenue was generated from seed sale. Extended and multiple spawning of milkfish from both the population gives the possibility to overcome the challenges of year-round seed production, and pave the way to initiate satellite seed rearing centers outside CIBA hatchery.

ENRICHED ROTIFER AND LENGTH-BASED SIZE GRADATION TO MANAGE DIFFERENTIAL GROWTH IN MILKFISH LARVAE

Uniform healthy larvae are success indicator in hatchery production of milkfish. Milkfish larvae show differential growth after three weeks of rearing. Differential size variation causes slow growth, the emergence of shooter, and price drop in commercial milkfish hatchery. An initiative was taken to compare the potential of live chlorella , commercial algal paste of *Nannochloropsis oculata* (Nanno 3600 TM , 68 billion cells/ml) and mix cocktail of six marine microalgae (SD Aquarist™) – *Isochrysis,Pavlova, Tetraselmis, Chaetoceros calcitrans, Thalassiosira weissflogii* and *Thalassiosira pseudonana* as rotifer enrichment source for larvae. Mass cultured *Brachionus plicatilis* (140 – 210 µm) were collected and enriched with frozen green commercial algae paste *Nannochloropsis oculata,* and fresh *Chlorella salina* (1:1 ratio) in a 100 L volume container overnight and were supplied as initial feed to the larvae @ 20-30 numbers ml-1 from 3 dph to 21 dph. Similar enrichment protocol carried out for SD Aquarist. *Nannochloropsis oculata* enrichment showed better survival (46.87%) compared to the other two sources, although size variation was evident in all the groups. Three size groups of milkfish larvae arise after third week i.e. large: 1.68-1.70 cm, medium: 1.09-1.11 cm and small: 0.74-0.76 cm. Larvae were collected from 8 t LRT and manually graded in commercially available sieves to uniformly stock in 1t LRT without altering previous feeding regimes. The initial result suggests 15 days post grading (till 30-32 dph) larvae achieves homogenous growth pattern of 1.9 to 2.5 cm and can be sold @ Rs. 4.0 /- per seed. Stakeholders can easily accept this practice without establishing a costly algal culture unit while undergoing satellite seed rearing.



Breeding response from two geographical population of milkfish (2018)



Different algae for rotifer enrichment and larval survival

GREY MULLET, *MUGIL CELPHALUS*

UPRIGHT PROGRESS IN CAPTIVE BREEDING OF GREY MULLET USING FARM REARED PARENTAL STOCKS

Grey mullet *Mugil cephalus* is one of the most significant candidate brackishwater finfishes priced for its roe in global markets and valued as a high-value food fish in domestic markets. An increasing concern is being raised over the dwindling natural seed resources, which have affected the traditional fishermen and grey mullet farmers alike. As an innovative approach, since 2017, CIBA is attempting to use a low volume RAS based breeding system for captive reproduction of the species within the farm premises and then transporting the fertilized eggs to a hatchery facility for further hatching and rearing. During June-July, 2017, five successive breeding trials resulted in larval production and the fertilized eggs were transported to CIBA's pilot-scale hatchery at Muttukadu for further rearing. Larvae survived only for 8 days post-hatch. In 2018, despite a drastically low salinity of 4 ppt in the pond system, three breeding attempts resulted in mass larval production. Female fish with average oocyte diameter of 535-550 µm were used. After a latency period, 15-16 h, 0.7 - 1.1 million eggs were obtained by dry stripping. Fertilization rate was observed to be 60%, and the size of fertilized egg and oil globule was 790- 810 µm and 290-300 µm respectively. Size of newly hatched larvae was 2.1 mm. At hatchery site, 1.25 lakh larvae were reared, using rotifer, *Brachionus plicatilis,* 5-20 no ml/ml, copepods and *Artemia* nauplii. Nanochloropsis, 1-2 lakhs cells per ml was used as the background phytoplankton. With all these differential efforts compared to the last year attempt, we obtained good survival up to 20dph this year as significant progress in captive breeding of mullet. Critical periods were recorded at 8 DPH and 13-15 DPH. Further refinements in larval rearing are in progress to standardize the captive breeding protocol of grey mullet in the near future.



Photographs of grey mullet larvae; 0h, 3h, 6h, 10h, 48h, 72h, 96h, 5DPH,6DPH, 7 DPH, 8 DPH,9 DPH, 12 DPH,15 DPH,18 DPH, 20DPH

GEOGRAPHICALLY ISOLATED GREY MULLET STOCKS DISPLAY ASYNCHRONY IN SEASON AND EXTENT OF SPAWNING IN CAPTIVITY

Globally grey mullet aquaculture is carried out without any distinctions between the groups of the grey mullet species complex. However, some recent studies show that biological differences may also have significant economic implications for aquafarmers. Our observations from captive reproduction conducted in east and west coast show that the peak spawning period of the two geographical groups is asynchronous. Grey mullet stocks from east coastal waters and reared in captivity spawned in the beginning of November, while stocks from west coast showed active spawning during between mid-June and mid-July. We also noticed there is a significant difference in the extent of spawning season in relation to the wild and captive stocks irrespective of the origin. In the east coast and west coast, spawning in wild happens during captivity October to January and May to July respectively. This indicates that captivity affected the onset and duration of spawning periods differently in grey mullets. Our attempts at captive breeding between 2016-18 using these two geographical stocks of grey mullet have yielded varying results, some of these may indicate their biological differences.

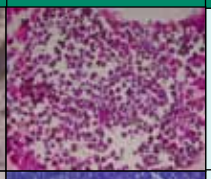
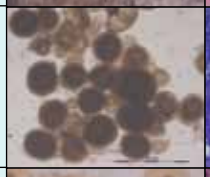
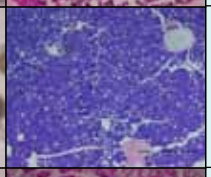
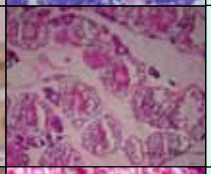
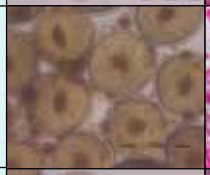
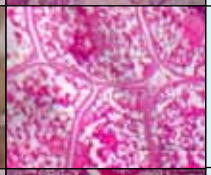
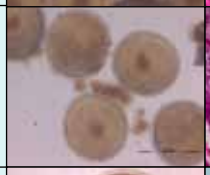
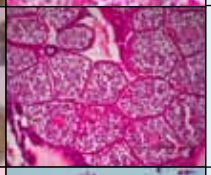
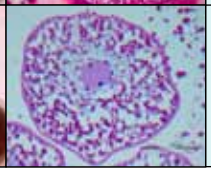


Spawning seasons of two geographical groups of grey mullet captivity in relation to wild (West coast wild grey mullet (Rekha et al., 20191); East coast wild grey mullet (Mohanraj et al., 19943)

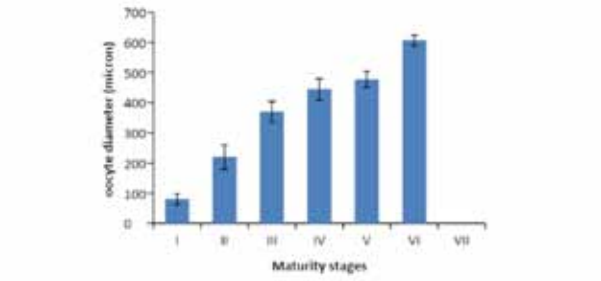
GOLD SPOT MULLET, *LIZA PARSIA*

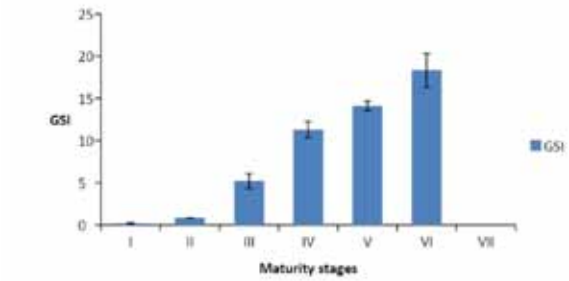
GONADAL DEVELOPMENT OF *LIZA PARSIA* REARED IN BRACKISHWATER POND

A total of 300 sub-adult and adult Goldspot mullet, *L. parsia* (size: 50 to 110 g) were stocked in pond and fed with broodstock diet (32% protein and 8% lipid) @ 5% body weight twice daily. During the breeding season (November to January) gonad development is studied. During spawning season, dissolved oxygen, salinity, Ph was 6.4, 7 ppt and 8.2, respectively. Female fish (size: 70-110 g, n= 6) of different maturity stages were collected from the pond. Different maturity stages were defined as: immature (stage I &II), early maturing (stage III), late maturing (stage IV), mature (V) and ripe (stage VI). Gonadosomatic index and oocyte diameter of different maturity stages are shown in figures. The result showed that stage I, II and III have central GV; Stage IV have migrating/ eccentric GV; Stage IV have peripheral GV; Stage V showed germinal vesicle breakdown (GVBD); Stage VI showed ovulated oocytes. Further, it is observed that oocytes having less than 100 µm in diameter are non-vitellogenic in nature and *Liza parsia* attained the maximum GSI and oocytes diameter of 606.55±17.02 and 18.31±2.0, respectively in captive condition. This observation evident that broodstocks of *Liza parsia* could be easily developed using the the apt feed in pond based system, and there won't be any much trouble in getting brood fish for captive breeding.

Stage of maturity	Oocytes	Histology	Vitellogenesis
Stage I (Immature-I, <100 µm)			Non-vitellogenic
Stage II (Immature-ii, Stage oocyte dia-100-350 µm)			Previtellogenic
Stage III (early maturing, Oocyte dia- 350-400 µm)			Previtellogenic
Stage IV (late maturing oocyte dia- 400-450 µm)			Mid-vitellogenic
Stage V (Mature, (oocyte dia-450-500 µm)			Post-vitellogenic
Stage VI (Ripe, oocyte dia-500-600 µm)			Non-vitellogenic

Oocytes diameter



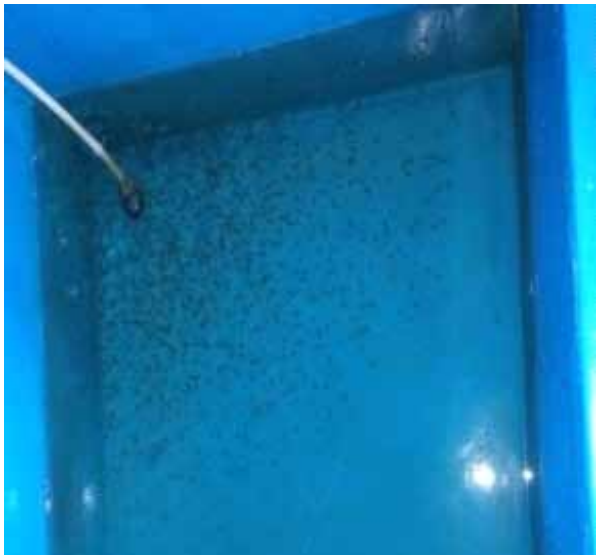


PEARL SPOT, *ETROPLUS SURATENSIS*

FARMERS ADOPT SEED PRODUCTION OF PEARLSPOT *ETROPLUS SURATENSIS* FOR ADDITIONAL INCOME GENERATION

Pearlspot fish culture has been constrained by the availability of quality seeds in the required quantity. Fish seed costs have been increasing over the years and range between Rs 4-10 per fish based on the size. Because of complex parental care and low fecundity, pearlspot could be an ideal species for homestead farming models and seed production. Year-round seed production provides an avenue to the farmers for additional income generation with simple infrastructure. Mr. Keerthiram, Alappuzha a fish farmer from Alappuzha signed MOU with ICAR-CIBA for adopting ICAR-CIBA's model for pearlspot seed production. He has successfully been producing pearlspot fry repeatedly from pairs of parent fish (breeding interval, 17- 35 days) through larval separation at the wriggler stage. He has been conducting larval rearing using *Artemia nauplii* and the fry produced has been used for stocking in his farm and sold to neighboring farmers. Farmers Mr. Baiju, Thrissur also successfully conducted homestead pearlspot seed production. Mr. Unni, from Ernakulam, has also initiated the activity after learning from them. This model may be promoted widely in Kerala, where this fish fetches good price.







Seed production of pearl spot



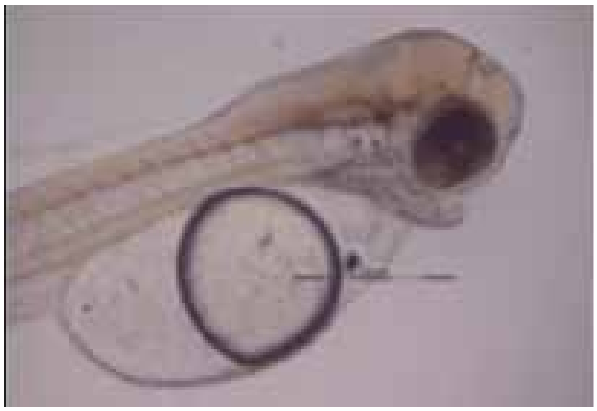
HILSA, *TENUALOSA ILISHA*

CAPTIVE BREEDING AND NURSERY REARING OF HILSA, *TENUALOSA ILISHA* IN AN EARTHEN POND SYSTEM

Hilsa, *Tenulosa ilisha* is an important commercial fish of the Indo-Pacific region, especially Bangladesh, India, and Myanmar. At present, the total catch has declined in these countries due to obstruction of natural migration for breeding, overfishing, water pollution and sedimentation in rivers. Therefore, to conserve and develop aquaculture of this species domestication and development of captive stock is essential. Wild mature migratory fishes were breed through dry-stripping, and larval rearing methodology was developed by using earthen ponds. Oozing male (270±5.0 g) and female (780±15 g) fish during its spawning migration (February to April) were captured from Hooghly River at Godakhali, and breed through dry stripping. Fertilized eggs were incubated and after hatching three different age group of larvae such as: 3 days post hatching (dph)-before yolk sac utilization, 5 dph- after yolk sac utilization and 12 dph-before oil globule utilization were stock in well prepared nursery ponds (100 m2). Stocking density in each pond were approximately 100000 individuals. During nursery, larvae were fed with *Artemia nauplii* (2 g Artemia cyst in each treatment) along with powder feed (20 g). At weekly interval, fermented GNOC (100 g) was applied in each pond. After 60 days of the nursery, it is found that the significantly higher survival (5%) in 3 dph and 5 dph group lower average weight (0.8 g) than the other two groups. However, the average size was significantly larger (1.8 g) in 12 dph group than the other two groups. Using this methodology, we were able to produce 5000 hilsa fry, and further reared to observe its performance in captivity.



Stripping of female



3 dph larvae (yolk sac and oil globule)





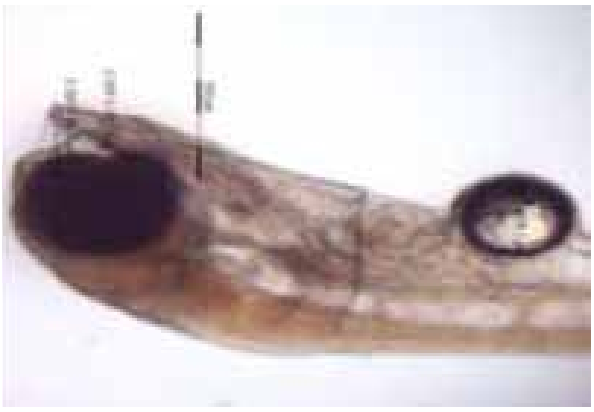
Stripping of male



Fertilized eggs



5 dph larvae (oil globule)



12dph larvae (little oil globule)

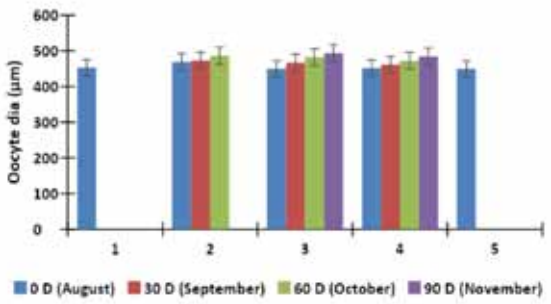




ORNAMENTAL FISH

INDUCED MATURATION AND VOLITIONAL SPAWNING OF SPOTTED SCAT: IN RAS BASED HOMESTEAD FISH BREEDING MODEL

Spotted scat is a well-known euryhaline species which is valued as ornamental and food fish. Simplified Induced maturation and breeding techniques in captivity will boost the seed production by small scale farmers in their backyard or in simple, compact hatcheries cater to the growing market demand. A Recirculatory system of 3000 L capacity and 12.9 m^3/day flow rate with central drainage was fabricated. Pairs were kept at 1:1 stocking density in each maturation/spawning tank. Females were induced either with varying doses of LHRha (100, 50, 25, 10 µg/kg body weight) or combination dose of LHRha + HCG (50 µg/kg b.w.+50 IU) which were delivered intramuscularly via cholesterol-based pellet. Males were induced with combination hormone dose of LHRHa + 17-αMT (25 + 25 µg/kg body weight). Experiment was successfully conducted for four months where hormone dose of 25 and 10 µg/kg could sustained the gradual increment of oocyte size. Oocyte size increased from initial dia of 450 ± 38.12 µm to 493 ± 18.5 µm with monthly LHRHa dose of 25 µg/kg and later led to successful spawning. Sperm density in males also increased from initial 17.68 ± 5.17 (X 10^9 spz/ml) to 25.21 ± 3.18 (X 10^9 spz/ml). Female scat brood fishes could be successfully induced to spawn with 25 µg/kg b. w. LHRHa monthly dose whereas combined dose pellet of 25 + 25 µg/kg of LHRHa + 17-αMT was helpful to increase sperm density in males. These optimized doses would be useful for attaining volitional spawning for larval production under RAS based captive conditions.



Effect of different hormone doses (Pellet) on oocyte diameter of female spotted scat

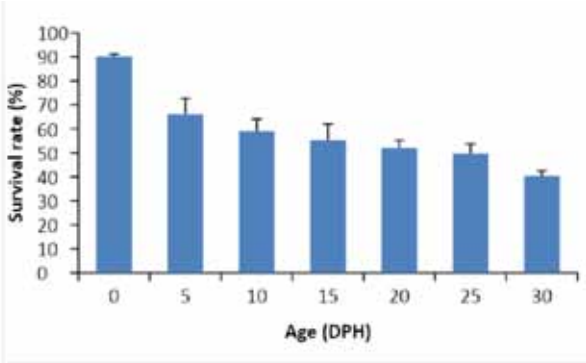


Just hatched scat larvae

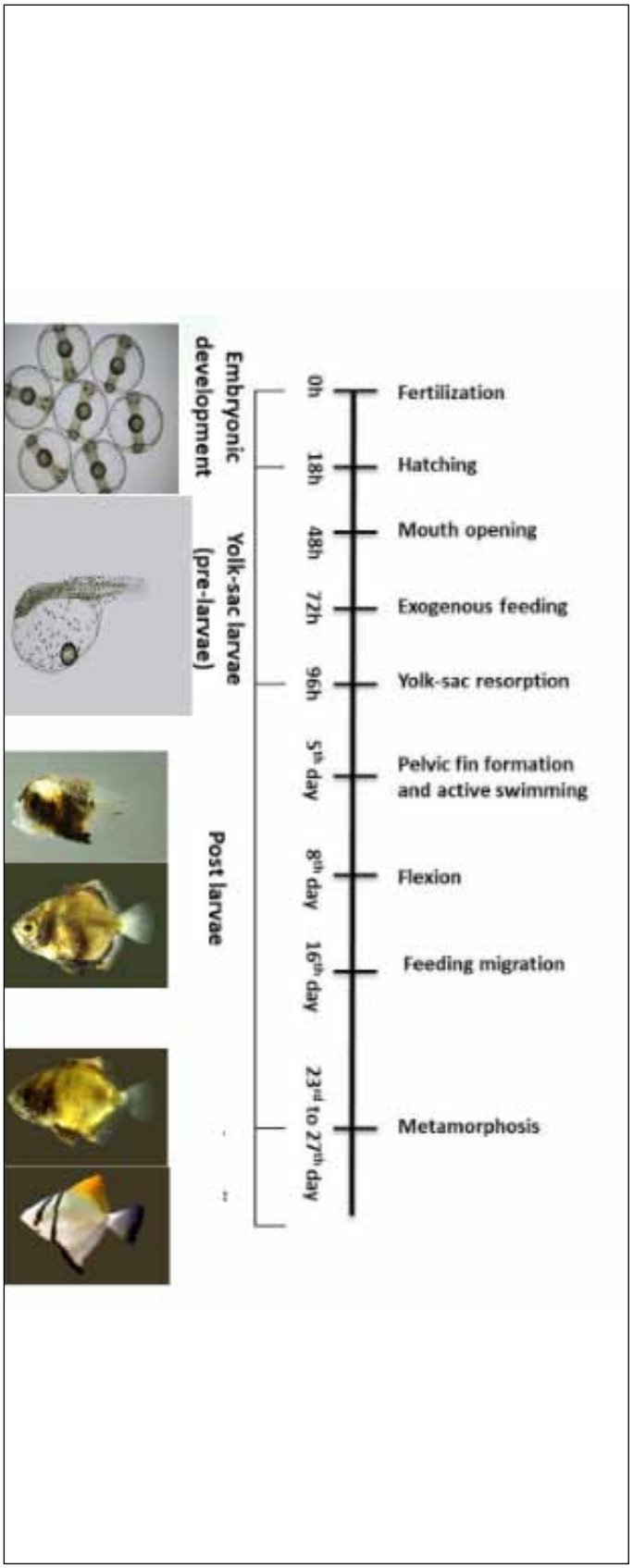
CAPTIVE BREEDING OF SILVER MOONY, *MONODACTYLUS ARGENTEUS* A POTENTIAL FISH FOR BRACKISHWATER AQUARICULTURE

Silver moony, *Monodactylus argenteus* is a species of high demand in the international ornamental fish industry. CIBA for the first time attempted the broodstock maturation, induced breeding and larval rearing of silver moony in captivity for the first time. Sub-adults of silver moony collected from Vennangupattu backwaters, Tamil Nadu, India (n=200 avg weight, 50 ± 7g) were maintained in fixed cages in pond system at Muttukadu Experimental Station on formulated broodstock feed (2mm, CP: 52%, CL: 10%) and *Artemia* biomass and monitored for sexual maturation in captivity. The breeding system consisted of FRP tanks, capacity 500 l (salinity 31 ppt, temperature 28^{0}C,) provided with hideouts. Female with oocyte diameter > 500 µm and males with oozing milt were selected to maintain a sex ratio of, male: female; 2: 1 in the breeding tank. Hormonal induction for breeding was done using LHRHa. Natural spawning and fertilization were observed after 36 h of hormone administration. The fertilized eggs were transparent, pelagic, non-adhesive with single oil globule. The diameter of the egg was 860 ± 14.11 µm. Fertilized Incubation was done in 200 l black, cylindroconical tanks. The incubation period was observed to be 18 h, and the hatching percentage was 90%. Newly hatched larvae were 1.60-1.67 mm.

Development of seed production in captivity of silver moony will pave the way for the transition of ornamental fish trade of this species from wild caught stocks to more sustainable breeding based mode.



The survival rate of Monodactylus argenteus during the larval rearing



The main events of larval development in Monodactylus argenteus

BROODSTOCKS DEVELOPMENT OF CANARA PEARLSPOTS, AND ORANGE CHROMIDE UNDER CAPTIVE CONDITIONS

Canara Pearlspot and Orange Chromide are high values chromides highly preferred in the ornamental fish industry. Broodstocks development of Canara Pearlspots, *Etroplus canarensis* and Orange Chromide, *E. maculatus* were carried out at MES, Muttukadu. Adults of Canara Pearlspots, *E. canarensis* were subjected to different brackishwater condition. But there were no spawning notices in brackishwater conditions. But there was continuous spawning in freshwater conditions. We are expecting there will be in spawning in brackishwater after exposing the fish for generations in brackishwater. In orange chromide, spawning is noticed in all the salinities.



Brood parents of Canara Pearlspots

STOCK MAINTENANCE OF POTENTIAL BRACKISHWATER ORNAMENTAL FISH SPECIES FROM SUNDARBAN TO EXPLORE THE CHANCES OF CAPTIVE BREEDING

Brackishwater ecosystem is the natural habitat of several ornamental fish species. Among them, only a few are being traded and have captive breeding protocols available. However, efforts in developing and popularization of seed production of untapped indigenous species will go a long way for building a robust ornamental fish industry in India. For this purpose, an 800 m^2 pond was prepared with crab and bird fencing as broodstock pond at KRC. Three different species, green pufferfish, *Dichotomyctere fluviatilis* (2 no.), mudskipper, *Pseudapocryptes elongatus* (215 no.) and Boddart's goggle-eyed goby/ mudskipper, Boleopthalmus boddarti (105 no.) were collected from Hooghly estuary and stocked at the broodstock pond. This stock is being strengthened further for captive breeding purpose.



Green pufferfish, Dichotomyctere fluviatilis



Mudskipper elongatus, Pseudapocryptes



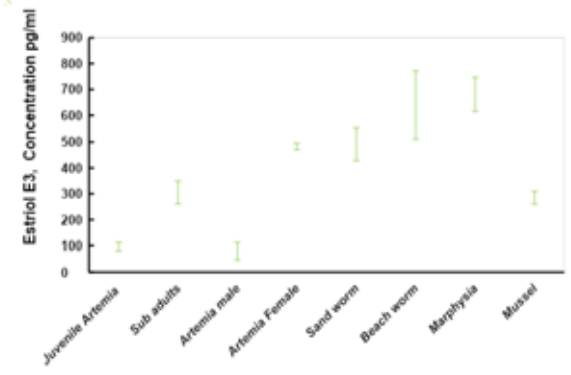
Boddart's goggle-eyed goby/ mudskipper, Boleopthalmus boddarti

LIVE FEED

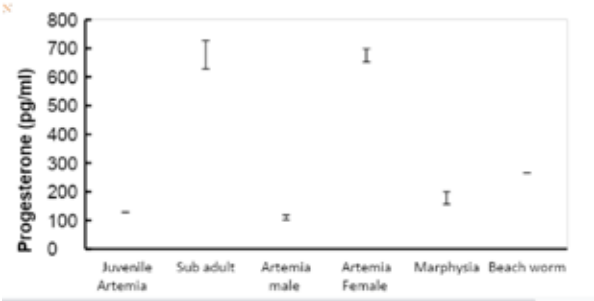
Although *Artemia* is not a natural diet of any of the aquacultured species, it is most convenient, least-labor-intensive and most widely used live feed in aquaculture facilities. *Artemia* has been one of the major focuses of research of CIBA for the last decades. The current year we have explored the potential of *Artemia* biomass as a maturation diet and as a vehicle for hormone delivery. Further, as a part of the diversification of live feed organism, we have studied the potential of copepod and nematodes. Copepod constitute the major part of the diet of early life stages of many finfishes, and crustaceans, however, use of copepod as a live food organisms in the aquaculture facilities is still limited. To address this issue, the potential for mass culture possibility of copepod has been explored during the current year.

ARTEMIA BIOMASS AS A QUALITY BROODSTOCK DIET AND BIOVEHICLE FOR HORMONE DELIVERY

To understand the role of *Artemia* biomass as a quality broodstock diet for penaeid shrimps, presence of vertebrate sex - steroid hormones, for example: progesterone and estradiol in different life stages and sexes of *Artemia* was studied and compared with conventional maturation diets (e. g. polychaetes: sand worm, Neries sp., Blood worm, *Marphysia*, beach worm and mussesls: *Perna virdis*). The level of estriol E3, major metabolite of estradiol, was found to be highest in in adult female Artemia 471±24.60 pg / ml E3 However, among the all tested maturation diet, polychaete Marphysa spp had highest E3 titre (616 ± 131 pg / ml) To understand its role as a vehicle for hormone delivery, Artemia was enriched with 20 mg estradiol/3 ml alcohol. After enrichment, 22 fold increases in estriol bio encapsulation efficacy was noticed. The preliminary studies indicated the potential for replacing polychaete with Artemia biomass.



Concentration of Estriol E3, a major metabolite of estradiol level (mean ±SD) noticed in different life stages of Artemia and different types of polychaete worms.



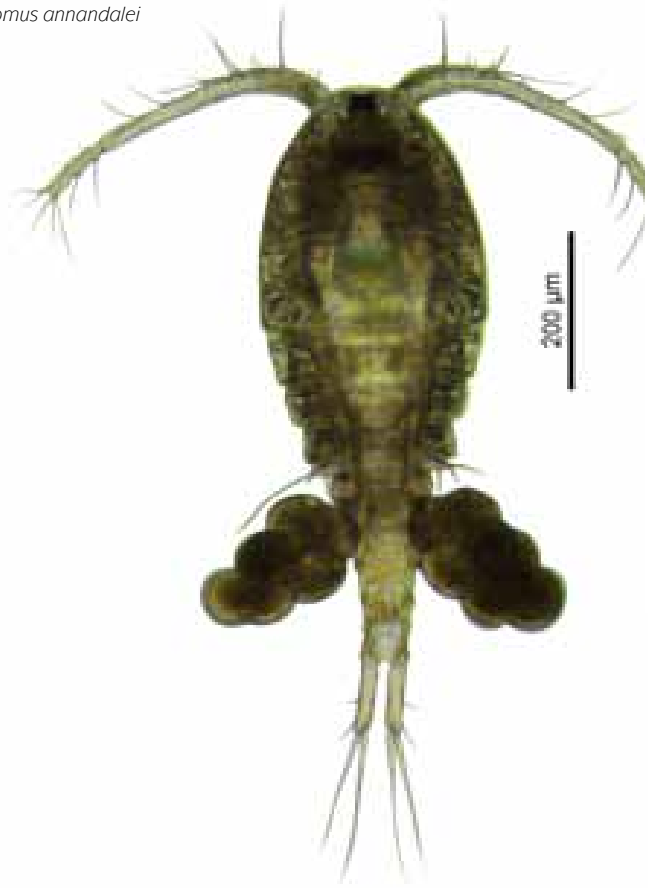
Concentration of progesterone (mean ±SD) noticed in different life stages of Artemia and different types of polychaete worms.

Artemia biomass production in indoor system recorded highest biomass 3.29±0.5 kg/m^3 at 500 nos/L followed by 1000 (2.69±0.3 kg/m^3) and 2000 nos/L (2.59±0.5 kg/m^3). At lower density more than 90% of population attained maturation

Copepods: Copepods are important crustacean live feed, and it has been increasingly used as a live prey in finfish and crustacean larviculture. Several experiments were carried out to develop a commercially viable mass culture procedure for copepods. The growth performance of three species of copepods: *Dioithona* sp (Cyclopoida), *Pseudodiaptomus annandalei* (Calanoida) and *Evansula pigmaea* (Harpacticoida) were evaluated under different combinations of microalgae for a period of 20 days. Highest density was observed in the treatment with *Dioithona* sp (4000±155nos/l) with in a period of 7 days with a combination of *Nannochloropsis* sp and *Isochrysis* sp (cell density of 35000 cells/ml) followed by *Pseudodiaptomus annandalei* (2700±78 no /L) with in a period of 10 days using a combination of *Chaetoceros* sp and *Thalassiosira* sp and *Evansula pigmaea* (1800± 65 nos/L) with in a period of 8 days with a combination of *Chaetoceros* sp and *Isochrysis* sp. *E. pigmaea* had smallest nauplii (48±1.1µm), and *P. annandalei* had the largest *nauplli* (75±2.6 µm).). Among 3 copepod species, maximum density can be produced within short duration is *Dioithona* sp



Pseudodiaptomus annandalei

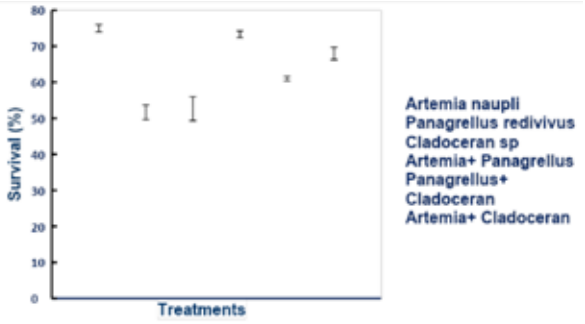


Dioithona spp



Evansula pigaea

Potential of Nematode and Cladoceran as live feed with reference to conventional Artemia based live feed: Ninety percent of *Artemia* cysts used in the global aquaculture industry comes from a single source (Great found lake, USA), where climatic changes would generate unforeseen issues in exploiting the wild Artemia cyst. At this background, potential of live feed such as Nematodes and Cladocerans were evaluated as shrimp larval feed with reference to the conventional Artemia based live feed. Nematode can survive up to 60ppt salinity, and can be cultured easily using yeast media and reached a maximum density of 0.1 million/ml within 2 days of culture period. An experiment was conducted using nematode species (*Panagrellus redivivus*) and Cladoceran species during the mysis stages of *P. indicus*. Experiment was conducted in 20 L plastic tubs with *P. indicus* zoea 3 with a stocking density of 100 numbers. *Artemia* naupli and Cladoceran species was fed at a rate of 10 no/ml and nematode at the rate of 100 no/ml and also in combination (1:1). No significant difference was observed among the treatments with control and combination of *Artemia* naupli and nematodes. Over all result indicate that microworm can be effectively used along with *Artemia* naupli during the mysis stage of *P. indicus* to reduce the cost of production.



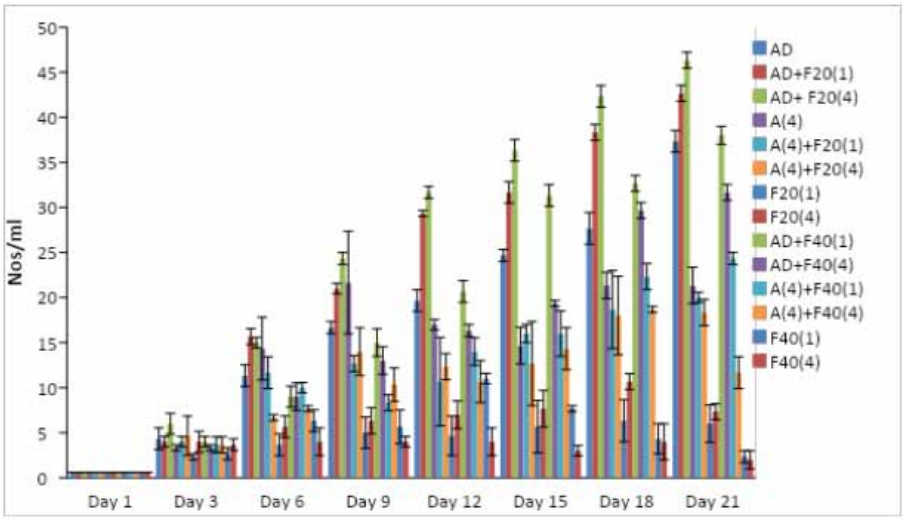
Percentage survival of P. indicus larvae in different treatments



Panagrellus redivivus

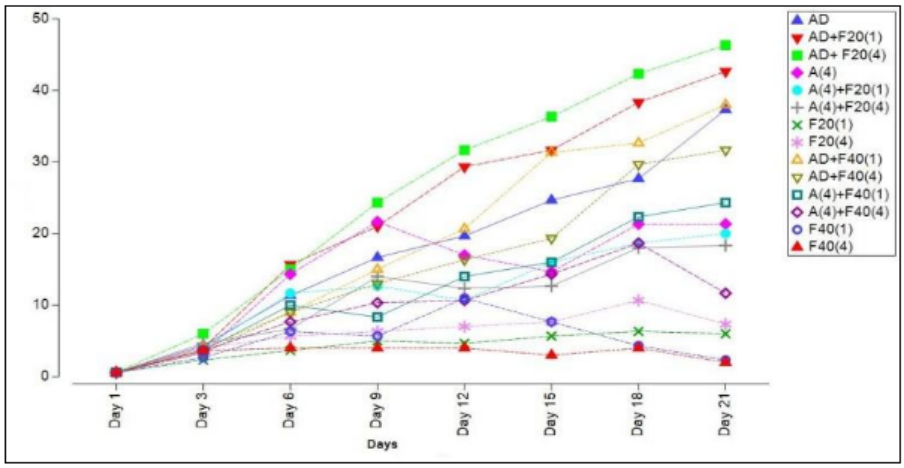
FISH TRIMMING HYDROLYSATE (FTH) AS PLANKTON BOOSTER FOR COPEPOD SP

An experiment was conducted using Cyclopoid copepod added with Fish Trimming Hydrolysate (FTH) at concentration of 20 and 40 ppm on daily basis and 4 days interval in combination with *Thalassiosira* sp and *Nannochloropsis* sp for a period of 20 days in 20L Plastic tubs. Copepod was added at the rate of 600 nos/l and counting was done in 3 days interval. Maximum density (Fig 3 & 4) was observed in the treatment added with 20ppm FTH on 4 days interval (46±0.9 nos/ml) followed by treatment with single dose (20ppm) i.e. 43±0.9nos/ml followed by treatment with single dosage of 40ppm i.e.38±1nos/ml with daily inoculation of algae and control treatment (37+1.2nos/ml). There is a significant difference was observed in the treatment with control and treatment added with 20ppm FTH on 4 days interval dosage ($p<0.05$). Minimum density was observed in the treatment with FTH alone (Fig 5). Over all result indicates that FTH can be used as plankton promoter in combination with microalgae at a concentration of 20ppm.

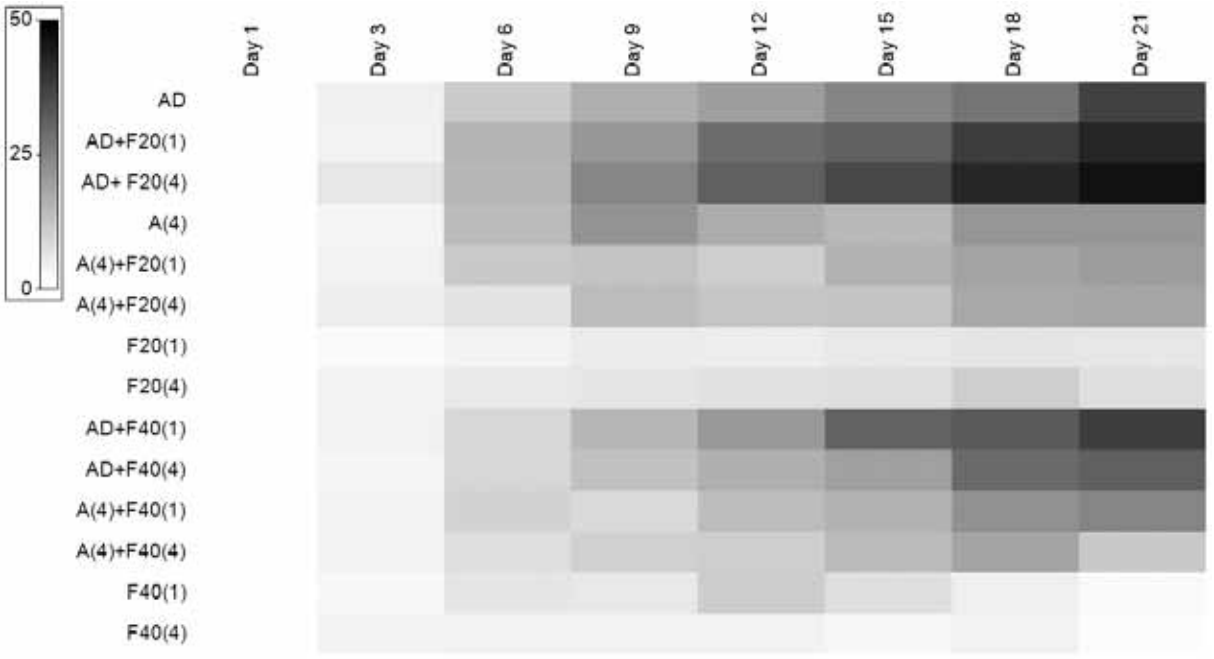


Density of copepod/ml in different experimental treatments

AD- Daily algae	FX(1)- FTH @ X ppm at single dose	FX(4)- FTH @ X ppm at 4 days interval	A(4)- Algae added 4 days interval



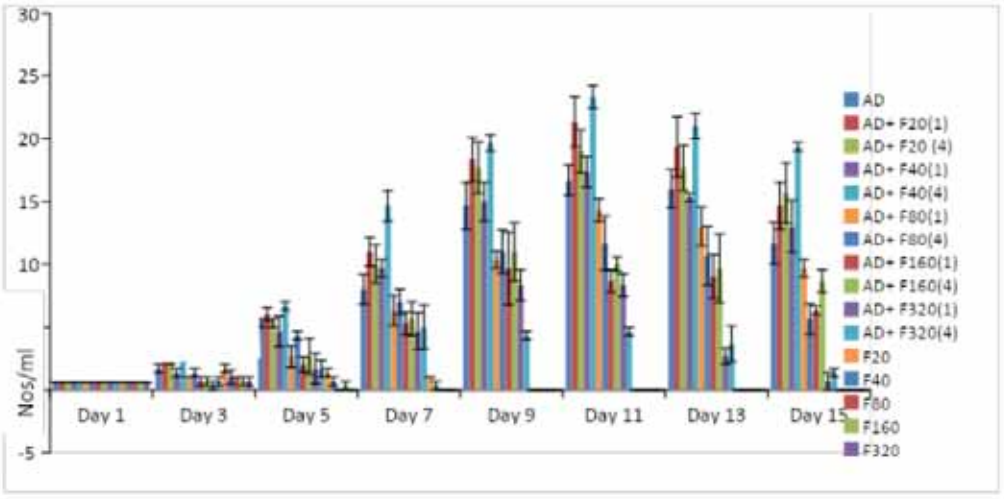
Dominance plot showing the density of copepod during different interval periods



Shade plot showing Cyclopoid density in different treatments

FISH TRIMMING HYDROLYSATE (FTH) AS PLANKTON BOOSTER FOR CLADOCERAN SP

An experiment was conducted using Cladoceran sp (*Eurycercus berinji*) FTH at a concentration of 20, 40, 80, 160 and 320ppm on daily basis and in 4 days interval in combination with *Thalassiosira* sp and *Nannochloropsis* sp for a period of 20 days. Cladoceran was inoculated at a rate of 600 nos/L and counting was done on 2 days interval. Maximum density was observed in the treatment added with 40ppm FTH (23+0.9nos/ml) on 4days interval dosage>FTH at 20ppm on single dose (21+2.02nos/ml)> FTH at 20ppm on 4 days interval (19+1.7nos/ml)> control (17+1.2nos/ml) with daily dosage of algae on 11th day. Minimum density was observed in treatment with FTH alone. Overall result found that FTH can use as plankton booster for Cladoceran species in combination with microalgae at lower concentration (40ppm on 4 days interval).



Density of Cladoceran in different experimental treatments

AD- Daily algae (NAN+THL)	FX(1)- FTH @ X ppm at single dose	FX(4)- FTH @ X ppm at 4 days interval	FX- FTH @ X ppm

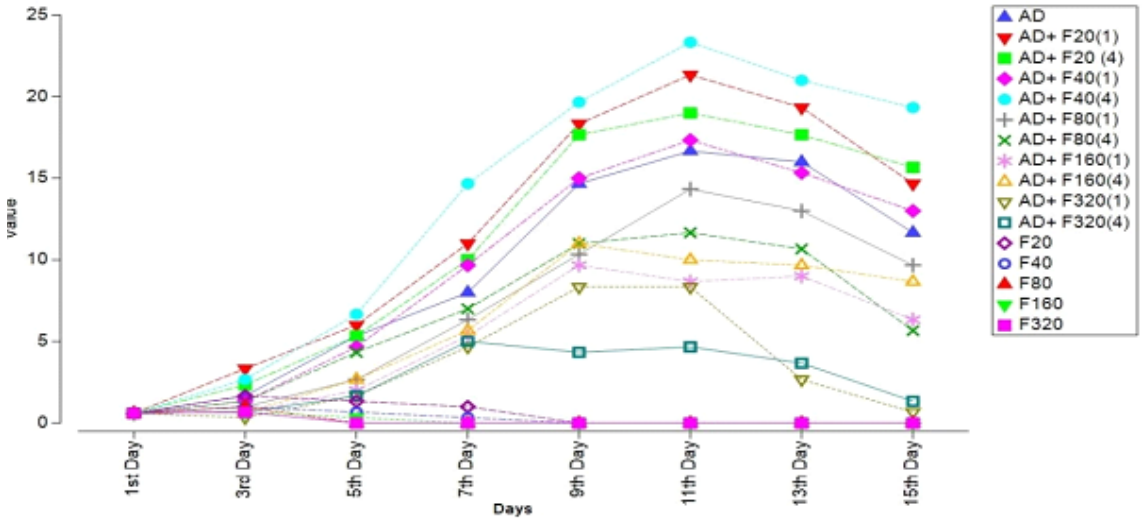
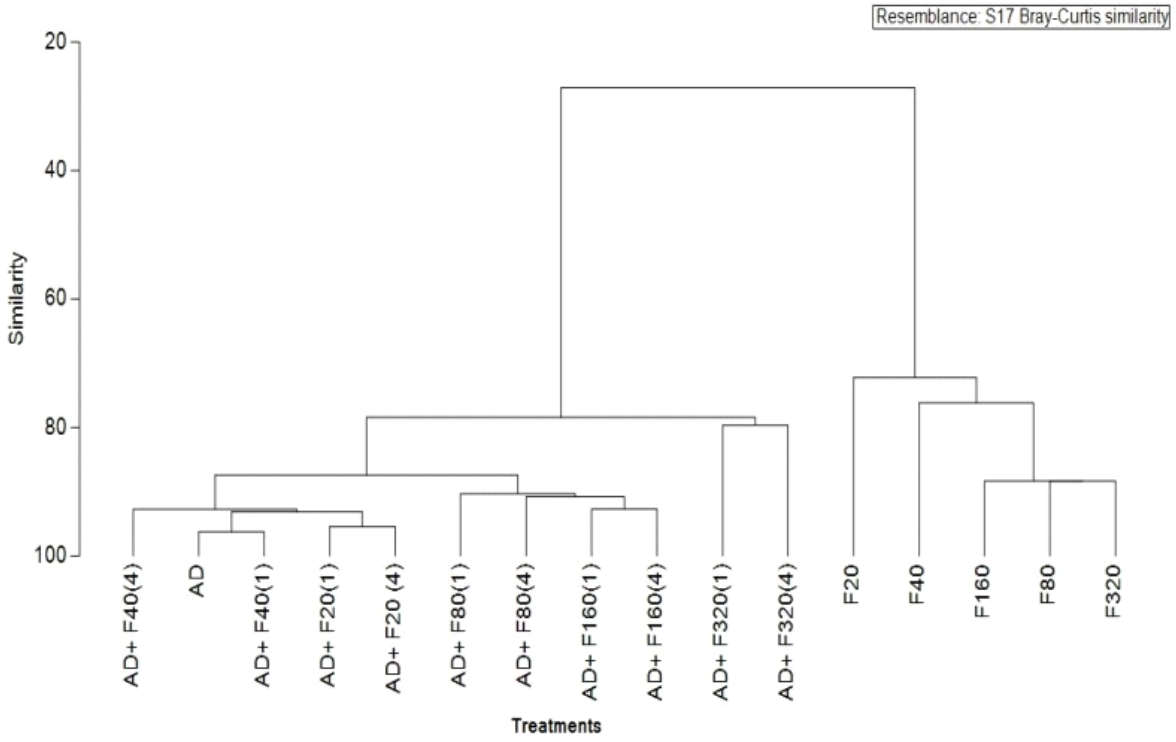


Fig 7. Dominance plot showing the density of cladoceran during different interval periods



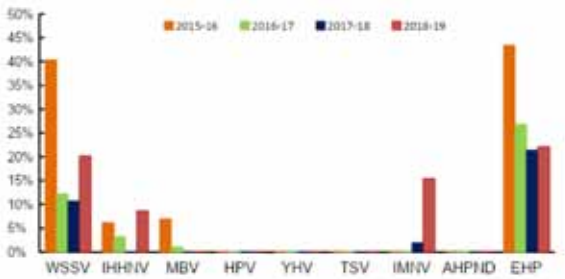
Cluster diagram showing similarity of different treatments

AQUATIC ANIMAL HEALTH

WSSV AND EHP CONTINUE TO BE THE MAJOR INFECTIOUS AGENTS LIMITING PRODUCTIONS IN INDIAN SHRIMP FARMING

Diseases are the biggest threat in shrimp aquaculture growth and sustainability. As part of the on-going active shrimp disease surveillance programme since the year 2014, a total of 523 shrimp farms have been screened for OIE listed pathogens in three maritime states viz., Tamil Nadu (TN), Andhra Pradesh (AP) and West Bengal (WB). During the last four years, the white spot syndrome virus (WSSV) and *Enterocytozoon hepatopenaei* (EHP) have been recognised as the predominant pathogens affecting shrimp farming in the two major shrimp farming states AP and TN. The hepatopancreatic microsporidiosis caused by *E. hepatopenaei* had the highest prevalence rate of 43% during 2015-16. However, the prevalence of EHP decreased over the years and during 2018-19, its prevalence was about 27%. The prevalence of the most dreaded white spot disease (WSD) was about 40% during 2015-16, which declined to 11% in 2017-18 and again increased to 20% during 2018-19. Infectious myonecrosis virus (IMNV) was first time observed during 2017-18 in India. Its prevalence was found to increase to about 15% during 2018-19. The prevalence of infectious hypodermal and haematopoietic necrosis (IHHN) disease ranged between 3-9%, over the last four years. The prevalence of other disease syndromes, attributable to poor farm management such as stunted growth, white faeces syndrome (WFS), loose shell syndrome (LSS), running mortality syndrome (RMS), white muscle syndrome (WMS) and black gill was about 15-30%, 7-26%, 1-11%, 0-20%, 2-11% and 1-5% respectively. White faeces syndrome (WFS) and stunted growth or size variation continue to be major issues due to poor farm management during the past four years.

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).



Prevalence of viral, bacterial and fungal diseases in Andhra Pradesh, Tamil Nadu and West Bengal TN and WB during 2015 – 19 (n= 523 farms)

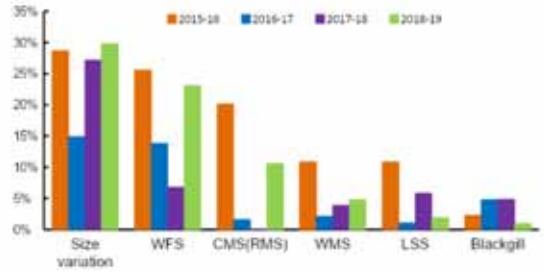


Fig. Prevalence of disease syndromes of shrimp in Andhra Pradesh, Tamil Nadu and West Bengal TN and WB during 2015 – 19 (n= 523 farms)

POLYCHAETE WORMS CAN TRANSMIT *ENTEROCYTOZOON HEPATOPEANEI* TO SHRIMP

Earlier studies at CIBA had revealed that the polychaete worms serve as carrier for shrimp pathogens such as WSSV (8.5% of the samples), EHP (7.6% of the samples) and multiple pathogens (WSSV and EHP in 3.6% of the samples). In an experimental study, EHP-infected shrimp when fed to polychaetes, the polychaetes attained the status of carriers and were capable of transmitting EHP to naïve SPF-*Penaeus vannamei* providing evidence that the polychaetes can be the source for EHP infection in shrimp hatcheries and vice versa. The study confirmed the horizontal transmission of EHP from infected shrimp to polychaetes and *vice versa*. However, no evidence of vertical transmission was recorded in different developmental stages of polychaetes.

Polychaete group (n=20/tank)	PCR(SWP)	Days post exposure (dpe)of EHP						
		0	15	30	45	60	75	90
Tank A	1st step	-	+	+	+	+	+	-
	Nested	+	+	+	+	+	+	+
Tank B	1st step	-	+	+	-	-	-	-
	Nested	-	+	+	+	+	-	-
Tank C	1st step	-	-	-	-	-	-	-
	Nested	-	-	-	-	-	-	-
Tank D	1st step	-	-	-	-	-	-	-
	Nested	-	-	-	-	-	-	-

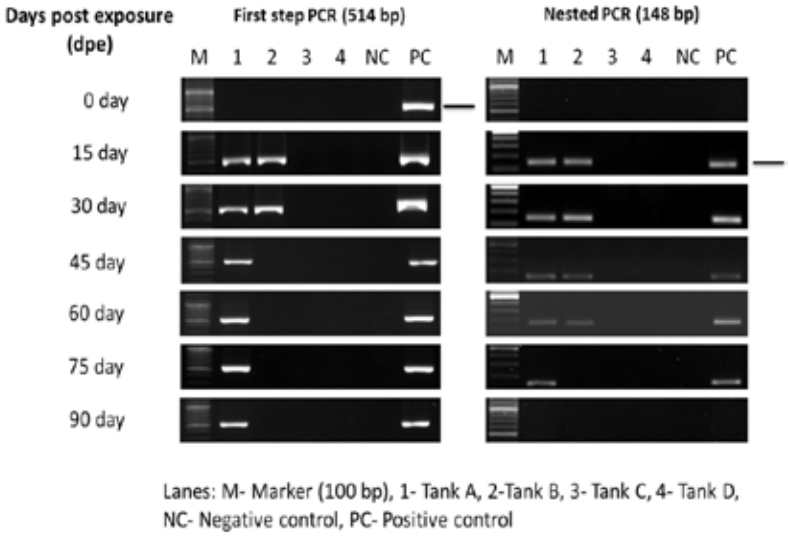
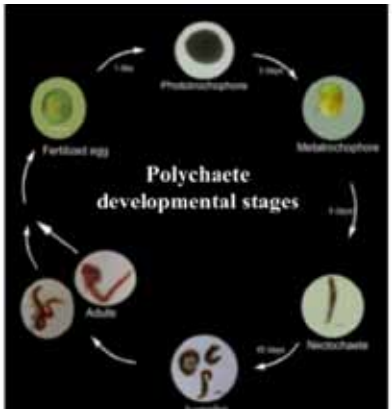
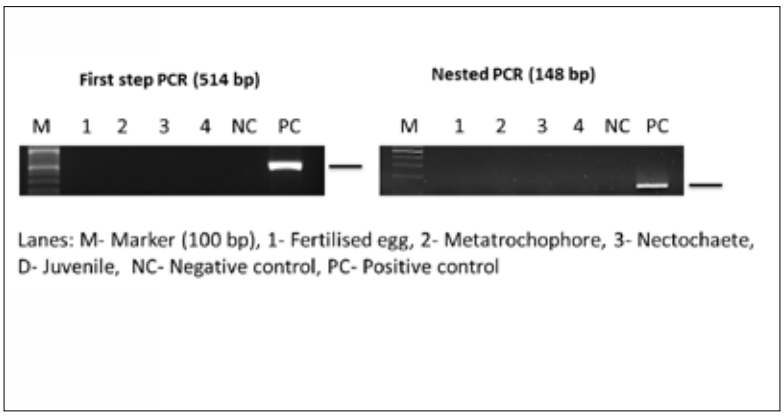


Fig. Horizontal transmission of EHP from shrimp to polychaete by oral feeding: PCR screening of polychaete worm for EHP at different days of post exposure (dpe) (0, 15 & 30)

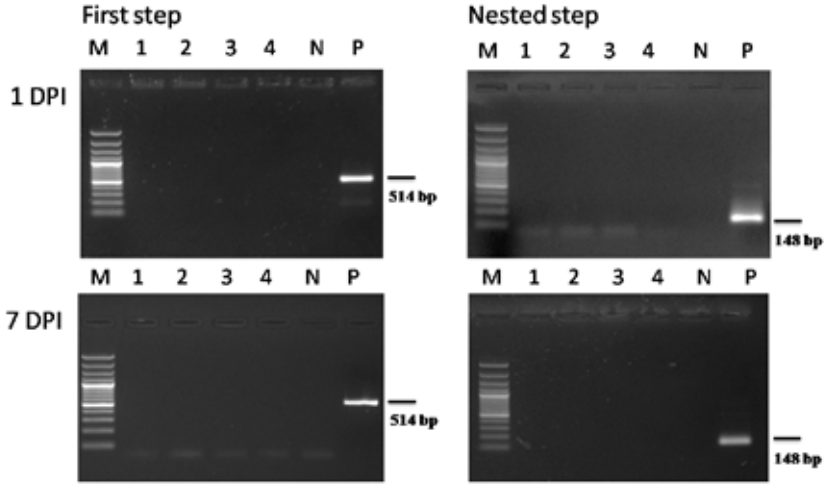




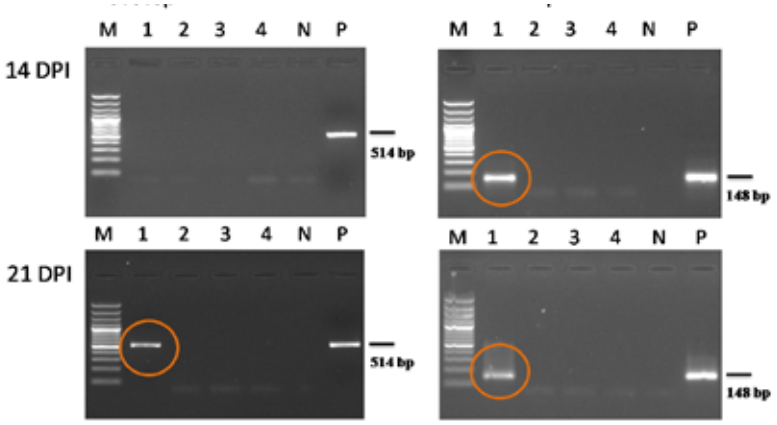
PCR screening suggests that EHP is not transmitted vertically among polychaetes

EHP SPORES REMAIN INFECTIOUS FOR MORE THAN A YEAR IN SEAWATER AT ROOM TEMPERATURE

Changes in the temperature strongly influence the viability of microsporidians such as EHP. Viability and infectivity of EHP spores stored in pond water with salinity 26‰ at different temperatures was examined. Pondwater collected from shrimp farm with history of EHP infection was stored at different temperatures (room temperature (RT), 4°C, -20°C and -80°C) and the infectivity of EHP was studied by bioassay experiments in shrimp post larvae for a period of three months. The EHP spores stored at 4°C, -20°C and -80°C for one month were unable to induce EHP infection in shrimp post-larvae up to 30 days of observation period by PCR. However, the EHP spores stored at room temperature were found to produce infection in shrimp within 14 days post-exposure (dpe). First detection of EHP infection (by nested PCR) was possible at 14 dpe, while the same group of animals showed first step positive at 21 dpe onwards till the end of the experiment. The spores were found to retain infectivity even after three months of storage at room temperature in seawater. The spores preserved at room temperature in seawater lost infectivity after 1 ½ years. The study concluded that spores stored at 4°C, -20°C and -80°C showed dramatic decrease in spore viability and infectivity to shrimp PLs, but spores stored at in seawater at room temperature were found to produce infection in shrimp within 14 days post-exposure and retained their activity up to 1 ½ years.



M- 100 bp marker, Lanes: 1 to 4 EHP- spiked water samples stored at different temperatures (1- at room temperature, 2- at 4°C, 3- at 20°C and 4- at 80°C), N- Negative control, P- Positive control



M- 100 bp marker, Lanes: 1 to 4 EHP- spiked water samples stored at different temperatures (1- at room temperature, 2- at 4°C, 3- at 20°C and 4- at 80°C), N Negative control, P- Positive control

Detection of EHP in the hepatopancreas of experimental animals exposed to seawater containing EHP spores at weekly sampling. [Note the amplification of EHP specific PCR products at 14 and 21 DPI].

GERMINATION OF EHP SPORES COULD BE EXPERIMENTALLY INDUCED

Generally, spore germination begins with an environmental trigger, which varies for different species depending on their habitat. Germination of EHP spore starts with general swelling of the spore followed by specific swelling of the polaroplast. The internal pressure of the spore culminates the discharge of the polar filament by eversion. The discharged polar tube can range in length from 50– 500 µm in length. The entire event of germination takes place in fewer than two seconds. If a potential host cell lies nearby, the discharging tube can strike this cell and pierce its membrane. Once the polar tube is fully discharged, the continued pressure within the spore forces the sporoplasm through the polar tube. Germination of EHP spores was induced by using several dyes, hydroxides, chlorides and buffers at different pH levels. In our preliminary investigations, germination of EHP spores was successfully attained by using potassium hydroxide and phloxine.

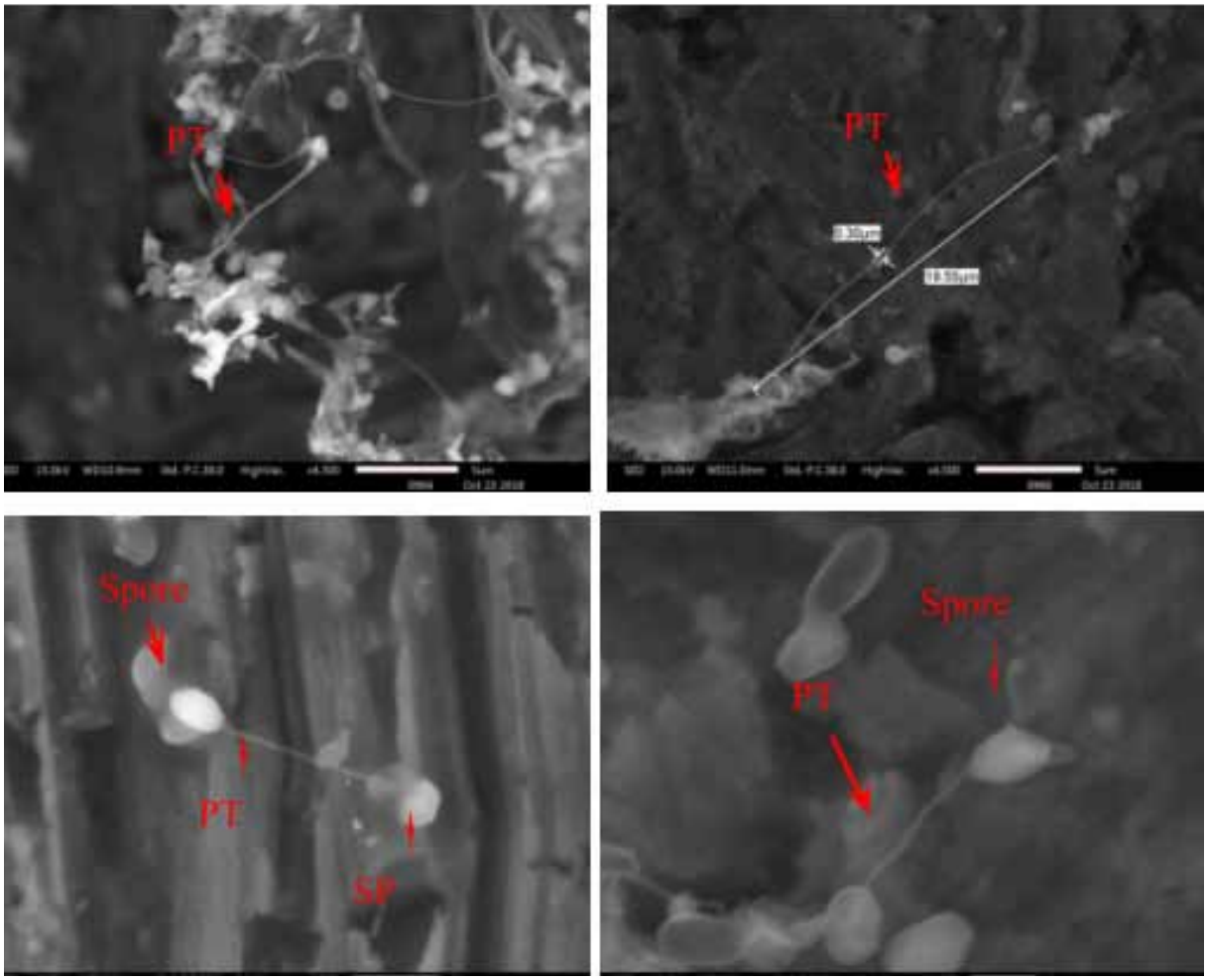


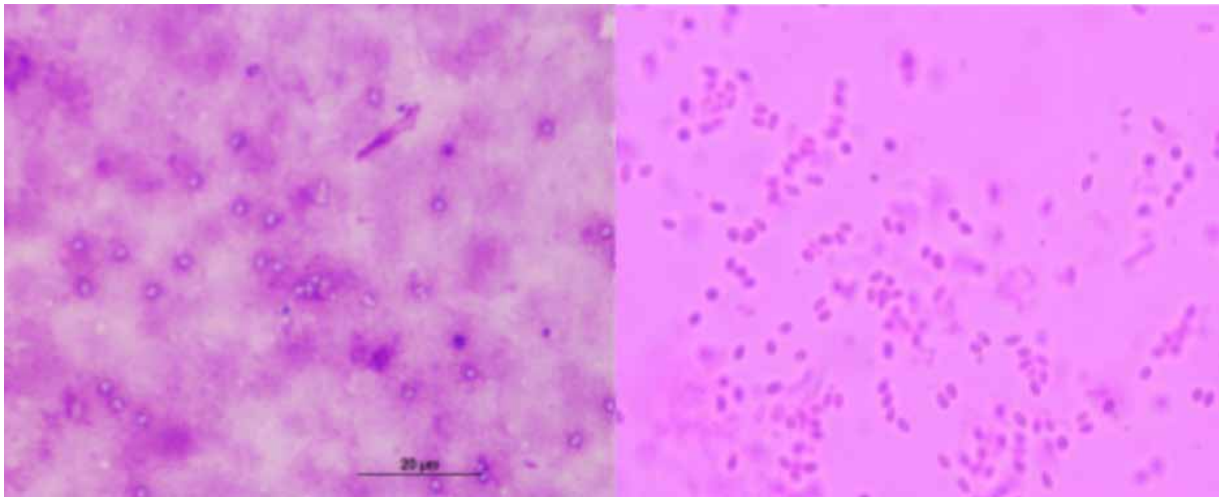
Fig. Scanning electron microscopic image of induced germination in EHP spores (PT- Polar tube, SP- Sporoplasm)

EHP IS THE LIKELY CAUSATIVE AGENT OF WHITE FAECES SYNDROME (WFS)

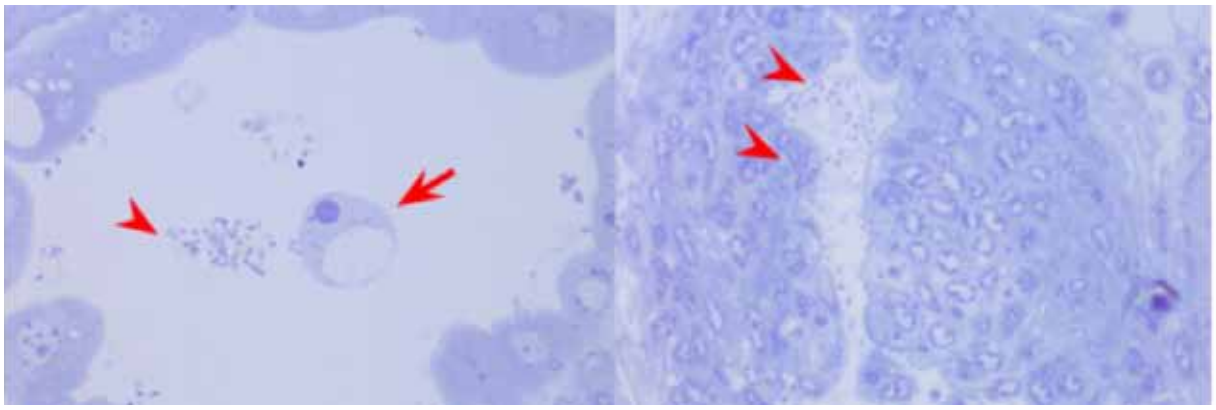
EHP infections in shrimp have been often reported to be associated with reduced feed consumption, growth retardation and white faeces syndrome (WFS). To study the association of EHP with WFS, a detailed investigation was carried out using affected animals collected from shrimp farms. The microscopic examination of squash preparation of hepatopancreas (HP) revealed aggregated transformed microvilli (ATM) like structures and dense EHP spores. Squash preparations of white faecal string collected from EHP affected shrimp farm also revealed presence of large numbers of mature EHP spores. Scanning electron microscopy (SEM) of white faecal threads also revealed dense mature EHP spores and rod-shaped bacteria. Transmission electron microscopy (TEM) showed immature and mature spores in epithelial cell cytoplasm and degenerated and germinated spores in tubule lumen.

In an experimental study, when the juvenile shrimps were fed with white faecal threads collected from WFS affected ponds, purified spores, EHP infected HP tissue, after 24-36 hrs, challenged animals produced only transparent and non-floating faecal threads. These faecal threads when tested were found to be positive for EHP by PCR. Further, dense mature EHP spores could be observed by scanning electron microscopy in the transparent and non-floating faecal threads.

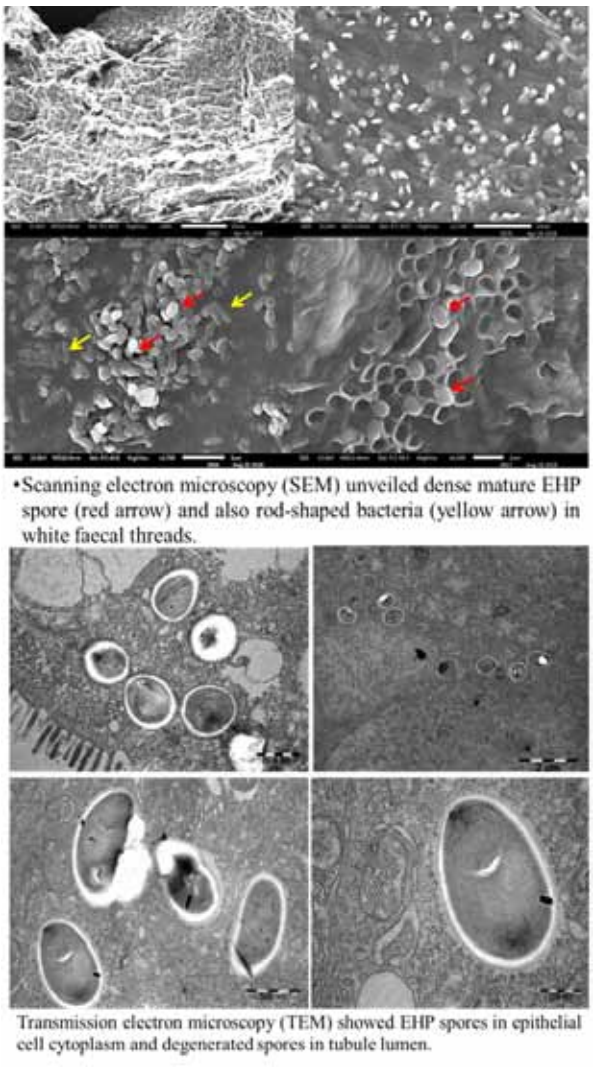
In our earlier studies EHP was detected by PCR in all the WFS affected and also in EHP-recovered animals. Further, epidemiological investigations in 322 farms also revealed a significant role of EHP with the increased frequency of WFS occurrences. However in EHP experimental infection studies, white faecal threads could not be produced under laboratory conditions. Thus it is evident that white faecal threads are one of the clinical sign of EHP and it also construed that white faeces syndrome probably caused by EHP.



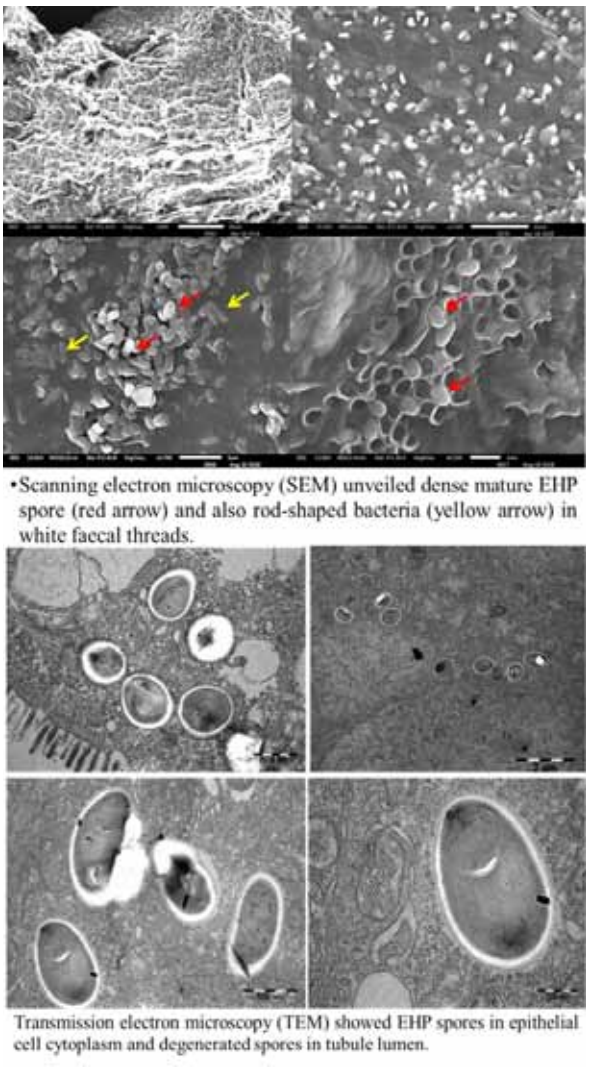
Squash preparations of WFS affected hepatopancreas (A) and WFS faecal strings (B) show dense EHP spores.



Semi-thin sections of HP tubules revealed sloughing of B cells and EHP spores (arrow) in epithelial cell cytoplasm and lumen of WFS affected HP tubules (E & F).



Scanning electron microscopy (SEM) unveiled dense mature EHP spore (red arrow) and also rod-shaped bacteria (yellow arrow) in white faecal threads.



Transmission electron microscopy (TEM) showed immature spores in epithelial cell cytoplasm and degenerated spores in tubule lumen.



Fig. A: Control shrimp faecal thread, B: Challenged shrimp faecal thread, C: White faecal thread collected form WFS affected farm.

VERTICAL TRANSMISSION OF WSSV TO LARVAL SHRIMP IS A POSSIBILITY

To assess the vertical transmission of WSSV, a controlled laboratory trial was conducted in Indian white shrimp *Penaeus indicus*. The animals collected from the wild and tested negative for WSSV were divided into four groups and injected with 50 µl of WSSV suspension having 10^1, 10^2, 10^3 and 10^4 copy numbers µl-1. After 58 hours post-infection, the animals became moribund with clinical signs of WSSV infection. At this stage, shrimps were killed and gill and ovary samples were collected in Davidson's fixative for histopathology and 90% alcohol for PCR (pleopod, gill and ovary). PCR analysis of samples from injected groups indicated all the samples to be positive for WSSV by 1st step PCR. Gill and ovary samples were processed for histopathology and subsequently by *in situ* hybridization. Intranuclear inclusion bodies reactive to the VP28 probe were observed in WSSV infected ovarian cells. Control cells did not have any such cells. The study indicates that even a lower dose of infection by WSSV have the possibility of vertical transmission.



WSSV VP28 probe reactive intranuclear inclusion bodies in ovary cells and gills of WSSV infected shrimps (Arrow)

MASS MORTALITY OF FARMED MUD CRAB, *SCYLLA SERRATA* IN ANDHRA PRADESH

Mud crab farming is fast developing in the coastal areas of Andhra Pradesh. The total area under mud crab culture was about 7360 hectares during 2017-18 as per the information from the Department of Fisheries, Andhra Pradesh. Occasional disease and mortality is not uncommon in mud crab culture. Apart from availability of seeds, in the current year, disease outbreak and mass mortality of farmed crabs was found to be the major stumbling block in profitable mud crab culture. Mass mortality of mud crab *Scylla serrata* culture was reported during September to November 2018 in Nagayalanka, Krishna district, Andhra Pradesh. For investigation of the problem, a total eight farms were selected, four affected with disease and four healthy ponds. All earthen ponds were stocked at 1000 per hectare using green local (GL) crabs (100-200g). Culture was carried out for 90 days to obtain a final average body weight (ABW) of above 500 g with survival between 50 and 55%, and FCR of 2.3-4.3. Crab mass mortality was observed with clinical signs such as white spots on the carapace, lethargy, fungal growth over the exoskeleton, chitinolytic spots on the abdominal flap, fouling, physical deformities of claw and chelate legs, light greenish to yellowish or pinkish discoloration followed by death. Mortality was observed on 65 th day of culture (DOC) and progressed up to 75% within a period of 10 days. Water salinity, pH, dissolved oxygen and temperature were 16.84 ppt, 8.13, 3.8% and 26.7 ^{o}C, respectively. Post mortem examination revealed that the gills were heavily infested with metazoan crustacean parasite, stalked barnacle, *Octolasmis* spp. Abdominal cavity contained about 30-40 mL serosanguinous fluid. Microbial load estimation in pond sediment, water and haemolymph of infected crab showed that there was significant increase in total plate count (TPC) and total *Vibrio* count (TVC) compared to that of healthy ponds. Polymerase chain reaction (PCR) screening revealed that the diseased samples were positive for white spot syndrome virus (WSSV). Histological studies showed that there was degeneration of gill tissue and were characterized by hypertrophied nuclei with marginated chromatin and eosinophilic to basophilic intranuclear inclusions. Haematological investigation revealed that total haemocyte count (THC) was lower in diseased crabs ($6.90\pm0.48 \times 10^6$ cells mL^{-1}) compared to healthy Scylla serrata ($17.28\pm0.46 \times 10^6$ cells mL^{-1}). In healthy crabs, small non-granular haemocytes (SNGH) constituted

14.13±0.83% of the circulating haemocytes (2.43±0.10 x 10^6 cells mL^{-1}) while large non-granular haemocytes (LNGH) constituted 45.25±2.32% (7.81±0.41 x 10^6 cells mL^{-1}). Semi-granular haemocytes or small-granular haemocytes (SGH) constituted 9.88±1.64% (1.70±0.27 x 10^6 cells mL^{-1}) while large granular haemocyte (LGH), constituting 30.75±1.55% (5.33±0.40 x 10^6 cells mL^{-1}). SNGH, LNGH, SGH and LGH (x 10^6 cells mL^{-1}) among the diseased crabs were significantly low as 1.85±0.20 (26.63±1.68%), 3.85±0.32 (55.63±1.14%), 0.42±0.07 (6.25±1.13%) and 0.79±0.08 (11.50±1.37%), respectively.



Figure: Crab mortality with clinical signs such as white spots on the carapace, fungal growth over the exoskeleton and fouling.



Figure: Crab with clinical signs such as fungal growth over the exoskeleton, chitinolytic spots on the abdominal flap and fouling.



Figure: Crab with heavy infestation of stalked barnacle, Octolasmis spp. in the gills (low power).



Figure: Crab gills with heavy infestation of stalked barnacle, Octolasmis spp. Scale bar: 5000 µm.

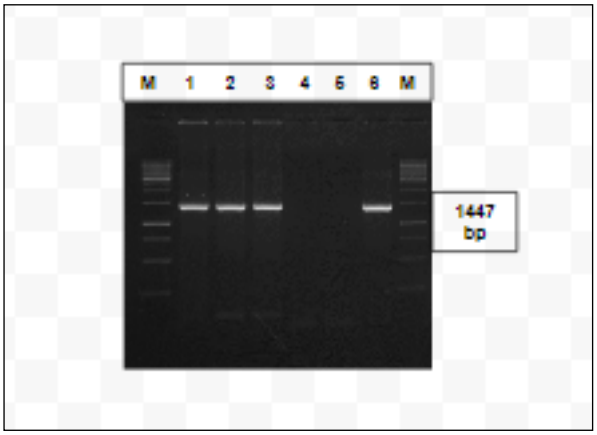


Figure: Lane M: Ladder; Lane 1-3: Crab sample positive for WSSV; Lane 4&5: negative control; Lane 6: positive control.

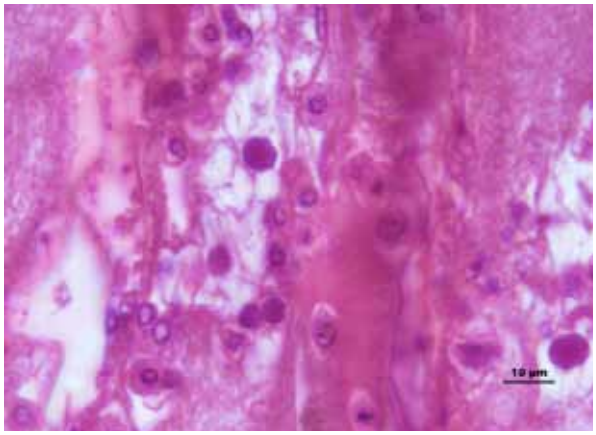
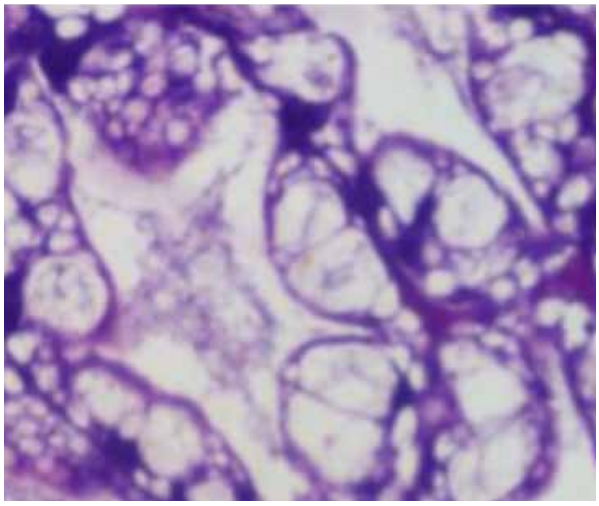
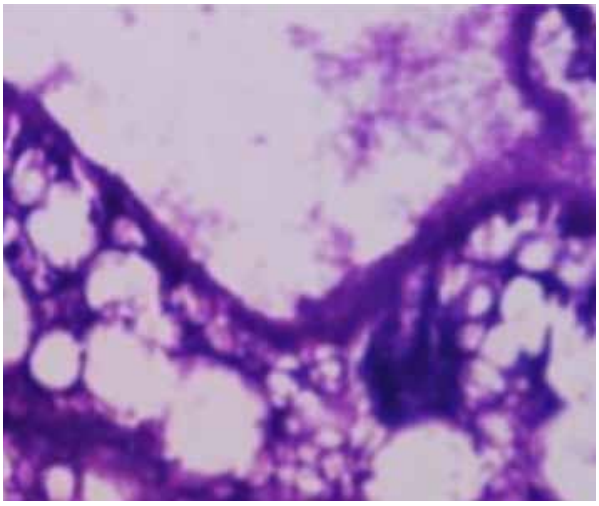


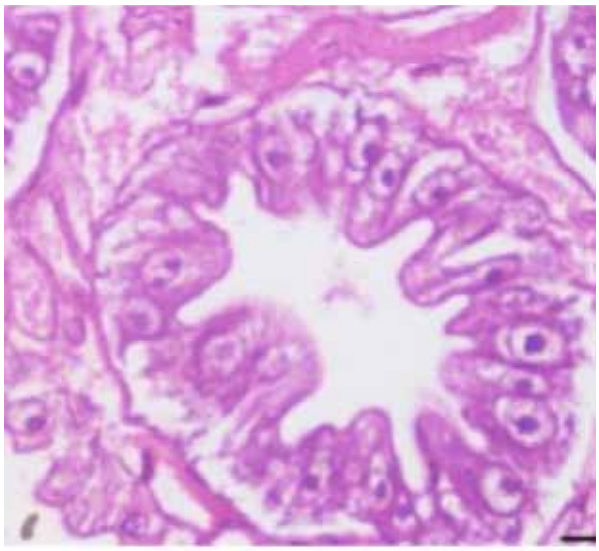
Figure: Histopathology of gill tissue showing degeneration and hypertrophied nuclei with marginated chromatin and eosinophilic to basophilic intranuclear inclusions. H&E. Scale bar: 10 µm.

COMPARATIVE PATHOLOGICAL CHANGES IN SHRIMP HEPATOPANCREAS IN RESPONSE TO VIRAL AND PARASITIC INFECTION

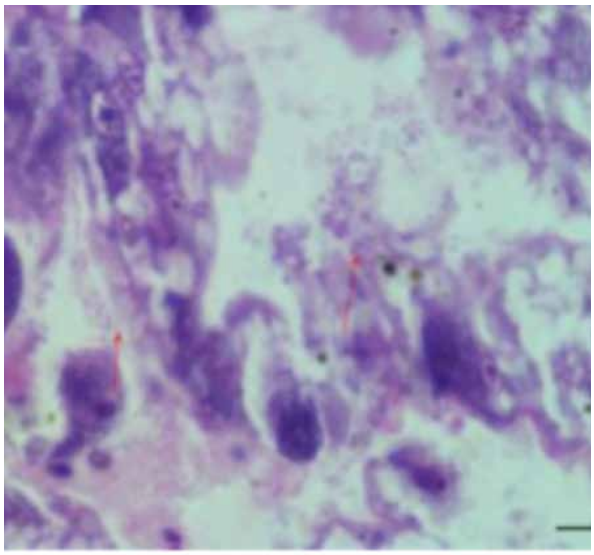
The hepatopancreas is a primary digestive organ of shrimp that plays the dual role of secreting digestive enzymes and absorbing nutrients. Histopathological examination of hepatopancreas in response to infection often serves as first step in identifying any new pathogens. Shrimp samples confirmed positive by PCR for WSSV, IHHNV, WSSV & IHHNV and EHP were used for histopathological analysis. The histological changes observed in hepatopancreas of WSSV infected shrimps were increased vacuolization of B cells, increased number of F and R cells, degeneration of hepatopancreatic tubular epithelial cells in few cases with presence of proteinaceous exudate in the tubule. The IHHNV infected shrimp hepatopancreas had normal hepatopancreatic cells like B, F, R & E cell with no changes. Few cases showed degenerated tubular epithelial cells. The combined WSSV and IHHNV infection had hepatopancreatic lesions similar to that of the WSSV infection. In comparison, EHP infected shrimp hepatopancreas had tubular cells like B, F, R cell necrosis and degeneration. Further haemolyph accumulation noticed between the tubules. The study suggests that these pathogens affect the hepatopancreatic architecture and thereby the functioning of the hepatopancreas.







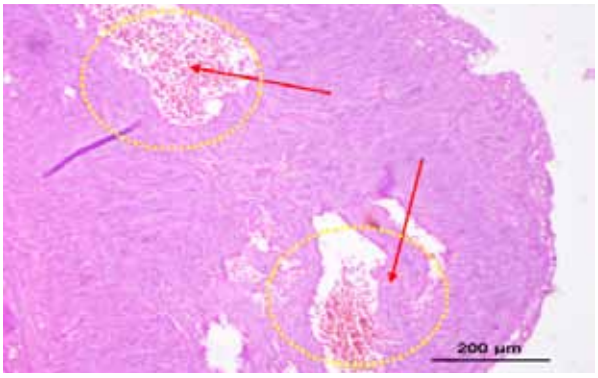
WSSV infected hepatopancreas appearing almost normal- H&E 100x



EHP infected hepatopancreas showing total necrosis and degeneration of hepatopancreatic cells- H&E 100x

TILAPIA LAKE VIRUS (TILV) CAN JUMP TO SEA BASS

Aquaculture of seabass, Lates calcarifer, has become popular in many coastal states of India. In a finfish disease surveillance investigation, the *L. calcarifer* samples collected from nursery, monoculture, cage culture and co-culture with tilapia from Andhra Pradesh and Tamil Nadu, when screened for Viral Nervous Necrosis (VNN), Iridovirus and Tilapia Lake virus (TiLV), all were found negative for VNN and Iridovirus infection. However, two farm samples co-cultured with tilapia experienced chronic mortalities and suffering with haemorrhagic encephalitis had TiLV infection. Challenge experiment conducted to test the inter species transmission of TiLV from infected tilapia to seabass showed successful transmission of TiLV with cumulative mortalities in fish challenged by different routes with varied experimental duration in inducing the disease. TiLV induced pathognomonic lesions were observed in the liver and brain in experimentally infected fish. Such jumping viral pathogens from tilapia could be a serious threat to aquaculture diversification with sea bass.



Haemorrhages observed in infected fish (H&E 40x)

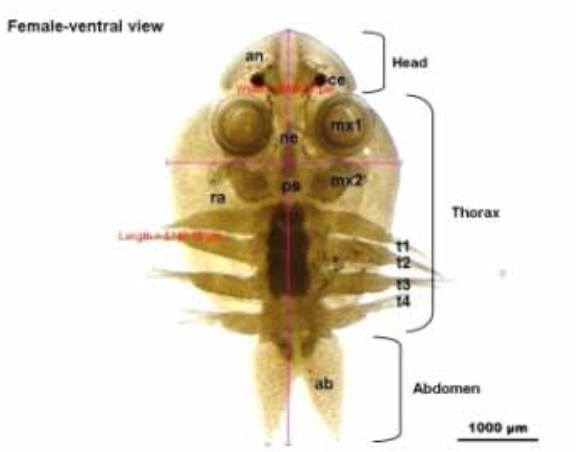


Seabass nursery sample collected from AP

PREVALENCE OF PARASITIC INFECTIONS IN BRACKISHWATER FINFISHES

Increasing intensification with lack of adequate health management strategies result in increased incidences of parasitic infestations. Parasites are the major concern for health, productivity and reproduction of finfish aquaculture. Cataloguing the prevalence of the parasitic infestation would help in formulating control measures. Hence, parasitic profiling was done in more than 2400 fishes and crabs of different species of varying sizes including *Lates calcarifer, Mugil cephalus, Scatophagus argus, Etroplus suratensis, Chanos chanos, Labeo rohita* and *Scylla serrata* collected from Tamil Nadu, Kerala, Andhra Pradesh and Maharashtra. Five major genera such as *Argulus, Caligus, Lernanthropsis, Zeylanicobdella* and *Octolasmis* were found to infect finfishes and crabs.

The tissue damages caused by these parasites were assessed by haematological and histopathological changes. Clinical signs such as lethargy, erratic swimming, reduced feeding, hanging at the surface, poor body condition, emaciated, anaemic, flashing and rubbing against surfaces with mortality of 80-100% was observed in fish affected with parasitic infestations. Haematologically, there was significant ($P<0.01$, $P<0.05$) decrease in RBC, WBC, haemoglobin, PCV, thrombocytes and myelocytes population. But there was an increase in lymphocytes and monocytes, suggestive of chronic infestations. Histologically, degenerative changes in gills, cloudy swelling, focal degeneration, fatty liver changes, diffuse tubular degenerative changes in kidney and increased white pulp with increased Melano-Macrophage Centres (MMC) was observed.



Female crustacean ecto-parasite, Argulus quadristriatus collected from Asian seabass, Lates calcarifer. Scale bar: 1000 µm.



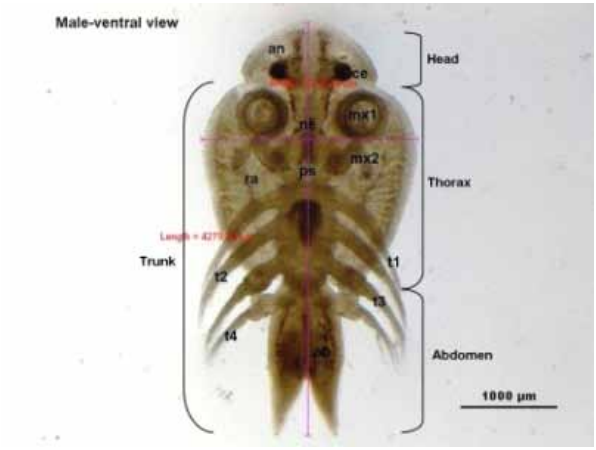
Male crustacean ecto-parasite, Argulus siamensis collected from rogu, Labeo rohita. Scale bar: 1000 µm.



Female crustacean ecto-parasite, Lernanthropsis mugilii collected from mullet, Mugil cephalus. Scale bar : 5000 µm.



Male crustacean ecto-parasite, Lernanthropsis mugilii collected from mullet, Mugil cephalus. Scale bar : 1000 µm.



Male crustacean ecto-parasite, Argulus quadristriatus collected from Asian seabass, Lates calcarifer. Scale bar: 1000 µm.



Female crustacean ecto-parasite, Argulus siamensis collected from rogu, Labeo rohita. Scale bar: 1000 µm.



Female crustacean ecto-parasite, Caligus minimus collected from Asian seabass, Lates calcarifer. Scale bar : 1000 µm.



Male crustacean ecto-parasite, Caligus minimus collected from Asian seabass, Lates calcarifer. Scale bar : 500 µm.



Leech, Zeylanicobdella spp. collected from Asian seabass, Lates calcarifer. Scale bar : 2000 µm.



Stalked barnacle, Octolasmis spp. collected from mud crab, Scylla serrata. Scale bar : 5000 µm.

PRIMARY CELL CULTURE OF MILK FISH

Milkfish (*Chanos chanos*) is a herbivorous euryhaline fish known for its relative resistance to disease and infections. Hence, it could serve as good model to study fish immune system, viral pathogenesis and preventive development such as vaccines. In the present work attempts were made to develop primary cell culture from fins, gills, spleen, kidney and brain tissues of milkfish using L-15 medium and foetal bovine serum (FBS). The brain tissues developed a monolayer with 100% confluence after 12 days of incubation. On subsequent subculture of monolayer, the cell attachment and 100 % confluences was attained in 120 hours by five passages and 72-96 hrs by seven to ten passages. However, primary culture could not be developed with kidney, spleen, gill and fin tissue.

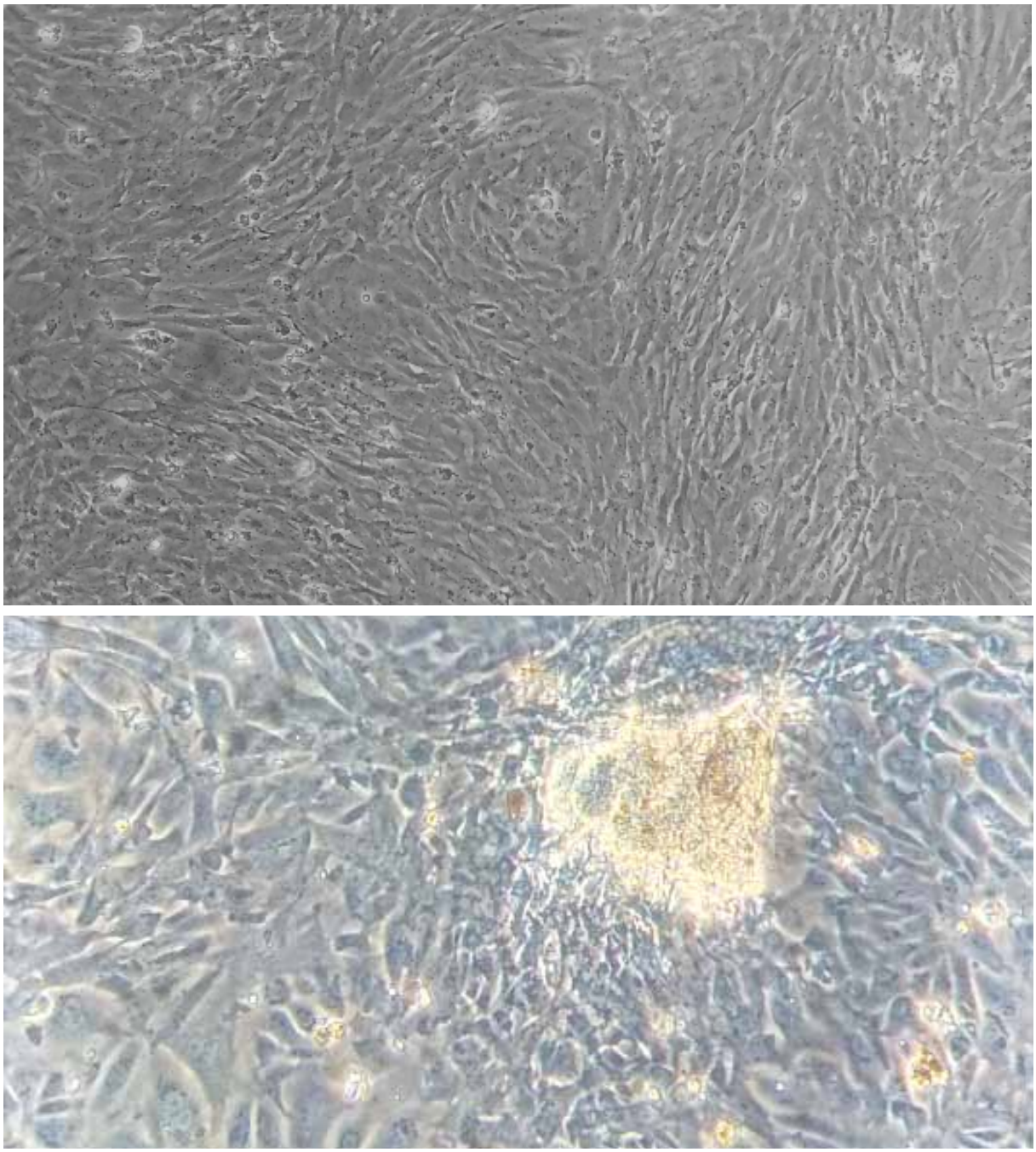


Fig. Development of primary cell cultures of milkfish brain in L-15 medium supplemented with foetal bovine serum

EHP SPORES FAILED TO BE CULTURED IN VERTEBRATE CELL LINES

EHP has posed a serious threat to shrimp farming. To understand the pathogenesis and infectivity of EHP spores, its propagation was attempted in vertebrate (fish and mammal) cell lines. Striped snake head fish (SSN-1), and mammalian cell lines such as Vero and Madin-Darby canine kidney (MDCK) known to be susceptible for microsporidians were used to for EHP propagation. The two mammalian and fish cell lines inoculated with EHP-spores were intact without any cytopathology. Further, when second and third passages were tested, they were found negative for EHP by PCR, indicating that these cell lines were not suitable for propagation of EHP.

METAGENOMIC MICROBIAL PROFILING OF ZOEA SYNDROME

Zoea-2 syndrome has emerged as a serious threat to Indian shrimp hatcheries, especially after introduction of *P. vannamei*. It causes delayed molting or impairment of metamorphosis, followed by mass mortality at zoea II stage. Metagenomic study was conducted to figure out the etiology of the zoea-2 condition. Five samples namely, during the 2nd (ZIIS2), 4th (ZIIS4), 6th (ZIIS6) and the 8th (ZIIS8) day of syndrome and one healthy (ZIISZN) sample that served as a control, were subjected to metagenomic analysis. Extracted DNA from these samples was sequenced on illumina platform and analysed using QIIME. The analyses revealed a significant microbial dysbiosis between healthy and diseased conditions. In total 49 phyla were identified, among which six were dominant, namely Proteobacteria, Firmicutes, Bacteroidetes, Actinobacteria, Planctomycetes, Cyanobacteria and which constitutes around 98.3% flora in all. In all the samples, Proteobacteria and Firmicutes were found to constitute around 40% and 30% of the total microbial population respectively. Some of the phyla such as Proteobacteria, Firmicutes, Actinobacteria, Planctomycetes, Cyanobacteria, Chloroflexi, and Verrucomicrobia showed significantly lesser in abundance in diseased samples compared to healthy one. On the contrary, Bacteriodetes and Acidobacteria showed a considerable higher abundance in zoea syndrome affected samples.

Analysis of bacterial abundance at the genus level showed the presence of 745 genera out of which 187 were present in all the samples and 46, 52, 63, 32 and 61 were unique to ZIISZN, ZIIS2, ZIIS4, ZIIS6 and ZIIS8 samples respectively. Among core genera 16 were dominant and belonging to the phyla Proteobacteria, Firmicutes, Bacteroidetes, and Actinobacteria.

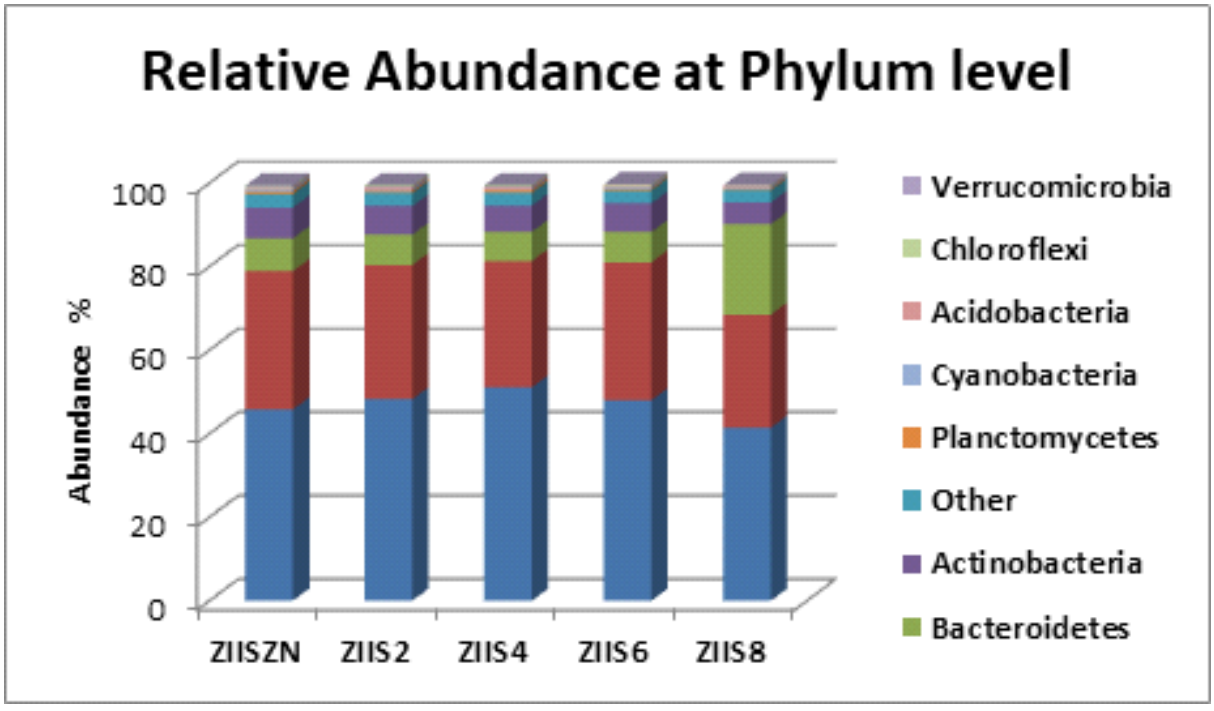
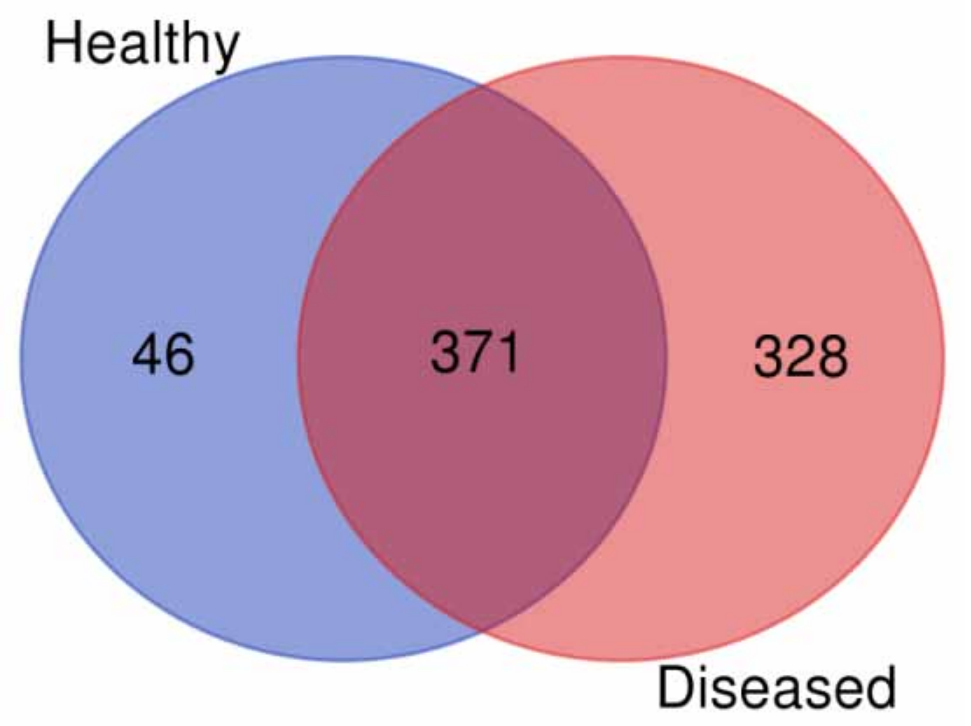
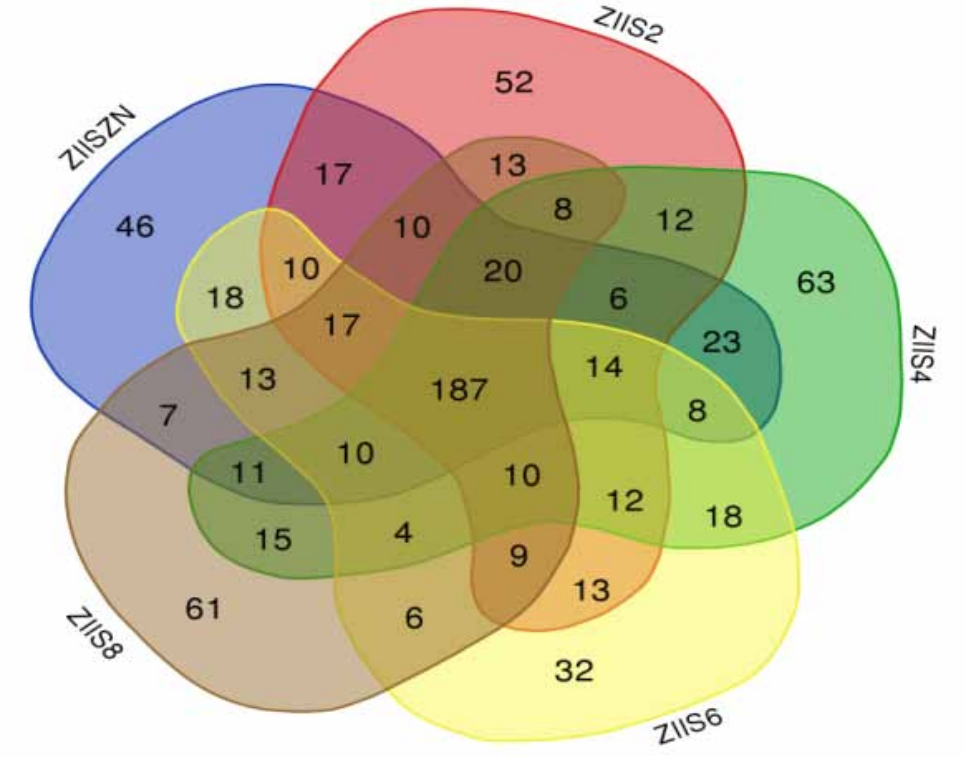


Fig: Bacterial abundance in zoea syndrome affected shrimp larvae at phylum level

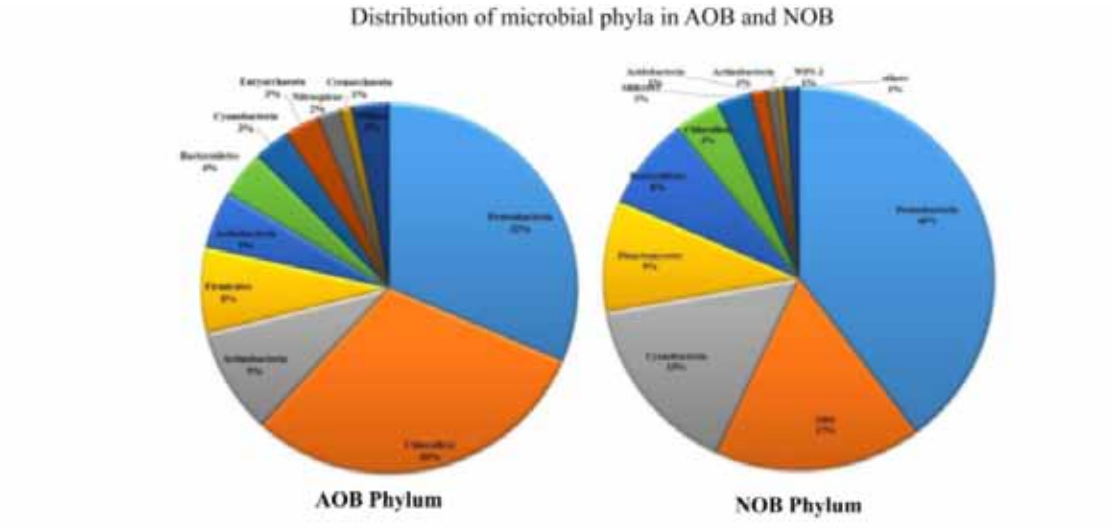




Some of the genera such Devosia, Unclassified Rhodobacteraceae, Nonlabens, Muricauda, Unclassified Flavobacteriaceae, Unclassified Flavobacteriales, and Pseudoalteromonas as were more abundant in zoea syndrome affected samples compared to the healthy larvae. There was no trend or pattern in the bacterial abundances with regard to dominant genera as the days of syndrome progressed. Overall, a total of 46 genera were seen specific to healthy, 328 specific to the syndrome and 371 genera common in both.

MICROBIAL PROFILING OF CIBAMOX

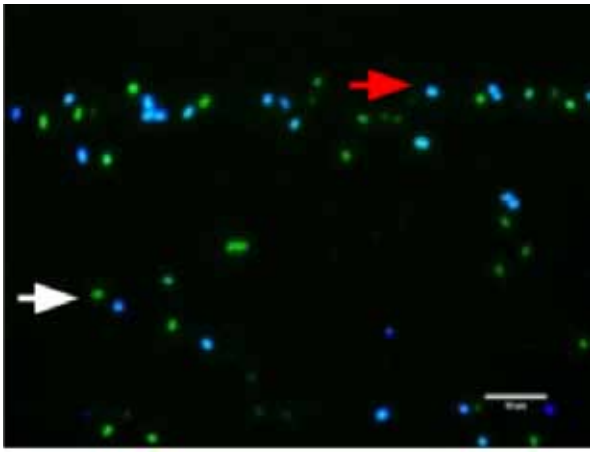
CIBAMOX, a product of CIBA, developed for mitigation of nitrogenous wastes in aquaculture ponds was subjected to microbial profiling by 16s rDNA metagenomics. The analysis revealed several novel bacteria involved in nitrogen metabolism. From the sequence analysis it was observed bacterial groups belonging to *Caldilineaceae* family were dominant in ammonia oxidation. A large percentage of microbes identified in the AOB and NOB enrichments belonged to the phylum Proteobacteria, which are widely established in environments and play important roles in the process of nutrient cycling and mineralization of organic compounds. Nearly 62% of the sequences in these enrichments were found to be unclassified genera, which show that there might be novel microbial flora involved in ammonia oxidation or aiding ammonia oxidation process.



DEVELOPMENT OF DIAGNOSTICS

RAPID DETECTION TECHNIQUE TO DIFFERENTIATE VIABLE AND DEAD EHP SPORE

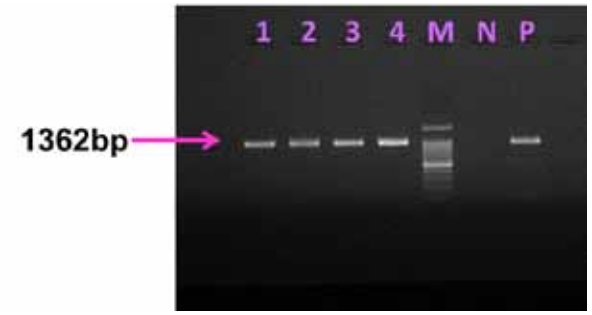
Purification of EHP spores are usually attempted by centrifugation step in different media using refrigerated centrifuge, which often render spore unsuitable for experimental infections. Hence, methods are required to ascertain the infectivity of the purified spores to assess the effect of treatments. The present study demonstrated a staining technique to assess the viability of EHP spores by combining the nucleic acid stain Sytox Green and the chitin binding stain Calcofluor White. These two stains were used to differentiate the live (freshly harvested) and dead (boiled) EHP spores. Dead spores were stained by Sytox Green and appeared yellow-green oval bodies through the blue (470-490 nm) excitation filter and white-yellow through violet filter (395-415 nm). The viable spores were stained by Calcofluor White which appeared as turquoise-blue through the violet filter (395-415 nm). This study demonstrated a staining technique to assess the viability of *Enterocytozoon hepatopenaei* microsporidian spores by combining the nucleic acid stain Sytox Green and the chitin binding stain Calcofluor White.



Fresh (live) and boiled (dead) spores of EHP stained with Sytox Green and Calcofluor White [Note: When viewed through a blue filter (470-490 nm), live spores are not visible, while dead spores fluoresce yellow green; When the same area is viewed under a violet filter (395-415 nm), dual stained live spores as turquoise-blue ovals and dead spores appear as bright white-yellow ovals]

DEVELOPMENT OF REAL TIME PCR ASSAY FOR DETECTION OF IRIDOVIRUS INFECTION IN FISH

Iridovirus is an emerging finfish pathogen in India. SYBR Green based real time PCR assay has been developed for detection of iridovirus with custom designed primers. The PCR products were cloned and the copy numbers determined using online tools and standard curve analysis that generated a linear range of 10^1–10^6 DNA copies. Melting curve analysis showed the specific target gene amplification. The detection limit of the assay was found to be as low as 10 copies. A membrane cofactor protein (MCP) gene based PCR was also standardised with custom designed primers for detection of iridovirus. The phylogenetic analysis of sequences from the Indian isolate formed clade distinct from the isolates from China and Taiwan.



MCP gene based PCR for detection of iridovirus

FARM INPUTS USAGE PATTERN IN INDIAN SHRIMP CULTURE

A number of inputs are used in shrimp farms presumably for enhancing productions and for various other purposes. A survey was conducted during 2017 to understand the input usage pattern in the shrimp farms. The study was carried out in major shrimp producing states, Andhra Pradesh, Tamil Nadu, Gujarat and Maharashtra. The farm inputs were classified into five major groups based on application as disinfectants, probiotics, environmental modifiers, nutritional supplements, and anti-microbial. Quantity of the farm inputs used was determined per tonne of shrimp produced. The study showed use of environmental modifiers being used highest quantity to improve soil and water quality, followed by probiotics (water, soil and gut probiotics) and disinfectants. No record of use of anti-microbial product was observed during the study.

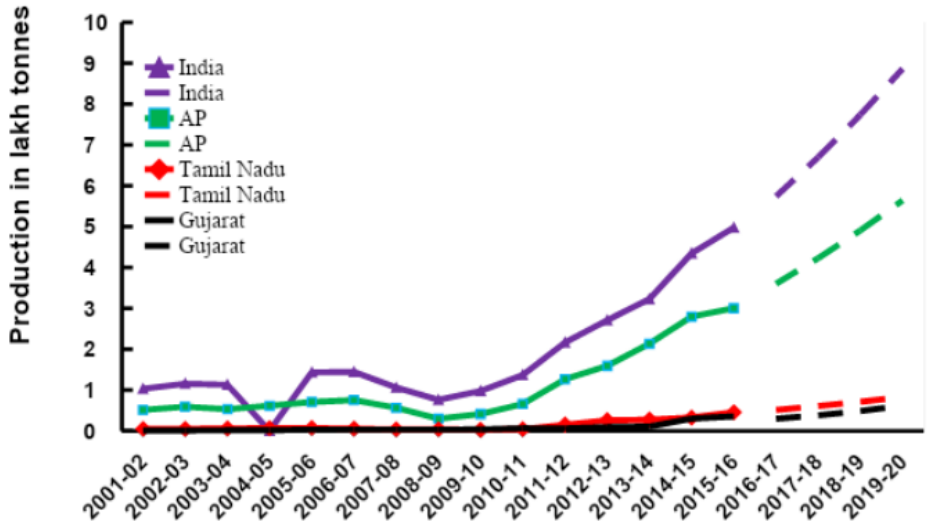
Table: Classification of farm inputs used for shrimp aquaculture in 2017 (kg ton-1 of shrimp production)

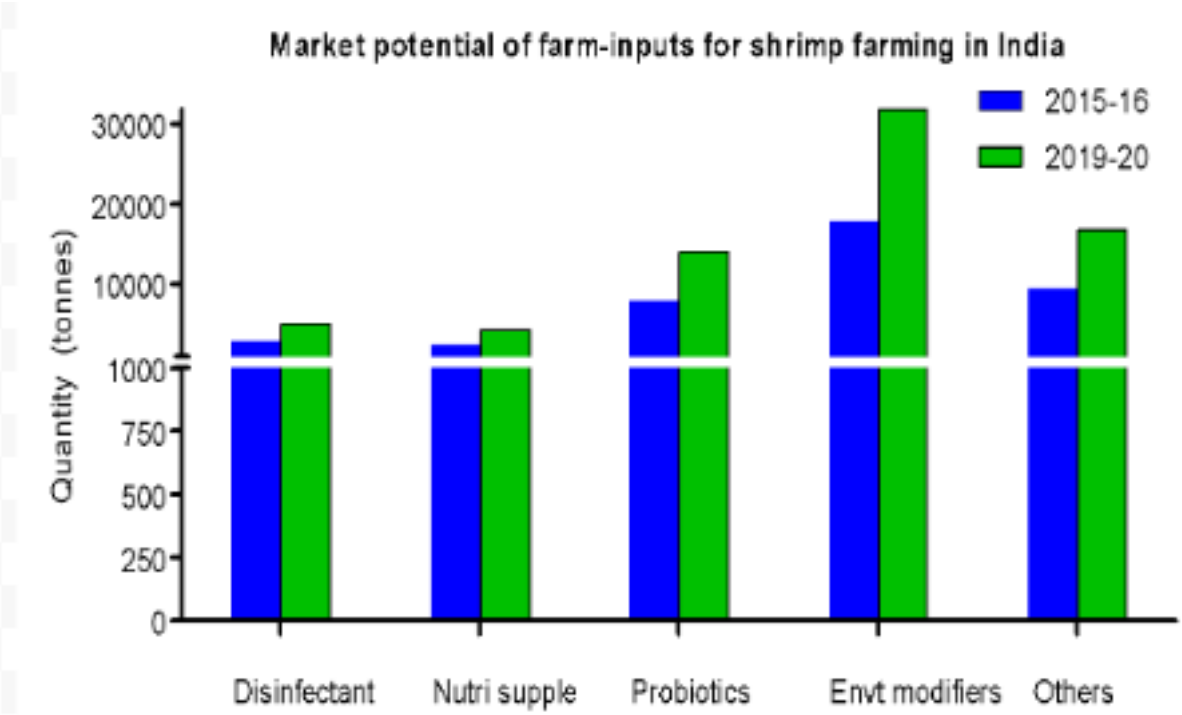
Farm inputs	TN	AP	Gujarat	Maharashtra
Disinfectants				
Oxidizing Agents	0.89	4.10	4.48	1.04
Detergents	3.13	1.88	4.20	6.76
Total	**4.02**	**5.98**	**8.68**	**7.80**
Probiotics				
Water Probiotics	7.75	2.95	7.25	8.35
soil Probiotics	6.13	17.06	5.18	4.99
Gut Probiotics	1.16	1.12	0.33	1.73
Total	**15.04**	**21.13**	**12.75**	**15.07**
Nutritional supplements				
Vitamins and Minerals	1.40	3.54	1.69	1.66
Binders	1.08	0.00	0.11	0.73
Total	**2.49**	**3.53**	**1.80**	**2.39**
Environmental modifiers				
Oxidising agents	5.74	0.00	2.85	0.00
Ammonia controlling agents	4.17	0.41	0.10	0.00
pH modifiers	0.43	3.00	3.20	0.00
Minerals	43.83	30.03	23.91	57.20
Total	**54.17**	**33.44**	**30.07**	**57.20**
Others				
Total	**11.36**	**24.97**	**0.12**	

MARKET POTENTIAL OF FARM INPUTS IN INDIAN SHRIMP CULTURE

Market potential of various farm inputs for shrimp production of India was estimated. Various parameters such as production, area and risk of environmental parameters, disease outbreaks for the years 2015-16 and 2018-19 were taken into account. Demand for disinfectants, probiotics, nutritional supplements and environmental modifiers for the four years from 2015-16 to 2018-19 was 2831, 7882, 2423 and 17919 tonnes respectively, whereas, forecasted demand for the year 2019-20 will be 31915 tonnes.

forecasted demand for the year 2019-20 will be 31915 tonnes.





Market potential of farm inputs in shrimp culture

PROBIOTICS

MILK FISH CAN REDUCE THE BACTERIAL LOAD IN P. VANNAMEI CULTURE POND

The mucus of some species of fish including milkfish (*Chanos chanos*) is known to be antibacterial. The levels of total heterotrophic aerobic bacteria (THAB) and total *Vibrio* (TV) in pond water were monitored periodically in milk fish - vannamei co-culture pond water. Control ponds were stocked with only *P. vannamei* (40 No sqm-1). Milk fish was stocked with two different stocking densities along with *P. vannamei* at 0.2 No sqm-1 and 0.4 No sqm^{-1}. Water samples were collected between 10:00 and 11:00 AM from three different locations in the pond, pooled and THAB and TV were enumerated on tryptone soy agar (TSA) containing 1% NaCl (w/v) and thiosulfate citrate bile salt sucrose (TCBS) agar with 2% (w/v) NaCl, respectively. No significant difference in terms of level of THAB and TV was observed up to 80 DOC of culture period. However, at 100 DOC, the level of THAB was found significantly higher ($p < 0.05$) in the control ponds (only vannamei) in comparison with milk fish vannamei co-culture. At DOC 100, the total Vibrio level was found higher in control group in comparison to two groups culturing milk fish, but significant difference was not observed ($p < 0.05$). No significant difference was observed while considering the average bacterial load throughout the culture period both in case of THAB and TV among different experiment group. The present study showed that the introduction of milk fish helps in reduction of bacterial load in the shrimp culture ponds.

Duration of culture (Days)	THAB Log_{10} CFU ml^{-1} (Mean ± SE)			TV Log_{10} CFU ml^{-1} (Mean ± SE)		
	A	B	C	A	B	C
DOC 0	3.630 ± 0.182	3.460 ± 0.194	3.358 ± 0.174	2.649 ± 0.036	2.720 ± 0.399	2.820 ± 0.322
DOC 20	4.387 ± 0.093	4.347 ± 0.041	4.428 ± 0.522	3.255 ± 0.105	3.199 ± 0.175	3.173 ± 0.188
DOC 40	4.911 ± 0.790	4.721 ± 0.152	4.974 ± 0.396	3.563 ± 0.033	3.711 ± 0.068	3.568 ± 0.539
DOC 60	4.929 ± 0.394	4.594 ± 0.171	4.498 ± 0.027	3.170 ± 0.159	3.112 ± 0.104	3.176 ± 0.141
DOC 80	4.716 ± 0.422	4.636 ± 0.089	4.793 ± 0.382	3.277 ± 0.310	3.134 ± 0.155	3.245 ± 0.200
DOC 100	5.491 ± 0.036[a]	4.635 ± 0.216[b]	4.652 ± 0.183[b]	4.066 ± 0.394	3.680 ± 0.226	3.613 ± 0.113
Average during culture	4.677 ± 0.252	4.399 ± 0.024	4.450 ± 0.172	3.330 ± 0.102	3.259 ± 0.144	3.266 ± 0.173

$p < 0.05$

A = Control (Only *P. vannamei* 40 Nos./sq.m.

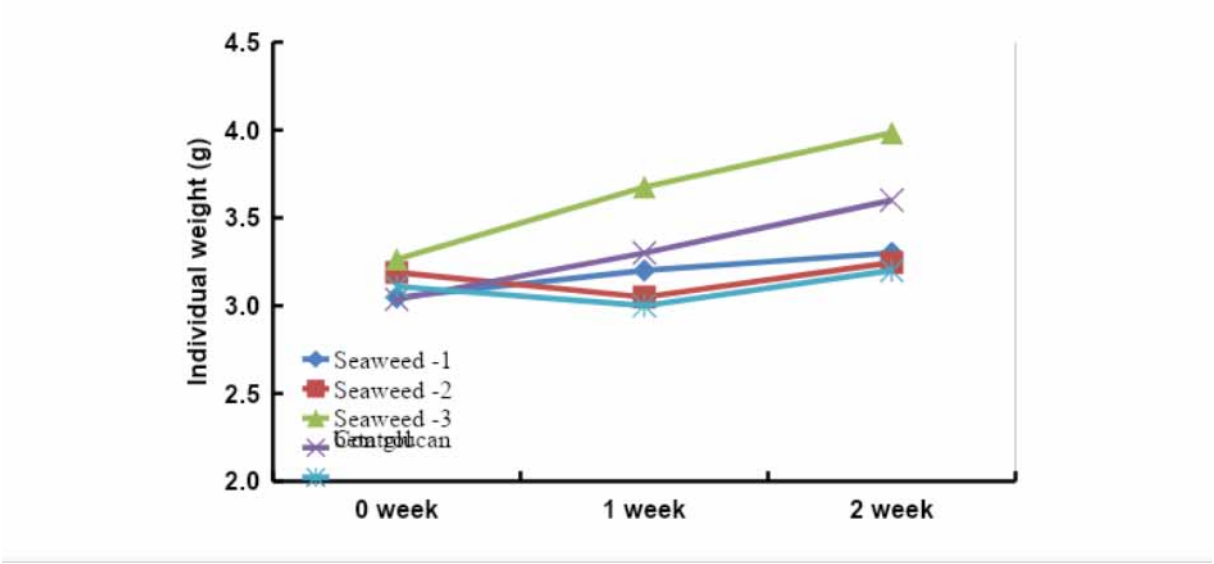
B = *P vannamei* (40 Nos./sq.m.) and Milk fish (0.2 No./sq.m.)

C = *P. vannamei* (40 Nos./sq.m.) and Milk fish (0.4 No./sq.m.)

APPLICATION OF BROWN SEAWEED EXTRACT AS GROWTH PROMOTOR FOR SHRIMP

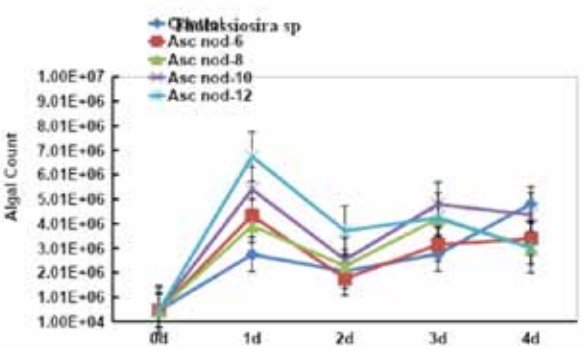
Brown seaweed (*Ascophyllum nodosum*) extract was used as immunostimulant and growth promoter for shrimp juvenile and growth enhancer for micro algae.

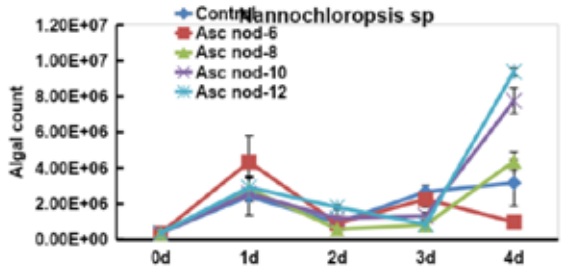
Crude extract of brown seaweed, was fed to shrimp by feed-top dressing. The shrimp fed with the micro algal preparation registered improved growth by 20% in a span of two weeks at three-fold dilution. However, at higher concentration, the extract was having negative effect on growth and survival.



APPLICATION OF BROWN SEAWEED EXTRACT AS ALGAL GROWTH ENHANCER

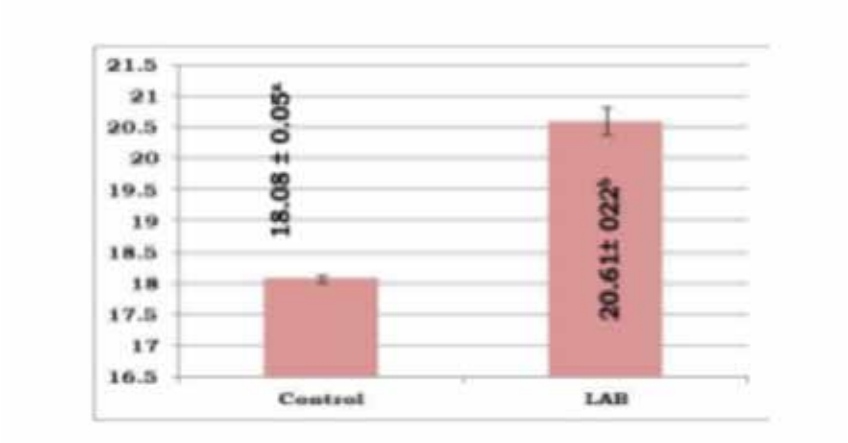
Thalassiosira sp and *Nanochloropsis* sp were used for studying the influence of seaweed extract on the growth of these algae. The brown seaweed extract was incorporated in the microalgal culture media at different dilutions before inoculation. The study confirmed growth promotion activity of the seaweed extract in improving the algal cell density in short span of time. *Thalassiosira* sp recorded rapid increase in the cell density (100 fold in one day) however a rapid decline was observed in the cell density subsequently. The growth of *Nanochloropsis* sp recorded a gradual increase until four days except for highest concentration of the extract which caused reduction in cell density after one day. In both the cases, 10^{-12} concentration of the crude extract showed highest growth promotion activity.



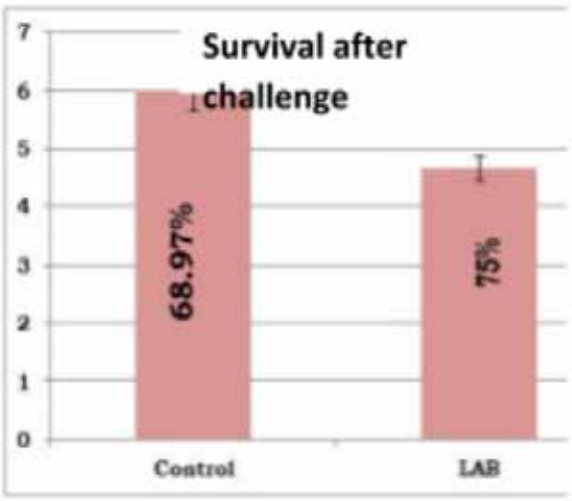


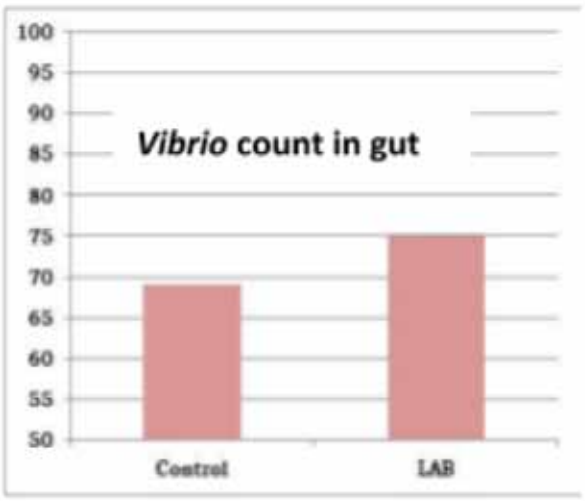
IMPROVED GROWTH PERFORMANCE AND SURVIVAL OF *PENAEUS VANNAMEI* WITH FEED SUPPLEMENTED WITH LACTIC ACID BACTERIA (LAB)

Different species of lactic acid bacteria (LAB) are known to have beneficial effect as gut probiotics and successfully used in shrimp culture in different countries. A feeding trial was conducted on *P. vannamei* with feed supplemented with two isolates of lactic acid bacteria (LAB) viz., *Lactococcus lactis* subsp. lactis SDKRC-5 and *Lactobacillus* isolate (SDKRC-6) at the level of 10^7 CFU g^{-1} of feed. These two isolates were previously selected on the basis of maximum inhibitory potential against *V. parahaemolyticus*. After 63 days of feeding trial, the LAB supplemented feed yielded 14% higher growth over the control. The survival in the LAB supplemented and control group were 93.3 and 83.3 %, respectively. A challenge trial was conducted on juvenile *P. vannamei* with virulent *V. campbelli* strain (10^6 CFU I/M injection). After 8 days of challenge, the survival in treatment and control groups was 75 and 68.97 %, respectively. The *Vibrio* counts in the gut of shrimp was significantly lower ($p<0.05$) in case of LAB treated group (4.671 ± 0.209 Log10 CFU g^{-1}) as compared to control (5.987 ± 0.327 Log10 CFU g^{-1}). The study showed that incorporation of two selected isolates of LAB aids in enhanced growth performance and survival of shrimp and also tolerant to challenge with virulent *Vibrios*.



Growth of P. vannamei fed with LAB incorporated feed after 63 days of culture

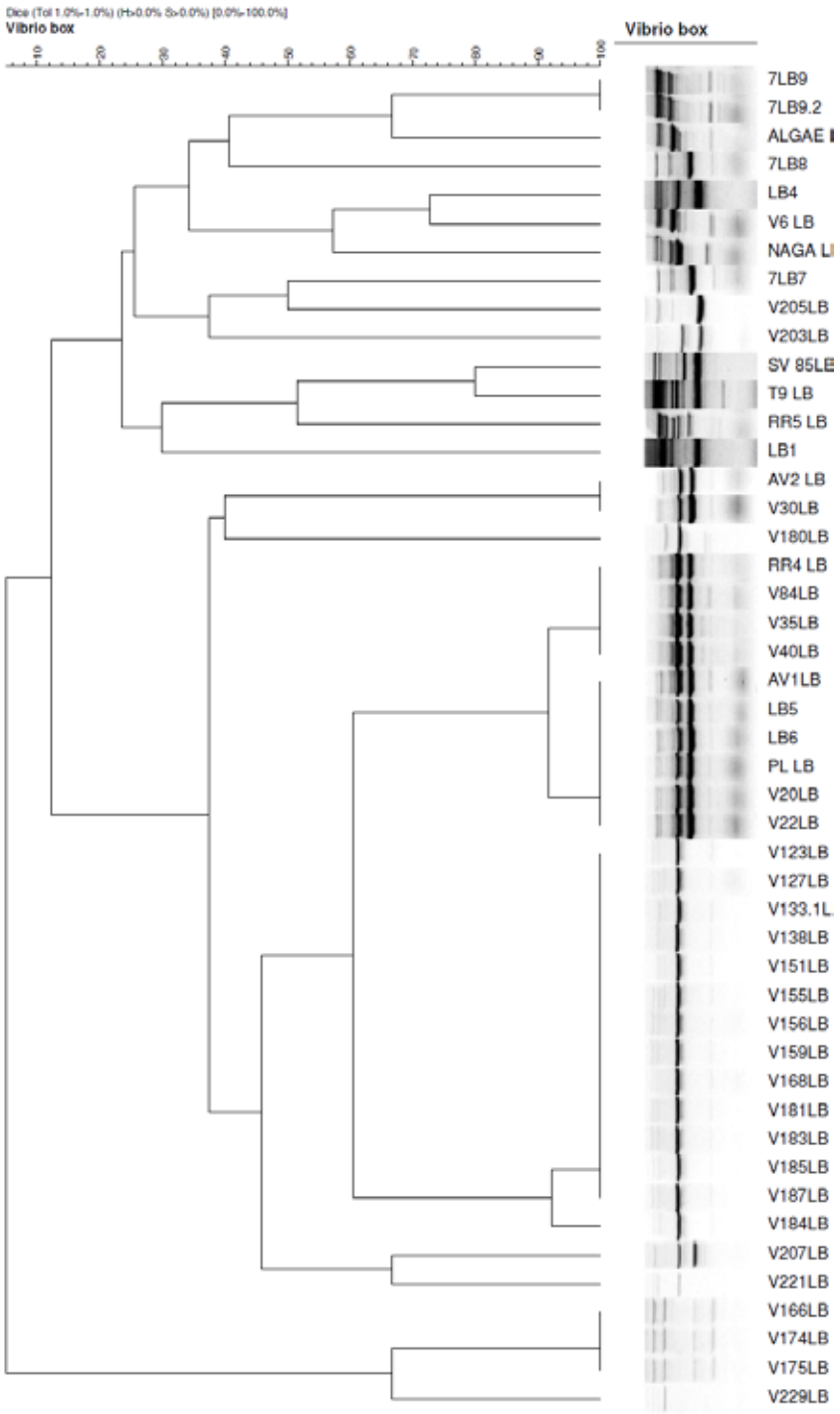




PROBIOTICS

BIOCONTROL OF VIBRIOS IN SHRIMP HATCHERIES USING BACTERIOPHAGES

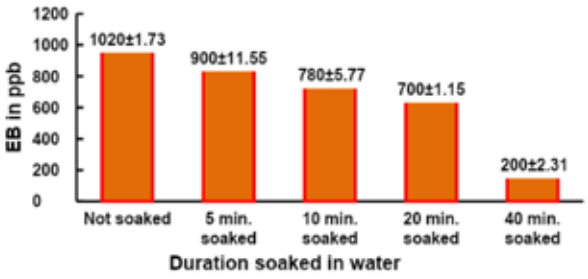
New luminescent bacteria and bacteriophages were isolated from shrimp hatcheries were studied for their susceptibility/host range. During the field trials, fresh luminescent *Vibrios* (47 isolates) and corresponding bacteriophages (36 nos) were isolated. Using BOX PCR, these luminescent *Vibrios* segregated into 17 groups at 60% hierarchical level.



THERAPEUTICS

EMAMECTIN BENZOATE EFFECTIVE AGAINST CRUSTACEAN PARASITIC INFESTATION IN ASIAN SEABASS

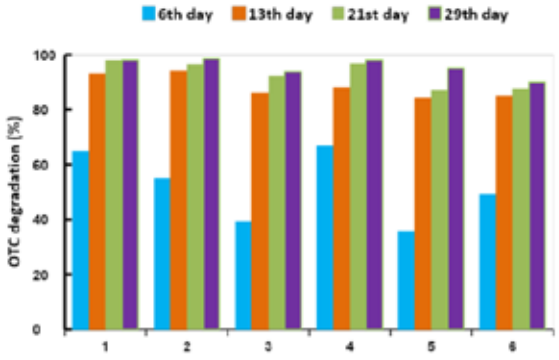
Finfish stocks often suffer parasitic infestation during captivity and culture. An experiment was conducted to assess the efficacy of emamectin benzoate (EB) against *Caligus minimus* infestation in Asian seabass. Proposed therapeutic treatment regimen of 50µg of EB kg-1 fish BW d^{-1} for 7 d was administered through feed. Significant improvement in survival (92%), reduction in parasitic load and improvement in haematological parameters were observed after fifth day of treatment. No parasite could be recovered on and after 7th day of treatment. In addition, leaching effect of EB was also determined at different time intervals by QTRAP 4000 LC-MS/MS analysis. It was found that there was 6.25 fold decrease in EB level after soaking the top-dressed feed in water for 40 minutes.



Withdrawal of emanectin benzoate (EB) from feed coated with 1250 ppb

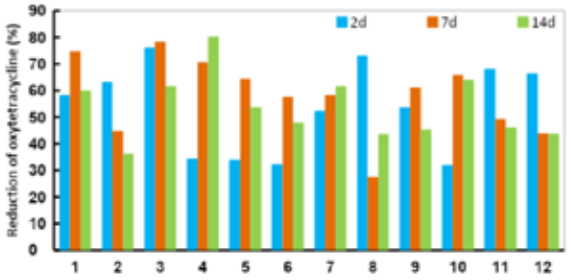
INFLUENCE OF PH ON OTC DEGRADATION UNDER VARYING SALINITIES

Oxytetracycline (OTC) is one of the few antimicrobials approved by the USFDA for use in aquaculture. Persistence of such antibiotics in the environment is an important issue and needs to be understood with regard to environmental characteristics. Influence of pH (5, 7 and 9) and salinity (5, 25 ppt) on OTC degradation with two different concentration of OTC (5 and 10 ppm) was studied in water. Water samples were collected periodically and the concentration of OTC was determined using HPLC. The results indicated that the rate of OTC degradation is lower at higher pH. The anionic form of OTC is repelled by the negatively charged clay in the sediment, which in turn inhibits the removal of OTC in water at higher pH. Between the salinities, OTC removal was high in lower salinity (5 ppt) compared to higher salinity (25 ppt).



EVALUATION OF *PLEUROTUS* SP EDIBLE MUSHROOM ON DEGRADATION OF OXYTETRACYCLINE

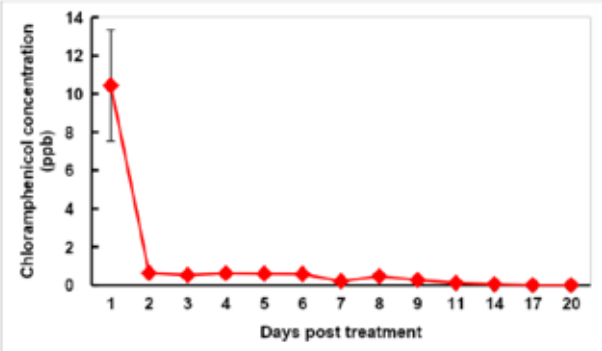
The *Pleurotus* sp an edible mushroom was evaluated for the degradation of OTC. The experiment was conducted in vitro in different salinities (1, 15, 30 and 45 ppt) with soil base at three different concentrations of OTC (50, 150 and 250ppm) and treated with the *Pleurotus* sp edible mushroom. It was found that the *Pleurotus* species have the potential to degrade the OTC at all salinities significantly ($p \leq 0.05$). Interaction effect of the treatment and salinity was significant ($p \leq 0.05$). More studies on evaluation of other species of mushrooms on degradation of oxytetracycline *in vivo* need to be explored.



WITHDRAWAL OF CHLORAMPHENICOL IN SHRIMP MUSCLE TISSUE

Withdrawal period of chloramphenicol in *Penaeus vannamei* was studied by feeding commercially available feed coated with chloramphenicol at the dose

of 500 mg kg^{-1} feed for 7 days. Concentration of the antibiotic in muscle tissue was determined by LCMS/MS. Concentration of chloramphenicol in the muscle tissues dropped drastically within two days of stopping feeding shrimp with antibiotic fortified feed and complete elimination of the antibiotic was observed at 20 days post cessation of antibiotic treatment.



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 2018 to March 2019, a total of 63 samples including imported *Artemia* cyst, frozen tissue and feed samples were tested for OIE listed shrimp and fish pathogens for the AQCS, Chennai. All the samples were tested negative for OIE listed pathogens.

Screening of samples for OIE listed pathogens

Sl.No.	Sample	No	DNA viruses		RNA viruses			Bacteria		Parasite
		Tested	WSSV	IHHNV	IMNV	TSV	YHV	AHPND	NHPB	EHP
1	Prawn frozen feed	2	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	Imported Artemia cyst	59	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
3	Sea fish (Gallons)	1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
4	Semi-moist feed	1	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
5	Total samples Tested	63	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve

NUTRITION AND FEED TECHNOLOGY

In any aquaculture, feed and its management cost often range from 40 to 60 % of the cost of production and a key factor in determining the profitability to the farmer. India's aqua feed sector was more vibrant with current production around 2 million metric tons of feed, and it is expected to grow further. Our dependency on overseas companies for the hatchery feeds is expensive recurring cost. Envisaging these situations, CIBA's nutrition research focus more on issues directly applicable to the stakeholders such as cost-effective grow-out feeds, indigenous hatchery feed technology, live feed, feed management options considering natural feeds etc.

CONVERSION OF FISH PROCESSING WASTE (TRIMMINGS) TO VALUABLE PRODUCTS FOR USE IN AQUACULTURE (PLANKTON ^{PLUS}) AND HORTICULTURE HORTI ^{PLUS})

Fish trimmings represents 25-50% the total fish/shrimp while processing for human consumption. Due to lack of proper disposal of the waste from the fish industry and fish market it creates sanitary and environmental problems. **An effort was put by CIBA to convert this processing waste to a more valuable products under the "Swatch Bharath" mission. A liquid product developed was branded as Plankton^{Plus}, which can be used for boosting plankton in aquaculture pond or as ingredients for feed formulation. The residual solid product can be as manure (Horti ^{plus}) for agriculture/horticulture crops. Plankton^{Plus}** has been tested for its efficiency in boosting phytoplankton and zooplankton. Its effect on growth performance in fish and shellfish showed promising results.



Fig. Conversion of fish waste to Plankton^{Plus}

NUTRIENT PROFILE OF PLANKTON^{PLUS}

The Plankton ^{Plus} has protein content of 47-49% and lipid of 20-22% and is rich in lysine, cysteine, histidine, glutamic acid, docosa hexaenoic acid and eicosa pentaenoic acid. It is also a high source of calcium (Ca-4.03%), phosphorous (P-1.43%) and iron (Fe-3.54 %).

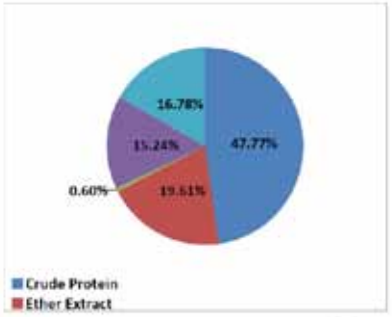
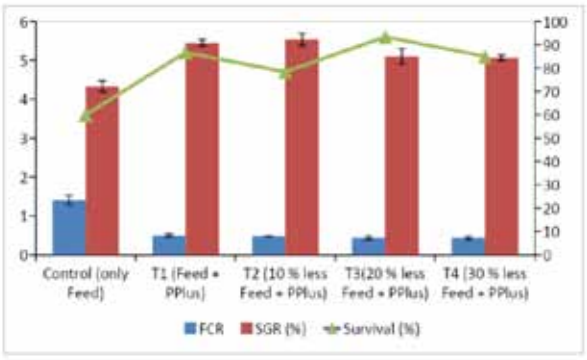


Fig. Proximate composition of Plankton^{Plus}

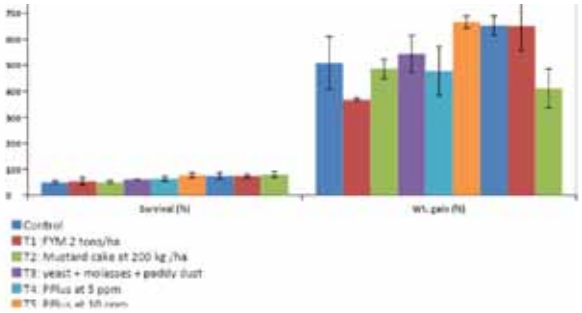
STUDY ON THE POTENTIAL OF PLANKTON^{PLUS} ON REDUCTION OF FEED REQUIREMENT IN *P. VANNAMEI*

A 45 days outdoor experiment was conducted to study the potential of Plankton^{Plus} on reduction of feed requirement in *Penaeus vannamei* culture without any water exchange. There was five treatments in the experiment; Control (only feed), T1 (Feed + PPlus), T2 (10 % less Feed + PPlus), T3 (20 % less Feed + PPlus), T4 (30 % less Feed + PPlus).The experiment revealed that **Plankton^{Plus} supplementation @20 ppm significantly (P<0.01) increased the average daily gain (ADG), specific growth rate (SGR), total biomass gain and survival of *P. vannamei* even when significantly less feed was offered**. Irrespective of dosages, a clear dominance of beneficial microalgae, *Isochrysis galbana* was noticed in all Plankton^{Plus} supplemented tanks. Weight gain was maximum when Plankton^{Plus}@20 ppm was supplemented without any reduction of feed quantity.



STUDY ON EFFECT OF PLANKTON^{PLUS} APPLICATION ON PLANKTON STATUS AND GROWTH PERFORMANCE OF *PEANEUS INDICUS* IN TANK REARING SYSTEM

Effect of Plankton^{Plus} (PPlus) supplementation at different dose (5, 10, 20, 40, & 80 ppm) on plankton status and growth performance of *Penaeus indicus* (ABW 0.32±0.01g) was studied and compared with other conventionally used materials (Cattle manure 20 g/100 L, Mustard cake 2 g/100 L, Juice prepared with fermentation of yeast 0.04 g+ molasses 0.3 g+ paddy dust 0.6 g / 100 L) for boosting plankton in tank rearing system. Weight gain and survival of shrimp was found to be higher in Plankton^{Plus} supplemented (10, 20 & 40 ppm) groups. **Prasinophyceae group of phytoplankton (*Tetraselmis* sp and *Halosphaera* sp) dominated in Plankton^{Plus} supplemented groups and abundance was increasing with increased concentrations of Plankton^{Plus}**. Cyanobacterial percentage was invariably less in all Plankton^{Plus} supplemented tanks.



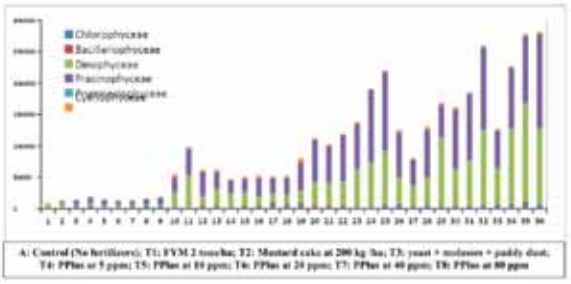


Fig: Number of cells of microalgae groups in PPlus tanks

FISH WASTE HYDROLYSATE RESIDUE (HORTI ^{PLUS}) AS MANURE FOR HORTICULTURE CROPS

The powdered form of fish waste hydrolysate residue was used as a manure and branded as Horti ^{plus}. Performance of Horti ^{plus} was tested in a pot experiment to determine its efficiency on the yield of vegetable crops, ladies finger (*Abelmoschus esculentus*) and brinjal (*Solanum melongena*). The treatments chosen for the study were Control i.e., Farm Yard Manure (FYM) @ 2t/ha, Horti plus @ 0.2 t/ha, Horti ^{plus} @ 2 t/ha, Horti ^{plus} @ 20 t/ha, FYM @ 2t/ha + Horti ^{plus} @ 2t/ha (mixed dose). **Higher yield of brinjal was found when Horti ^{plus} was applied @2t/ha. Yield of ladies finger was higher when Horti ^{plus} @2 t/ha along with FYM @ 2 t/ha was used**. Study revealed potential of Horti ^{plus} as promising manure to be used for raising horticulture crops.

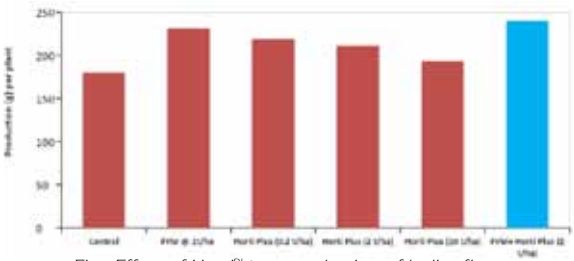


Fig : Effect of Horti^{Plus} on production of ladies finger

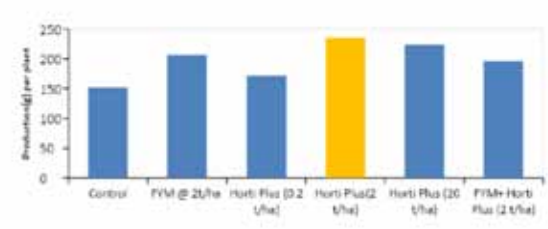
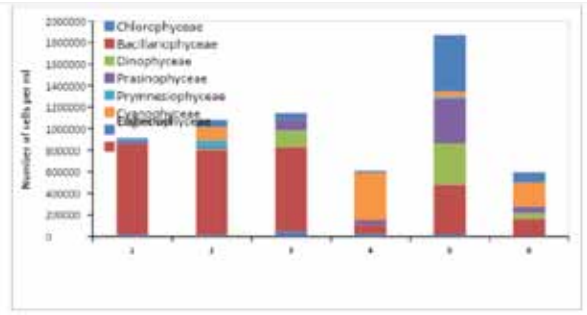
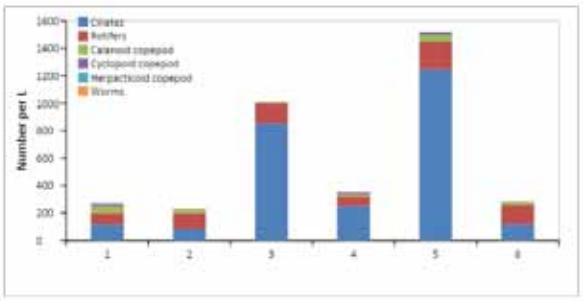


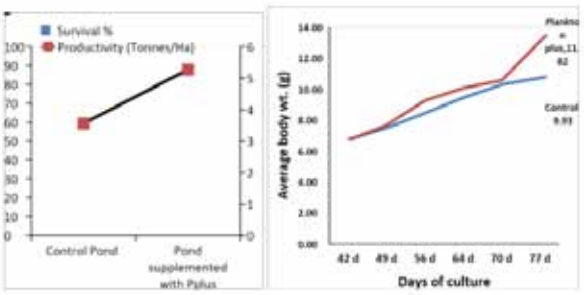
Fig : Effect of Horti^{Plus} on production of brinjal

PLANKTON^{PLUS} AS COST EFFECTIVE PLANKTON BOOSTER – A DEMONSTRATION IN FARMERS POND

A 77 days trial was conducted in shrimp (*Penaeus vannamei)* ponds at Bapatla, Andhra Pradesh, India to study the effect of Plankton Plus (PPlus) on augmenting plankton in shrimp culture pond. PPlus was supplemented @ 10 ppm in split doses. Control ponds were supplemented with rice bran-yeast-mollases juice and dolomite as and when required to maintain the bloom and water quality. At the end of the culture period, average weight of shrimp was higher (11.82 g) in pond supplemented with PPlus compared to control (9. 93 g). **There was a significant increase (12.31%) in survival, and enhancement of yield to the tune of 1.71 t/ha in pond supplemented with Plankton ^{Plus} compared to control. Plankton ^{Plus} supplemented ponds were dominated by beneficial microalgae (Bacillariophyceae, Prasinophyceae and Dinophyceae etc.) and zooplankton. Enhanced growth performance of *Penaeus vannamei* might be due to the augmented density and diversity of phytoplankton and zooplankton** in the Plankton ^{Plus} supplemented ponds.









Healthy looking shrimps from farmers pond where PPlus was used

LIVE FEEDS

PUFA ENRICHMENT IN ARTEMIA USING PROTIST, THRAUSTOCHYTRIDS: A NUTRITIONAL SOLUTION FOR MAXIMUM SURVIVAL AND GROWTH OF LARVAL FINFISH AND SHELLFISH

Thraustochytrids are osmoheterotrophic, oleaginous, eukaryotic, unicellular monocentric fungi-like protists. Thraustochytrids are one of the potential and richest sources of PUFA. Thraustochytrid isolate (*Aurantiochytrium* sp) was (Isolate from CUSAT, Cochin) developed in mass scale and evaluated its potential to culture and enrich artemia and rotifers (Lipid: 43.7 %, Protein 37.7% and DHA 40% of total fatty acids). Significant differences were observed in survival and growth of artemia fed with live and lyophilized Aurantiochytium sp. **Average growth (total length 11 mm) and survival (97%) was maximum in artemia fed with microalgae Nannochloropsis along with 250 mg lyophilized *Aurantiochytium* sp**.. Study revealed the prospective use of new isolates of Thraustochytrids in aquaculture nutrition.

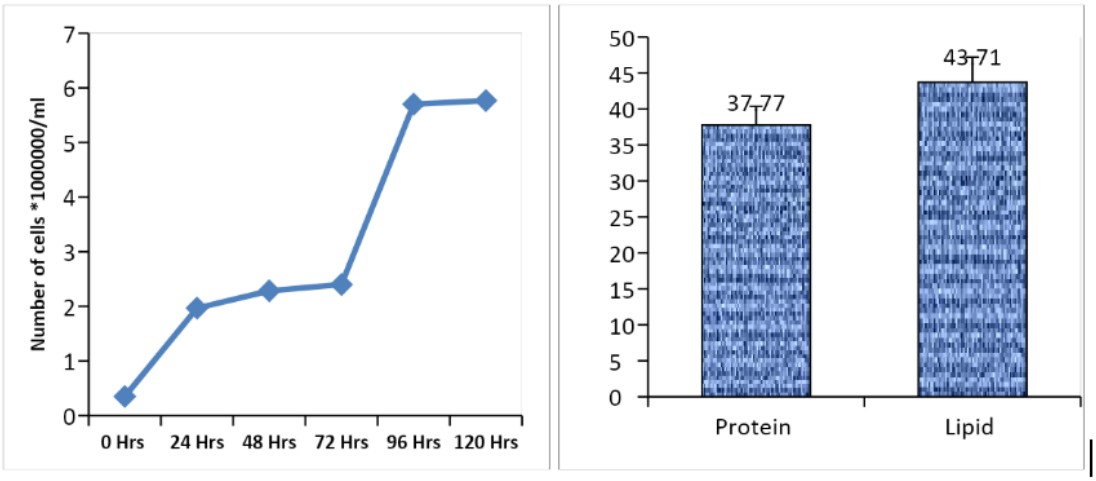
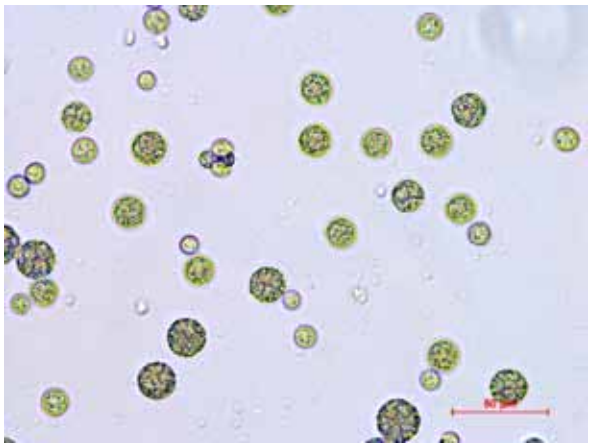
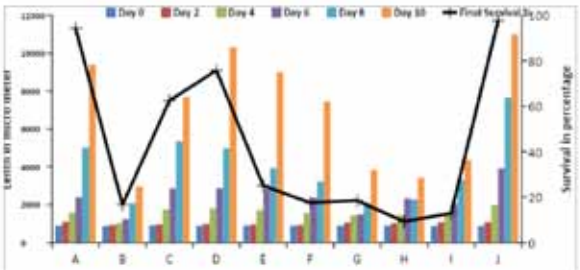


Fig. Growth curve of Aurantiochytrium sp, and percentage of protein and lipid content in Aurantiochytrium sp

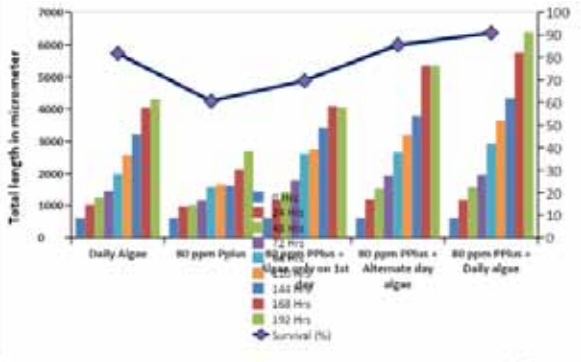




Survival and growth of artemia. A: Fed with Nannochloropsis occulata, B: Without any feed, C: Freeze Dried Aurantiochytrium (FDA) @ 125 mg/1500 Nos, D: FDA @ 250 mg/1500 Nos, E: FDA @ 375 mg/1500 Nos, F: FDA @ 500 mg/1500 Nos, G: Wet Biomass Aurantiochytrium (WBA) @ 0.5 g/1500 Nos, H: WBA @ 1 g/1500 Nos, I: WBA @ 1.5 g/1500 Nos, J: FDA @ 250 mg/1500 Nos + Nannochloropsis occulata

PLANKTON *PLUS* PROMOTES GROWTH OF ARTEMIA

Potential of Plankton *Plus* for culturing the zooplankton (Artemia) was evaluated by feeding them with different concentrations of PPlus (20 ppm, 40ppm, 80ppm and 160 ppm) and 80 ppm was found to give better survival and growth compared to other doses. Study was conducted to reduce use of microalgae by supplementing PPlus for artemia culture. For this purpose, PPlus (80 ppm) was added along with microalgae (*Nannochloropsis occulata*) at different frequency of application, i.e., one-time (first day) application, alternate day application and daily application. The growth and survival of artemia were significantly ($p<0.05$) higher when PPlus was used with daily application of microalgae. Interestingly, the growth and survival of artemia were also higher when PPlus was supplemented with alternate day algae application compared to daily algae feeding without PPlus. The experiments clearly revealed that **Plankton *Plus* supplementation @ 80 ppm with microalgae improved artemia biomass production and can reduce the usage of algae by 50 % for artemia culture**.



Growth and survival of artemia fed with Plankton Plus

EVALUATION OF NEWER FEED INGREDIENTS FOR USE IN AQUAFEEDS

WEEVIL INFESTED SWEET POTATO MEAL AS A NOVEL INGREDIENT IN SHRIMP FEED

Sweet potato weevil is the most serious pest of sweet potato, with reports of losses as high as 97% in areas where the weevil occurs resulting in huge loss of the crop. This weevil infested sweet potato meal (WSPM) is unfit for human

Nutrient/ ingredient	Weevil infested Sweet potato meal		
	Low infestation	Medium infestation	High infestation
			
Moisture	11.23	11.66	11.78
Crude Protein	4.13	4.21	5.1
Ether Extract	1.11	1.3	1.62
Total Ash	3.65	4.02	5.15
Crude Fibre	4.56	4.54	7.34
NFE	75.32	74.27	69.01
AIA	0.59	0.69	0.86

consumption and is disposed of as waste. In order to ascertain its potential as an ingredient in the diet of *P. vannamei*, nutritional composition was analyzed and feeding experiment was conducted for 60 days in vannamei juveniles (4.26± 0.21) by using WSPM at 5,10,15, 20, and 25% replacing wheat, a commonly used carbohydrate source, on (W/W) basis in the shrimp diet. **The sweet potato meal contains higher NFE, indicating the nutritional richness of available carbohydrate**. As the level of weevil infestation increases, there is a slight increase in crude protein. The chemical analysis indicated that **weevil infested sweet potato could be explored as an alternate ingredient to wheat.** The results also revealed that WSPM could be effectively used up to 10% in the vannamei diet without affecting growth and FCR.

EFFECT OF YEAST FERMENTATION OF GROUND NUT OIL CAKE ON NUTRIENT DIGESTIBILITY, GROWTH AND NUTRIENT UTILIZATION IN *P. VANNAMEI*

Ground nut oil cake (GNC) was fermented with yeast, *Saccharomyces cerevisiae* at 60-65% moisture for three days. The fibre fractions are not much influenced by yeast fermentation in ground nut oil cake except the reduction of cellulose fraction (8.77 to 7.78%). The nutrient digestibility in terms dry matter and protein were determined by ingredient substitution method in *Penaeus vannamei* (Average initial weight 12.87g). The apparent dry matter and protein digestibilities increased from 56.92 to 60.87 and 79.07 to 85.12%, respectively from raw ingredient to fermented ingredient. For optimization of the inclusion level in shrimp feed, nine test feeds having 0, 2.5, 5.0, 7.5 and 10% levels of raw and yeast fermented GNC were prepared by replacing fishmeal. The results indicated that yeast fermented GNC can be included up to 10% whereas raw GNC could be included up to 5% in *P. vannamei*.

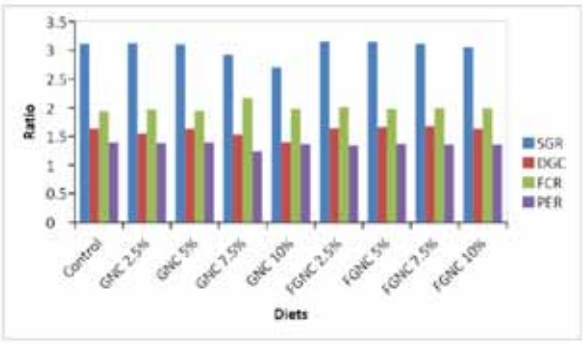


Fig 1: Effect of fish meal replacement with varying levels of unfermented and yeast fermented ground nut oil cake in the diets of P. vannamei on Growth and nutrient utilization

EFFECT OF FERMENTATION OF MANGROVE LEAVES ON PROXIMATE AND MINERAL COMPOSITION

In order to utilize the mangrove leaves as an ingredient in aquafeeds, the mangrove leaves, *Avicennia marina* were collected from Nagayalanka, A.P. The proximate and mineral profiles were analysed. These leaves contain 66.8, 2.88, 1.12, 3.86 and 5.77% of moisture, crude protein, ether extract, total ash and crude fibre, respectively on as is basis. The mangrove leaves contained 173, 245, 149, 805, 4.2, 2.7 and 0.5 mg/100g of Ca, K, Mg, Na, Fe, Mn and Zn, respectively. The effect of fermentation on changes in proximate composition has indicated not much variation except for slight reduction of crude fibre levels.

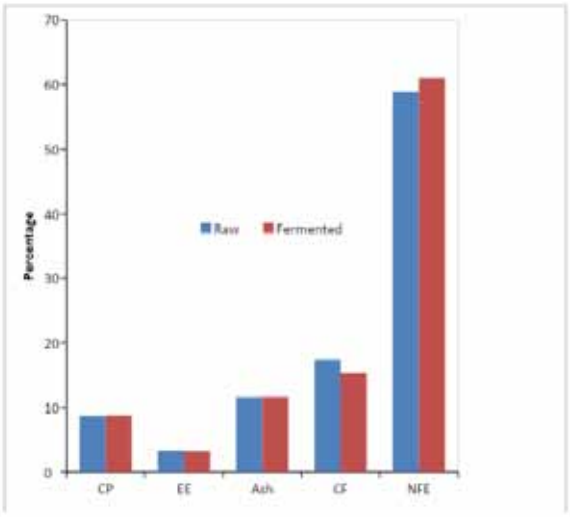
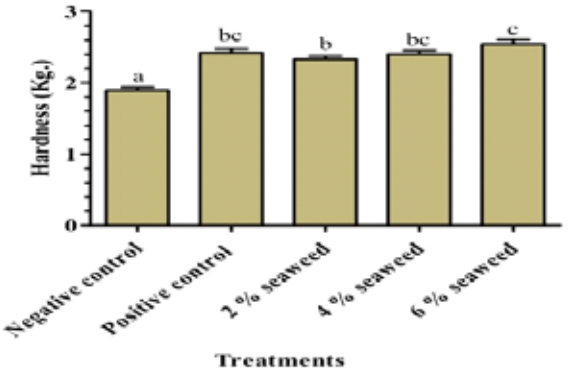


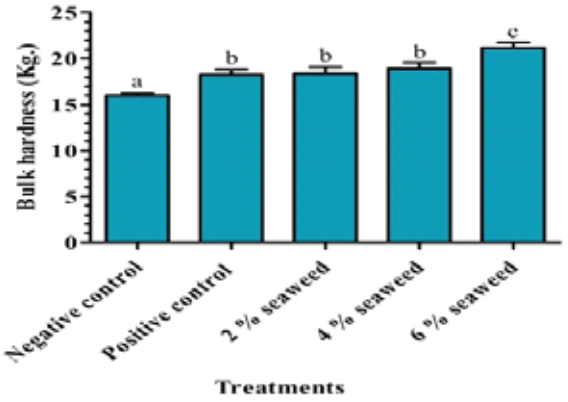
Fig 2: Effect of yeast fermentation of mangrove leaves on proximate composition

SEAWEED AS A SOURCE OF NATURAL BINDER IN SHRIMP FEED

Seaweed, *Gracillaria tenuistipitata* has been selected as a potential natural binder and its effect was studied in the diet of *P. vannamei* feed. Seaweed was included at 0 (negative control), 2, 4 and 6% in the CIBA Vanami^{Plus} feed and compared against the standard control diet containing synthetic binder as a positive control. Experimental feeds prepared were subjected for hardness and bulk hardness studies using TA. XT plus texture analyzer. Feed was compressed with 2 mm (for hardness) and 32 mm diameter (for bulk hardness) cylindrical probes with 60 % compression, 1mm/sec speed, and 0.001 g trigger force. Results indicated that hardness of the pellets of different treatments was significantly different ($P < 0.05$). **Hardness (2.54 kg) and bulk hardness (21.22 kg) in 6% seaweed incorporated feed were similar with commercial feed (2.42 kg) indicating the potential of seaweed as alternate for the synthetic binder in shrimp feed preparation**. In addition, seaweed is also known to offer other nutraceutical benefits for the farmed shrimp.



Hardness of single pellets of different feed (Mean ± SE, n=10).



Bulk hardness of single pellets of different feed (Mean ± SE, n=10).

PROXIMATE AND MINERAL COMPOSITION OF WILD AND CULTURED *GRACILARIA TENUISTIPITATA*

Comparative study was conducted to assess the nutrient composition of wild and cultivated seaweed. Crude protein was significantly higher in cultured Gracilaria compared to wild Gracilaria. Na, K, P, Mn and Se content were significantly higher in cultured compared to wild seaweed. Results indicated that cultured Gracilaria could be of used as a potential ingredient for aquafeed preparation.

Proximate composition (%)	Wild	Cultured
Moisture	88.10 ± 0.04	90.16 ± 0.21
Crude protein	19.42 ± 0.14^a	22.57 ± 0.08^b
Crude lipid	0.55 ± 0.01	0.51 ± 0.06
Crude mineral	37.62 ± 0.02^a	38.61 ± 0.03^b
Insoluble mineral	8.47 ± 0.45	8.56 ± 0.84
Crude fiber	7.35 ± 0.15^a	6.39 ± 0.15^b
Mineral composition (g/kg)		
Calcium	2.31 ± 0.023^a	2.23 ± 0.009^a
Magnesium	6.28 ± 0.036^a	6.38 ± 0.035^a
Sodium	26.33 ± 0.007^a	27.46 ± 0.009^b
Potassium	107.48 ± 0.006^a	108.48 ± 0.005^b
Phosphorous	2.11 ± 0.052^a	3.83 ± 0.004^b
Iron	2.38 ± 0.005^a	1.89 ± 0.667^a
Copper	• ± 0.00^a	0.01 ± 0.001^a
Manganese	0.11 ± 0.001^a	0.37 ± 0.007^b
Zinc	0.31 ± 0.005^a	0.18 ± 0.004^b
Selenium	4.10 ± 0.057^a	7.55 ± 0.008^b

Each value represents Mean ± S.E, n = 3. Values in the same row with different superscripts are significantly different ($P < 0.05$)

Proximate (%) and mineral composition wild and cultured seaweed

NUTRIENT PROFILE OF MARINE MACROALGAE

Six species of marine macroalgae, Red algae (*Gracilaria corticata, Champia compressa*), Brown algae (*Turbinaria conoides, Dictyopteris*) and Green algae (*Halimeda*

macroloba, Caulpera racemosa) were analysed for proximate, fatty acid and mineral compositions. Biochemical composition of collected seaweeds species revealed that crude protein, total Ash, crude fiber ranges from 5.03 to 9.17%, 37.31 to 70.22%, 8.1 to 14.56%, respectively on dry matter basis. Total lipids range from 420 to 1660 mg/100g while PUFA content was 52.41 to 376.70 mg/100g on dry matter basis. Mineral profile revealed that high Ca (g/kg) content was observed in *Halimeda macroloba* (141.43) and lowest was in *Gracilaria corticata* (8.321) while Se (g/kg) was high in *Halimeda macroloba*, *Gracilaria corticata* (0.91) and low in *Turbinaria conoides* (0.68) and Zn ranges from 0.02 to 0.26 g/kg. Seaweeds are rich source of minerals, low in crude protein, total lipids and PUFA. Among collected seaweed species *Halimeda macroloba* has shown higher mineral profile. Cultured *Gracilaria tenistipitata* contain lower Ca and Fe (0.235, 0.555) and higher P and Se (3.825 and 7.532 g/kg) in cultured seaweed samples compared to wild (2.863 and 2.371; 2.02 and 4.001 g/kg, respectively).

LEUCAENA LEUCOCEPHALA AS A LOW-COST FEED INGREDIENT IN MILK FISH (*CHANOS CHANOS*) FINGERLINGS

Leucaena leucocephala is a fast-growing leguminous plant which can be grown on dry lands. It is a cheap source of protein (CP-21.06 %) with high nutritional value. To reduce the cost of the feed this study has been conducted. Four iso-nitrogenous diets (CP- 29%), with *Leucaena* leaf meal (LLM) at 0, 5, 10 and 15 % were formulated and tested on milk fish in a 49 days trial. No significant difference in average body weight gain was observed between control and 5 % LLM fed group. Body weight gain reduced ($P<0.05$) when LLM was incorporated above 5 % level. Histopathological observation revealed no effect on liver tissue at 5% level but degenerated nucleus and vacuole formation found at 10% and 15% level which indicates **LLM can be incorporated safely at 5% level without affecting growth and survival of milkfish**.

AVAILABILITY OF MARINE PROTEIN SOURCES IN SUNDARBAN, WEST BENGAL

Fish is an important part of the regular diet and is a cheap source of protein for the peoples of West Bengal. About 78% of total fish catch is consumed in fresh condition, 6% is used as dry fish and rest is used as frozen fish. Around 20% of the dry fish are used for fish meal/poultry feed. A survey was conducted during November 2018 to January 2019 to have information on availability of dry fish and common species used for making dry fish in Namkhana, Kakdwip and Sagar block of

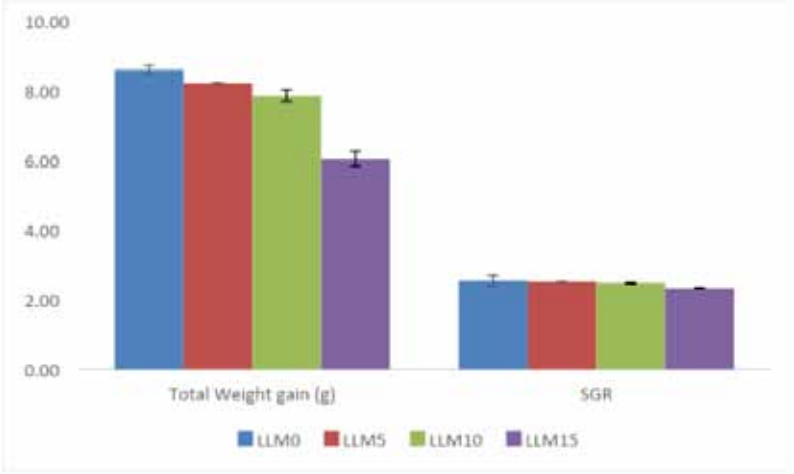


Fig. Growth performance of milk fish (Chanos chanos) fed different level of LLM in the diet

South 24 Parganas of West Bengal. Available dry fish species were *Trichurus russelli* (1.5 t), *Harpodon nehereus* (11 t), *Setipinna phasa* (8 t), *Coilia ramkarati* (10 t) and *Atrobucca nibe* (16 t). The highest protein content was found in Atrobucca nibe (CP-69.25%) whereas other species contained protein ranging from 62 to 64%. Total 15000 t of dry fish at Frazerganj, 18900 t at Kalisthan, 200 t at Kakdwip, 10150 t at Sagar and 450 t of Acetes at Mousumi were produced during last winter.



Harpodon nehereus (Bombay duck)

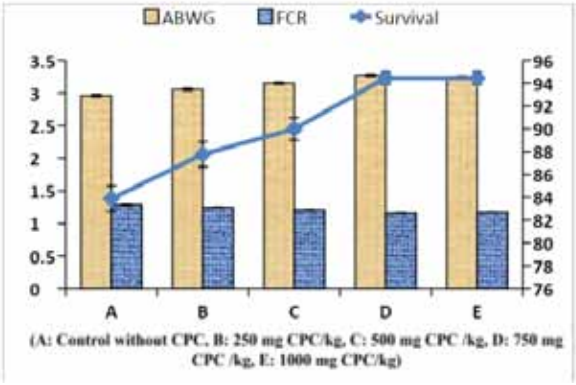


Women engaged in fish drying

FEED ADDITIVE

EFFECT OF DIETARY C-PHYCOCYANIN IN GROWTH AND HEALTH OF *PENAEUS VANNAMEI*

C-Phycocyanin, an intense blue pigment extracted from locally isolated spirulina, *Arthrospira maxima*, used to formulate shrimp feed with different concentrations. **A significant increase ($p<0.05$) of average body weight gain, survival rate and better FCR was observed in *Penaeus vannamei* juveniles fed with feed containing 750 and 1000 mg C-Phycocyanin/kg of experimental diet** compared to other treatments (250 and 500 mg/kg C-Pycocyanin inclusion) and control (0% C-PC) in a 45 days trial. A challenge study with pathogenic *Vibrio parahaemolyticus* for 5 days post feeding trial revealed that the animals fed with higher concentrations of C Phycocyanin (750 and1000 mg/kg) had better survival and less haemolymph vibrio load. Study revealed that C-Phycocyanin extracted from spirulina can be incorporated in the shrimp feed formulations for boosting growth and immunity.



KRILL OIL AS FEED ADDITIVES

A study was conducted to evaluate the effect of Krill oil supplementation on growth and immunomodulatory potential of *Penaeus vannamei* juveniles. Krill oil was included at 0.1 (T1), 0.2 (T2), 0.4 (T3), 0.8 (T4) and compared against the supplemented control diet without krill oil supplementation (0.0%). After feeding trial, shrimps from each treatment group were challenged with 0.1 ml of virulent *V. parahaemolyticus* suspension at a concentration of 10^7 CFU ml^{-1}. The post-challenge sampling was performed after 7 days of injection. The growth and survival rate of shrimps fed with krill oil diet was significantly ($p<0.05$) higher as compared to control group. Study revealed that 0.4 % krill oil may be incorporated in diet of *Penaeus vannamei* juveniles for getting better growth and survival.

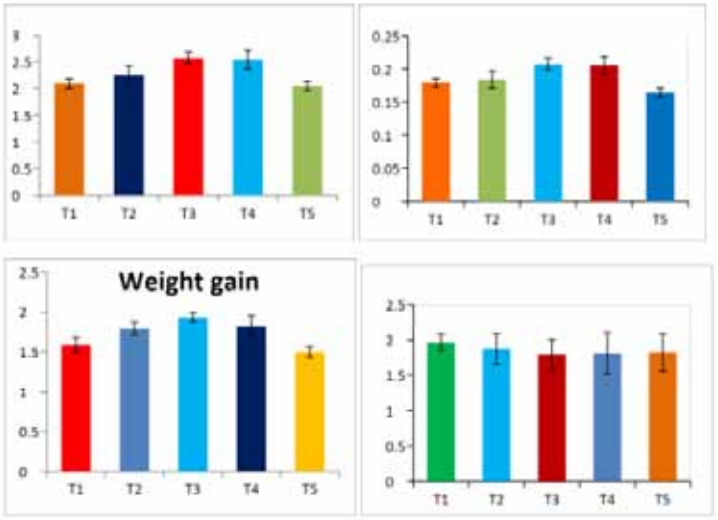


Figure: Growth and nutrient utilization of Pacific white shrimp fed with krill oil.

OPTIMIZATION OF NUTRIENT REQUIREMENTS

EARLY WEANING OF SEABASS LARVAE WITH IMPROVED INDIGENOUS SEEBASS LARVI *PLUS*

A suitable micro-particulate feed is critical input for attaining optimal growth and survival after weaning the larvae from live feeds. A 12 day feeding experiment was conducted in triplicates for testing indigenous larval micro-diet in Seabass larvae. Experiment was conducted in 500 L capacity circular FRP tank. Seabass larvae, 21 dph (10.52±0.45 mg) stocked at a density of 500 larvae/tank were fed at 10% body weight twice daily. The final avg. body wt. and total length after 12 days were found to be 127.29±11.14 mg, 2.3±0.3 cm, respectively. Survival (%) was found to be 80.03%. **The relatively lower feed cost and higher growth performance with indigenous larval feeds indicates its potential as an alternative to commercial feed for larval rearing of seabass**. Further studies are required for optimization of larval nutrient requirements and feed management practice to further reduce the feed cost and enhance the returns.

OPTIMIZATION OF LEVEL OF TAURINE IN DIET OF *CHANOS CHANOS* LARVAE

For optimization of taurine level in diet of *Chanos chanos* larvae, isoproteinous (CP-47 %) isolipidic (EE-9 %) feed was prepared with varying level of taurine i.e., 0, 0.25, 0.5, 0.75, 1.0 and 1.25 %. *Chanos chanos* larvae (Av. Body wt. 0.061±0.005 g) were randomly distributed in 18 glass tanks (90 L water each) of recirculatory aquaculture system (RAS) @ 20 larvae per tank and the feeding trial was carried out in triplicate for 60 days.

Average daily gain, Weight gain percent, specific growth rate were higher and FCR was lower in *Chanos chanos* supplemented with 1 % taurine. Survival (%) was higher (P>0.05) in all taurine supplemented groups though statistically not significant. Survival was maximum in group supplemented with 1.0 % taurine. Experiment revealed that 1.0 % taurine supplementation was found to be optimum in diet of *Chanos chanos* larvae.

VITAMIN E REQUIREMENT FOR MILK FISH LARVAE

A forty five day study was conducted to examine the effect of dietary vitamin E supplementation on growth of milkfish, *Chanos chanos* larvae. Five iso-nitrogenous and iso-energetic (550 g protein per kg and 120 g lipid per kg) experimental diets were prepared with varying levels (0, 100,200,400 ppm) of vitamin E (α-tocopheryl acetate) supplementation. Milkfish larvae with a mean body weight of 48.25± 5.32 mg were fed with experimental diets in triplicates following a completely randomized design. Study revealed that milkfish fed with diet supplemented with 200–300 mg/kg of vitamins E showed enhanced ($p < 0.05$) growth performance, and survival. The results of the feeding experiment based on the second-order polynomial regression analysis revealed that the **dietary vitamin E requirement for optimal growth of *C. chanos* larvae was estimated to be in the range of 196–218 mg α-tocopheryl acetate per kg.**

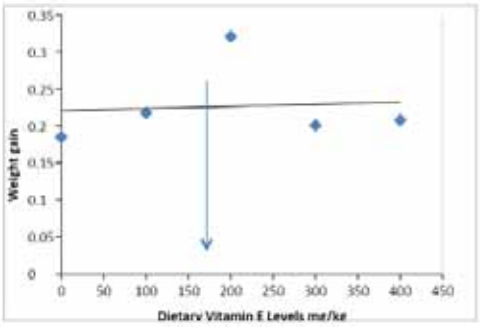
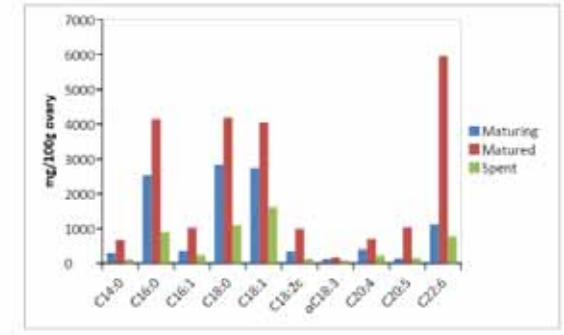


Figure: Estimation of dietary vitamin E requirement for optimum growth of C. chanos larvae using second-order polynomial regression analysis

MOBILIZATION OF FATTY ACIDS IN HILSA DURING DIFFERENT STAGES OF MATURITY

Hilsa, *Tenualosa ilisha* is a highly valued anadromous clupeid distributed in the Ganga-Brahmaputra-Meghna river. In order to develop a suitable brood stock feed, the mobilization pattern of fatty acids were analysed in pond reared brood stock at varying stages of maturity. The muscle of immature fish contains 2466, 796, 953, 1308,176, 284 and 1450 mg/100 g of C16:0, C16:1, C18:0, C18:1, C20:4, C20:5 and C22:6, respectively. The matured ovary contained 4141, 1021, 4174, 4038, 695, 1028 and 5940 mg/100g of C16:0, C16:1, C18:0, C18:1, C20:4, C20:5 and C22:6, respectively.

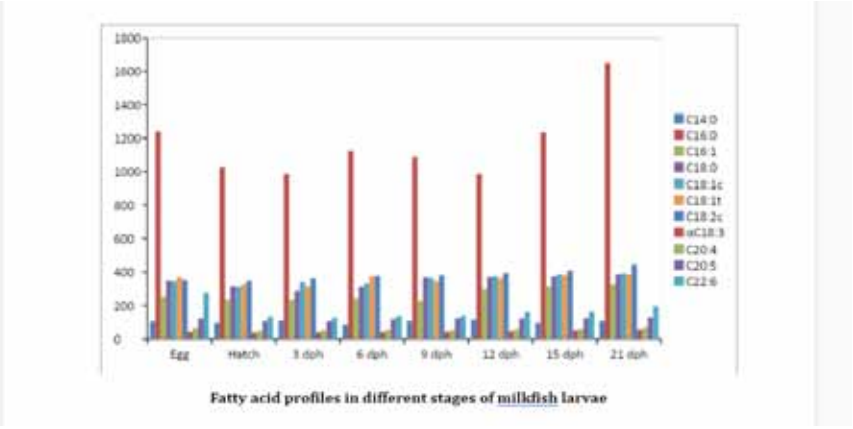


FATTY ACID PROFILES IN THE OVARY AT DIFFERENT STAGES OF MATURITY IN HILSA

The fatty acids like C14:0, C18:1, C18:2c, C18:3 have been reduced by more than 95% in matured fish muscle compared to immature fish muscle. Whereas the fatty acids like C16:0, C18:0, C20:5 and C22:6 were reduced by ~90% and C20:4 by 71%. The retention (%) of mobilized fatty acids in the ovary varied significantly among the fatty acids. **Even though C20:4 is the least mobilized fatty acid from the muscle it is the highest retained (96%) in the ovary whereas the C16:1 is the highest mobilized fatty acid but its retention in the ovary is the lowest (22.7%). The variation of retention (%) of fatty acids might be due to utilization of certain fatty acids like C16:0, C16:1 for energetic purposes and certain fatty acids like C14:0, C18:0, C20:5, C22:6 and C20:4 are selectively retained.** This information will be a base for developing broodstock diets for captive breeding of hilsa.

FATTY ACID PROFILES OF MILK FISH EGG AND LARVAL STAGES

Hatchery produced milkfish egg, larvae (0, 3, 6, 9, 12, 15 and 21 day) are analysed for fatty acid profiles. The DHA content of egg, hatch and 21day old larvae are 277, 136 and 194 mg/100 g. The reduction of fatty acids like DHA (51%), ARA (26%) and EPA (24%) is very high in hatchling, indicates their significance during the embryogenesis of milkfish egg. The changes in amino acid and mineral profiles are also studied.



Fatty acid profiles in different stages of milkfish larvae

FEED MANAGEMENT OPTIONS

EFFECT OF DELAYED INITIAL FEEDING ON GROWTH AND SURVIVAL OF MILKFISH, *CHANOS CHANOS* LARVAE

This study investigated the effect of delayed initial feeding on growth and survival of milkfish, *Chanos chanos* larvae under controlled conditions. Growth parameters were evaluated by assessing morphometric characteristics of the larvae. Two experiments were conducted at different initial feeding time i.e., at 24 h, 48 h, 72 h, 96 h and 120 h. Milkfish larvae initiated first feeding at 120 h after hatching have achieved comparatively lesser growth in total length and total weight than that of 24 h and 48 h. **The morphometric characteristics (total length, head depth, body depth, eye diameter, gut height, musculature height, yolk volume) of 5 DPH larvae had significant differences between 24 h and 120 h initial feeding.** Similarly, significant differences were noticed between 24 h and 72 h initial feeding for all the morphometric characteristics. There was no significant difference in the yolk volume utilization of 1 DPH and 2 DPH larvae among different treatments. Experiment on the effect of delayed initial feeding on the survival of Milkfish larvae revealed that after 21 days of rearing, survival was higher in milkfish larvae initiated feeding at 24 h (40.86%) compared to 72 h (19.28%) and 96 h (7.72%). Complete mortality was recorded on 6 DPH for the larvae initiated feeding at 120 h. The present study suggests that **the feeding of milkfish larvae must be initiated at 24 h post hatching for getting better growth and survival.**

COMPENSATORY GROWTH IN SHRIMP VANNAMEI

Compensatory growth is already proved in fishes. However, the reports on such a compensatory growth in shrimp are clashing. In fact, this kind of compensatory growth is beneficial for the farmers in the management point of view. Therefore, to confirm the presence or absence of compensatory growth this study was conducted with stunted shrimp from the aqua mimicry feeding trials. Here the shrimps were brought to normal feeding regime as our standard shrimp feeding chart. The growth performance was observed for another 55 days. Self-cleaning microcosm tanks served as rearing system. The stunted shrimps were found to have faster growth compared to the normal shrimps. **The weekly weight gain in the stunted shrimps was more than 3 g per week, while it was only around 1.6 g per week in the normal shrimps.** Compensatory growth in shrimp is evidenced from the results of this study.

PENAEUS VANNAMEI-MILKFISH CO-CULTURE WITH LOW PROTEIN FEED

Penaeus vannamei (40 no./m2) was co-cultured with milkfish stocked at two densities (0.2 and 0.4 no./m2) for 107 days in 0.15 ha ponds. CIBA made low protein feed (CP-32%) was used for the culture. Milkfish was stocked (ABW-5 g) after 15 days of vannamei stocking. **Culture of *P. vannamei* with the lower density milkfish (0.2 no./m2) yielded better production (shrimp- 5.8 ton/ ha, milkfish 0.5 ton/ ha) and survival (Shrimp- 68%, milkfish-100%).**

Table. Performance of vannamei-milkfish with low protein feed

	Vannamei-milkfish (0.2/ha)	Vannamei-milkfish (0.4/ha)
Final wt, g (Vannamei)	21.25±0.07	23.15±1.12
Final wt, g (Milkfish)	250.00±0.10	210.00±30.00
Feed Conversion Ratio	1.16±0.03	1.30±0.22
Productivity, kg/ha	5773.5 ±106.5	4676.5±636.5
Operational cost, Rs.	115300±200	109150±2450
Gross income, Rs.	271057±4795	228059±31563
Benefit Cost Ratio	1.67±0.0.02	1.77±0.09

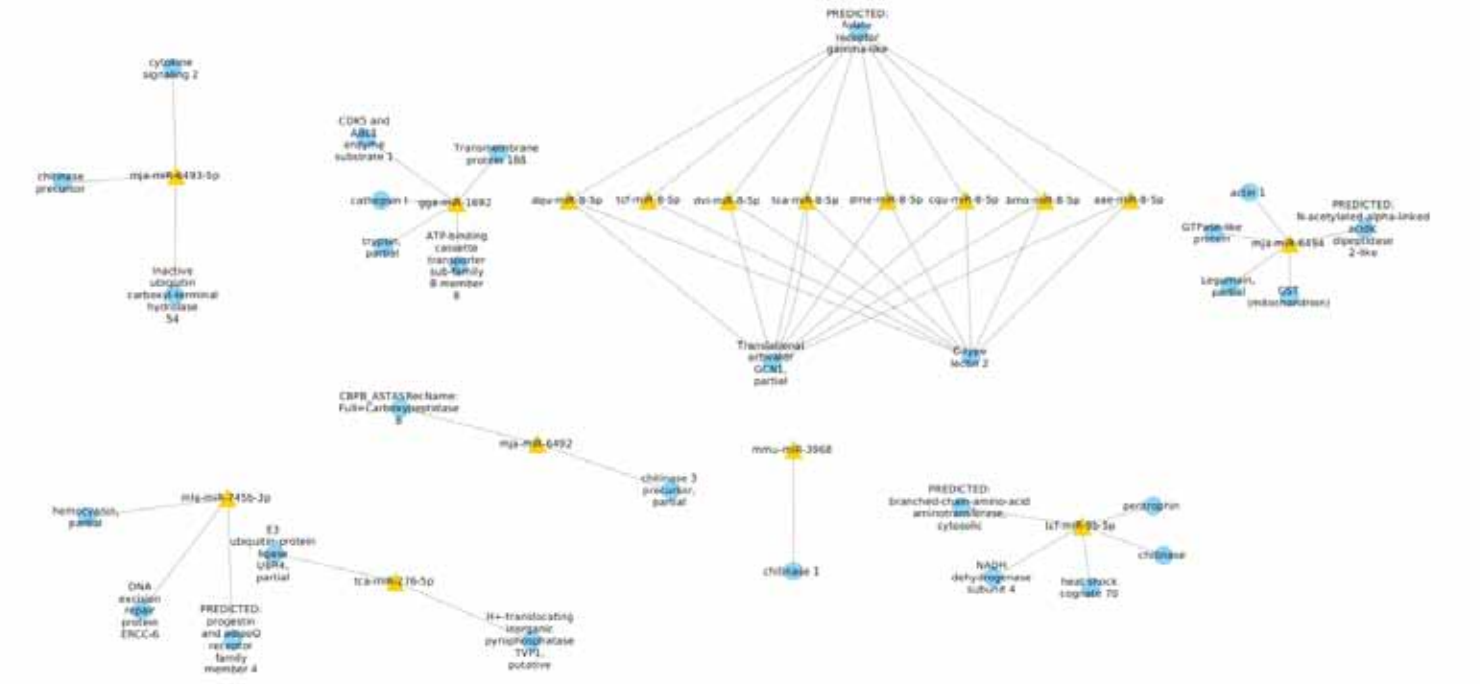


Harvested milkfish-vannamei

GENETICS AND BIOTECHNOLOGY

MIRNAS EXPRESSION PROFILING DURING WSSV INFECTION

In recent years, the importance of viral and host microRNAs (miRNA) in mediating viral replication and control of host cellular machinery, has been realized and increasing efforts have been taken in order to understand the interactions of miRNAs from host and pathogen during infection. small RNA sequencing was performed to identify the miRNAs involved in shrimp (*Penaeus vannamei*) immune responses under WSSV infection condition. The expression profiles of miRNAs of shrimp infected with WSSV under two contrasting conditions of field outbreak and controlled experimental conditions were compared and as a result, 23365 known miRNAs and 481 novel miRNAs were identified. Amongst the most abundantly expressed miRNAs, the hypoxia related miR-210 and immune pathway related miR-29b were expressed only in infected shrimps of both conditions. The other miRNAs included miR-8-5p, having a functional role in modulation of chitin biosynthesis and miRNAs targeting chitinase, an important enzyme involved in growth and moulting in shrimps, indicating an interaction between WSSV infection with moult cycle of shrimp. The miRNA target prediction revealed several immune-related gene targets such as cathepsin, c-type lectin, hamocyanin and ubiquitin protein ligase. The shrimp miRNA mja-miR-6489-3p, was also found to target early virus gene wsv001 of WSSV. Our study, therefore, provides the comparative analysis of miRNA expression from shrimp during WSSV infection in two different conditions.



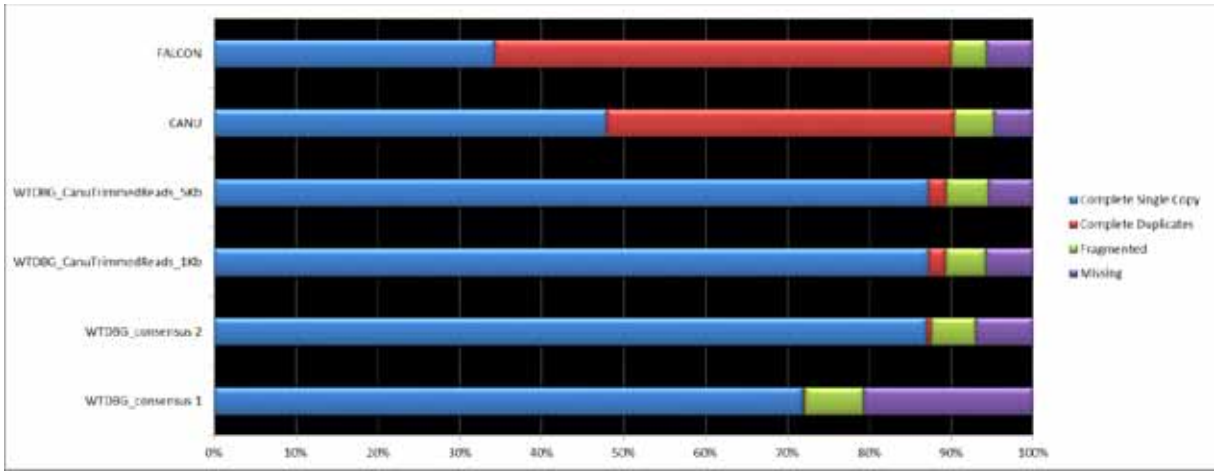
THE INTERACTIONS BETWEEN MIRNAS AND TARGET GENES OF WSSV INFECTED *L. VANNAMEI* SHRIMP CONTIG-LEVEL ASSEMBLY OF *PENAEUS INDICUS* GENOME WITH LONG-READS

PacBio sequence data was generated on pacific biosciences sequel platform using magnetic bead loading and 600-minute movies. The 20 Kb sequencing libraries were used for sequencing where inserts over 17 Kb size were retained based on BluePippin size selection. About 20,857,430 reads of 176,539,267,324 bases length of sequence data which is equivalent to 71X coverage of genome was used for building contig-level genome with assemblers Falcon, Canu and WTDBG2.

The comparative quality metrics of various assemblies are presented in Table 1. The assembly with Canu is almost close to the total length of genome. The BUSCO scores for the assemblies generated is shown in Figure 1. The assemblies generated with WTDBG2 have higher BUSCO scores for complete single copy genes. Especially the assembly made with raw reads using consensus 2 algorithm has about 73% genome represented in 12,278 contigs with a N50 of about 1 Mb. Generation of optical map and HiC data, scaffolding and chromosome linking are in progress.

Quality metrics of various assemblies generated with Falcon, Canu and WTDBG2.

Statistics	CANU	FALCON	WTDBG			
			CANU reads, >1kb	CANU reads >5kb	consensus 1	consensus 2
Total Length, Gb	2.36	3.39	1.33	1.31	1.55	1.8
N50, bp	54 266	69 258	73 486	72 942	1 201 053	991 596
No of Contigs	83893	76547	37371	36715	2168	12278
BUSCO Score (%)	95.2	94.2	94.2	94.6	79.3	93



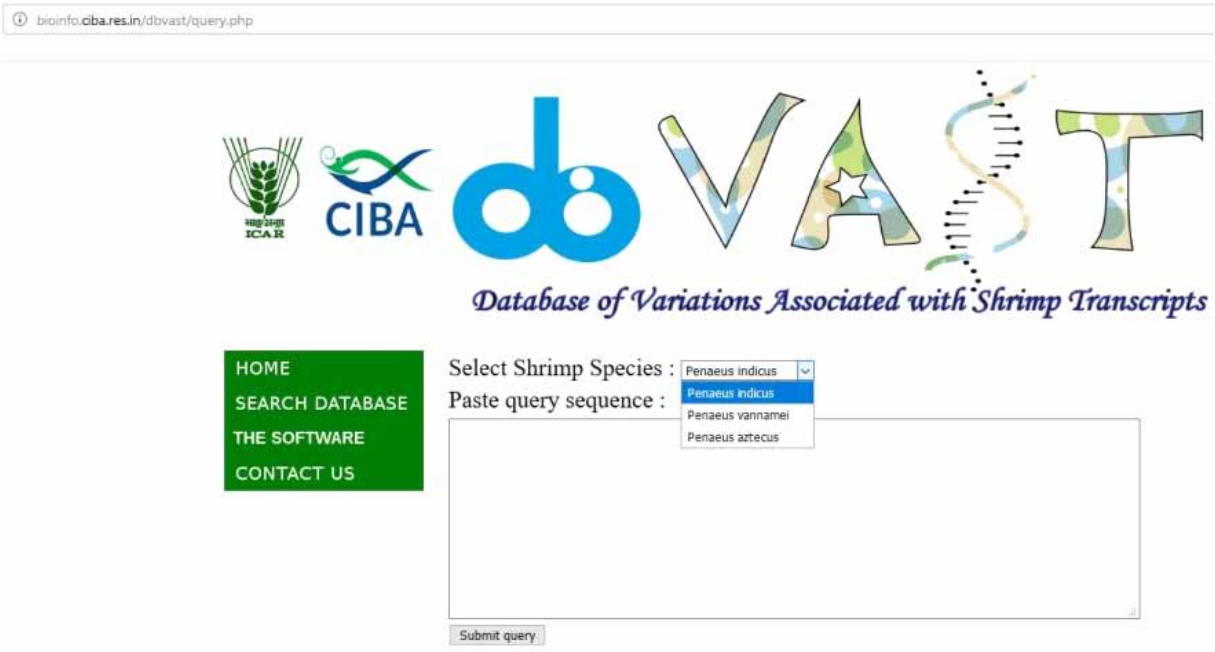
Busco statistics for six assemblies generated with Falcon, Canu and WTDBG2.

DBVAST: DATABASE OF VARIATIONS ASSOCIATED WITH SHRIMP TRANSCRIPTS

Farmed shrimp are an important export commodity for foreign exchange earnings in several coastal countries across the world. The shrimp constitutes one of the important aquaculture commodities which contribute significantly to human food consumption . Though genetic improvement programmes are in operation since two decades, the genomic resources that help in augmenting culture production are scanty. For example the Single Nucleotide Polymorphisms (SNPs) in coding sequences that could become potential selection criterion in selection programs are not yet documented. Therefore either by utilizing the datasets available at Genbank or the datasets generated at ICAR-CIBA, we have documented SNPs in annotated transcripts of three important shrimp species, *Penaeus vannamei, Penaeus indicus* and *Penaeus aztecus* and presented them for browsing as an on-line application in a friendly manner.

For *P. indicus*, the RNAseq reads SRX4808137, SRX4808138 and SRX4808143 were used for building reference transcripts. Whereas for *P. vannamei* and *P. aztecus*, the RNAseq data of *P. vannamei* obtained from GenBank, SRX3556257 and SRX3556279 was used to build reference transcripts. First, the good quality reads obtained after quality control with Trimmomatic V0.36 were assembled *de novo* in Trinity v2.3.2 to generate transcripts. Later, CD-HIT version 4.6 was used to cluster transcripts that were similar by more than 95% which were then annotated in Blast2GO v4.1.9.

Then pooled RNAseq datasets (SRX4808140, SRX4808141 and SRX4808142 for *P. indicus*; SRX1870278 for *P. vannamei*; SRX1871046 for P. aztecus) were utilized to document SNP variations against reference transcripts. The good quality reads of pooled-samples were aligned on to annotated transcripts using bowtie2 v2.3.2 to generate a sequence alignment map (SAM) file which is converted to binary alignment map (BAM) file and then sorted using samtools-1.2. Then a pileup was generated for sorted bam file using samtools-1.2 which is then piped to bcftools-1.3.1 to generate variant call format (VCF) file. The SNP variations that satisfy the following criteria were then extracted from



A screen shot of dbVAST tool.

VCF file, a) the raw read depth at SNP site is ≥ 10; b) both the reference and alternate alleles are supported by at least 5 reads; and c) the phred-scaled quality score for the assertion made in alternate allele is ≥ 20.

The data of blast and SNP statistics of the transcripts were loaded in to relational database as separate tables using MySQL ver. 5.5.24 database management system installed on debian server. A database retrieval system has been developed using PHP scripting language embedded into HTML pages as a web-tool, dbVAST. The database is presented as a user-friendly on-line tool, where users are required to select a shrimp species and submit a query sequence of interest (Figure 1). Input query would be searched against annotated transcripts of the database using blastn algorithm to find the most similar transcript. If the search gets a hit in the database, then the sequence of the most similar transcript along with its blast and SNP statistics would be retrieved from the corresponding data tables and displayed on the screen.

MRF: MISSING REGION FINDER

The white spot syndrome virus (WSSV) continues to be the major pathogen that has potential to inflict mass mortalities of shrimp during culture. Though first reported in 1995 and genome fully deciphered in 2001 (Feng Yang et al 2001), the WSSV is a difficult pathogen to contain in culture environments. The genome sequence of this virus does not show similarity to any other pathogen and this has severely limited the annotation of WSSV genomes. Therefore WSSV alone was aptly placed in a new Genus *Whispovirus* under Family *Nimaviridae*. Unique sequence coupled with circular nature of genome lead to difficulty in annotating the genome features of this virus. Except for few features all the other coding sequences (CDS) were annotated serially with a common prefix like WSSV (AF440570), wsv (AF332093), ORF (MF768985) etc. in the order in which they were assembled and submitted as linear sequence at GenBank. As the annotation nomenclature varies across genomes, the results inferred on a WSSV genome could not be easily comparable to other genomes. This has remained a grey area in comparative genomics studies of WSSV isolates. For example a CDS is annotated as wsv162 in AF332093, WSSV218 in AF440570, hypothetical protein in KT995472, KT995470 and KU216744, ribonucleotide reductase large subunit in KT995471, wsv161 in KY827813, orf90 in AF369029 and orf215 in MF768985.

Another issue of concern is very high similarity in sequence of WSSV isolates where complete genome sequence is available. In this case, traditional similarity-based methods estimate about 99% identity among isolates of WSSV. Despite high similarity, WSSV exhibits considerable variation in genome size from 280591 bp (MG702567) to 314232 bp (MG264599). In addition to variations in common sequence features, the CDS missing in some isolates might be correlated to some property of the virus and needs to be documented.

The need to study the deleted regions and to sort the nomenclature issue has motivated us to develop a tool that could compare two genomes of interest, one as reference and another as query and find the deletions (complete and partial) in query genome with respect to the reference genome. The deletions could be miniscule or regions stretching up to several kb. Then mapping of the deleted regions to generic feature format version 3 (gff3) table of the reference genome missing CDS in query genome could be fetched. Such a tool has potential to sort the nomenclature issue concerning WSSV genomes, as users can compare several genomes against a single reference genome. In such case, findings of comparative genome analysis in the annotation nomenclature of a single reference would be easily comprehensible.



A screen-shot of MRF tool.

In this study, we developed a new tool, Missing Region Finder (MRF) and demonstrated its utility to gain insights about WSSV genomes. Main purpose of developing the MRF tool is to compare a query genome against a reference genome and find deleted genome regions in query and tabulate the CDS in these deleted regions as per the annotations of reference genome. This is achieved in two stages. First, the genomic regions that are missing in the query compared to reference are identified and their coordinates are mapped. Next, using gff3 table of the reference genome, the CDS present in missing regions of query genome are tabulated. The tool is made available to all users in a web based online platform. The back end of the tool was implemented in a perl program, which reads the input files from the user and computes the missing regions in the query genome. The graphic user interface (GUI) was implemented using PHP and HTML, with stYles rendered by CSS.

PHYLOGENOMICS OF SHRIMP IN SUBORDER, DENDROBRANCHIATA

The controversy surrounding the taxonomy of penaeid shrimp is well known. Researchers across the globe were divided on the taxonomic revision in Genus *Penaeus* sensu lato where six new genera were created. The Food and Agriculture Organization (FAO) which is the repository for aquaculture statistics still uses old genus names. Many stakeholders related to trade, policy matters etc. are often confused as some researchers are using old genus names and others prefer to use new genus names. To address this issue, earlier we had conducted maximum likelihood and Bayesian phylogenetic inferences on complete mitochondrial genome sequences which indicated monophyly of *Penaeus* sensu lato. This year, average aminoacid identity (AAI) which indicates genome-wide similarity was estimated between all the species in each genus of order, Decapoda. The genera where complete mitochondrial genome sequence is available for at least 2 species were considered. The comparison of AAI estimates in order Decapoda with the estimates among species of *Penaeus* sensu lato would throw additional evidence for splitting or retaining the single genus *Penaeus*. Overall for 162 species belonging to 45 genera in order Decapoda, 405 AAI estimates were obtained in this study. The arithmetic mean and median of these estimates is 88.86 and 88.57 respectively. In *Penaeus* sensu lato, 45 AAI estimates were obtained among 10 species. The arithmetic mean and median of these 45 estimates is 93.92 and 93.37 respectively. Both these averages in Penaeus s.l. are higher than

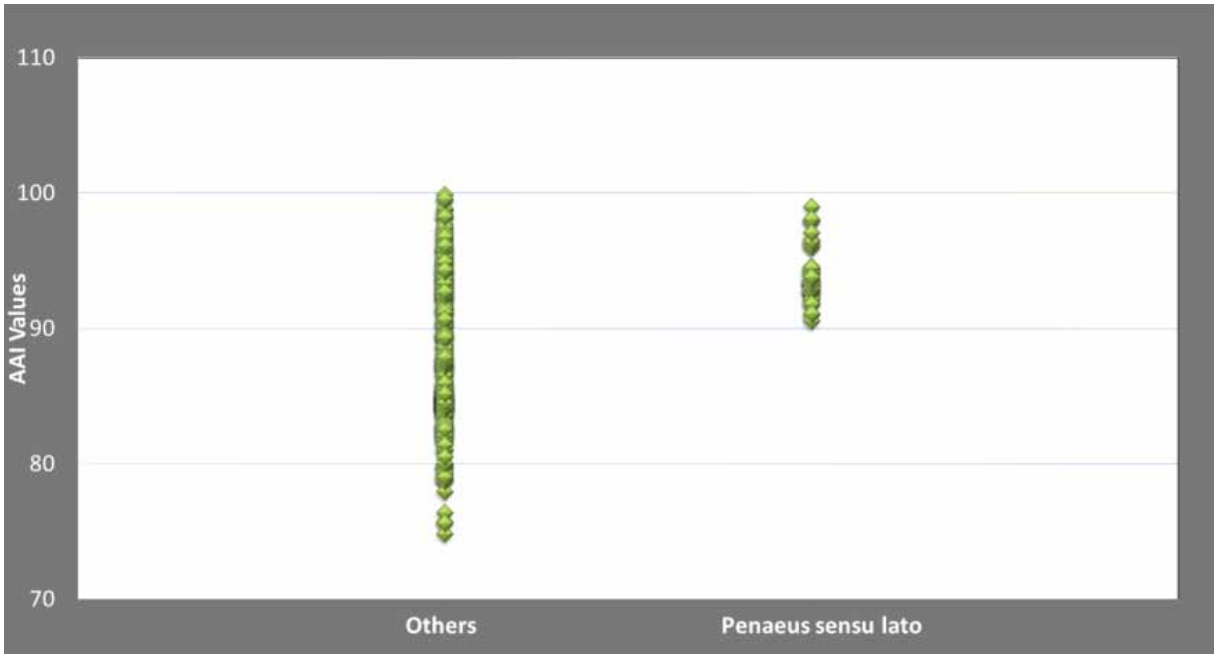
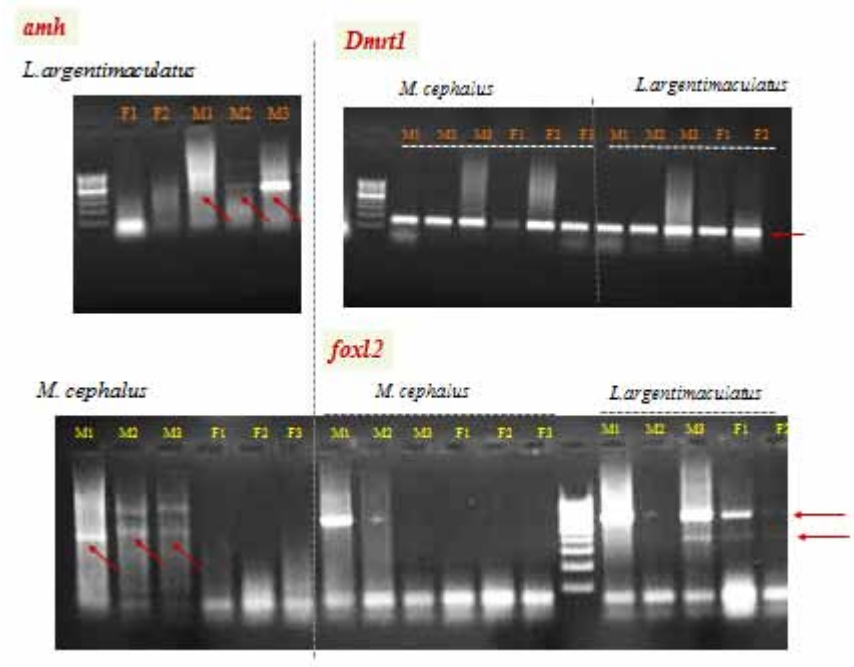


Figure 4. The plot of AAI estimates obtained between species of Penaeus sensu lato and between species of all other genera in order Decapoda.

that obtained for species in Order, Decapoda. All the AAI estimates obtained among species of *Penaeus* s.l. are higher than the average estimate obtained among species in Order, Decapoda. Though there are no set standard values for AAI estimates to fix different species in a genus, it is expected that the species of same genus have high AAI estimates. When it comes to shrimps of Penaeus s.l., the AAI estimates are all above 90% (Figure 4). With such high estimates of AAI among them, these species qualify to be kept under one genus. The AAI estimates did not support polyphyletic status for Penaeus sensu lato and suggest restoration of old nomenclature.



Expression of sex related genes in M. cephalus and L. argentimaculatus

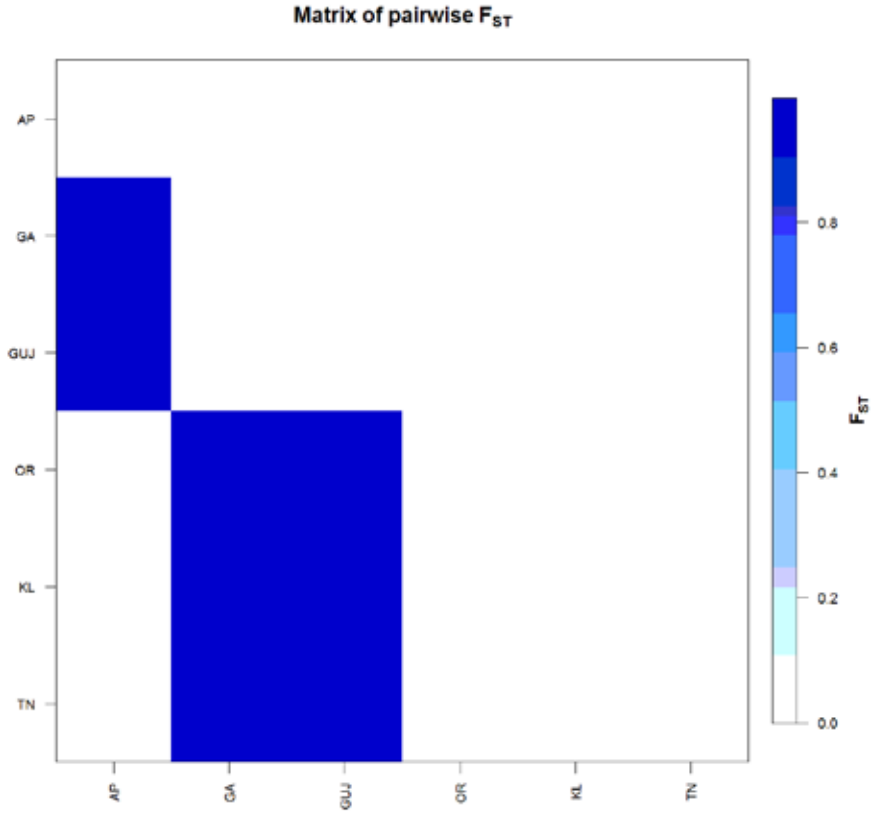
SEX DISCRIMINATION IN FISH

Discriminating sex in most of the commercially important brackishwater finfishes are difficult as no easily identifiable morphological difference exits between the sexes. In the absence of sexual dimorphism, identifying the sex markers was attempted in grey mullet, *Mugil cephalus* and red snapper, *Lutjanus argentimaculatus*. The expression of sex specific markers reported in other fishes namely doublesex and

mab-3 related transcription factor 1 (*dmrt1*), forkhead box L2 (*foxl2*) and anti-mullerian hormone (*amh*) were analysed using genomic DNA. The results indicated male specific expression for *amh*, while both *dmrt1* and *foxl2* exhibited strong expression in both males and female fish, suggesting the possibility of using *amh* as markers for sex discrimination in fish.

POPULATION STRUCTURE OF GREY MULLET, *MUGIL CEPHALUS*

The flathead grey mullet (*Mugil cephalus*), the most widespread mugilid species, inhabits estuarine, intertidal, freshwater and coastal marine habitats and forms commercial and subsistence fisheries in many parts of the world (FAO, 2000). Knowledge on the genetic structure of fish populations is important for the development of management and conservation strategies. The genetic diversity and population structure of *M. cephalus* along the Indian coast was examined with a 842bp segment of ATPase 6/8 gene of mitochondrial genome. Samples of M. cephalus were collected from 6 locations along the Indian coast namely Puri (12), Nagayalanka (16), Chennai (13), Fort Vypin (12), Goa (10) and Gujarat (10). The genetic identification of the species was confirmed using mitochondrial gene CO1. ATPase 6/8 gene was amplified by PCR using universal Primers. The pair-wise FST values indicated the presence of two distinct stocks along the Indian coast, one between Odisha and Kerala and the other between (Goa and Gujarat). A total of 13 haplotypes were identified among the samples analysed. The highest nucleotide diversity was observed in Goa stocks.



The pair wise FST matrix between different stocks of Mugil cephalus

ESTABLISHMENT OF PEARLSPOT FULL-SIB FAMILIES AND THEIR GROWTH PERFORMANCE

To fulfil the increasing demands for fish as food, progress must occur towards greater aquaculture productivity. The first step towards increasing the productivity would be to produce genetically improved fish varieties. Here we established two pealspot full-sib families on experimental basis to record the growth parameters which would be useful for selection.

Adult Pearlspot fish were grown in FRP tanks for breeding. Two pairs were identified and transferred to two different FRP tanks. After spawning, the larvae were cultured in the tanks to develop them into fries till 60th day. Meantime, hapas (1mX2m) were placed in the lagoon and it was surrounded by crab fencing net (Fig.1) to avoid the entry of crabs and to protect the hapas from crab bite. The two full sib fries were then stocked in different hapas to culture them at Muttukadu lagoon. At the time of stocking the P^H and the salinity of the lagoon were 7.47 and 38PPT. The total body length and body weight of both the families were recorded and are presented in Table1. Coefficient of variation (CV) was higher for body weight than the total body length in both the families. Higher the CV indicates higher the variance exists among the individuals in the family which will facilitate to carry out selection among them efficiently.

Growth parameters of pearlspot stocked in lagoon

Growth parameters		Family1	Family2
Total body length	Mean on the day of stocking (cm)	2.1 to 3.3 (60th day post hatch)	1.2 to 2.0 (40th day of post hatch)
	Mean on 30th day of stocking (cm)	5.64±0.08	5.59±0.12
	Coefficient of variation (%)	6.5	8.4
Body weight	Mean on the day of stocking (cm)	0.9-2.1	0.7-1.8
	Mean on 30th day of stocking (cm)	4.7±0.2	4.3±0.25
	Coefficient of variation (%)	19.4	23.2

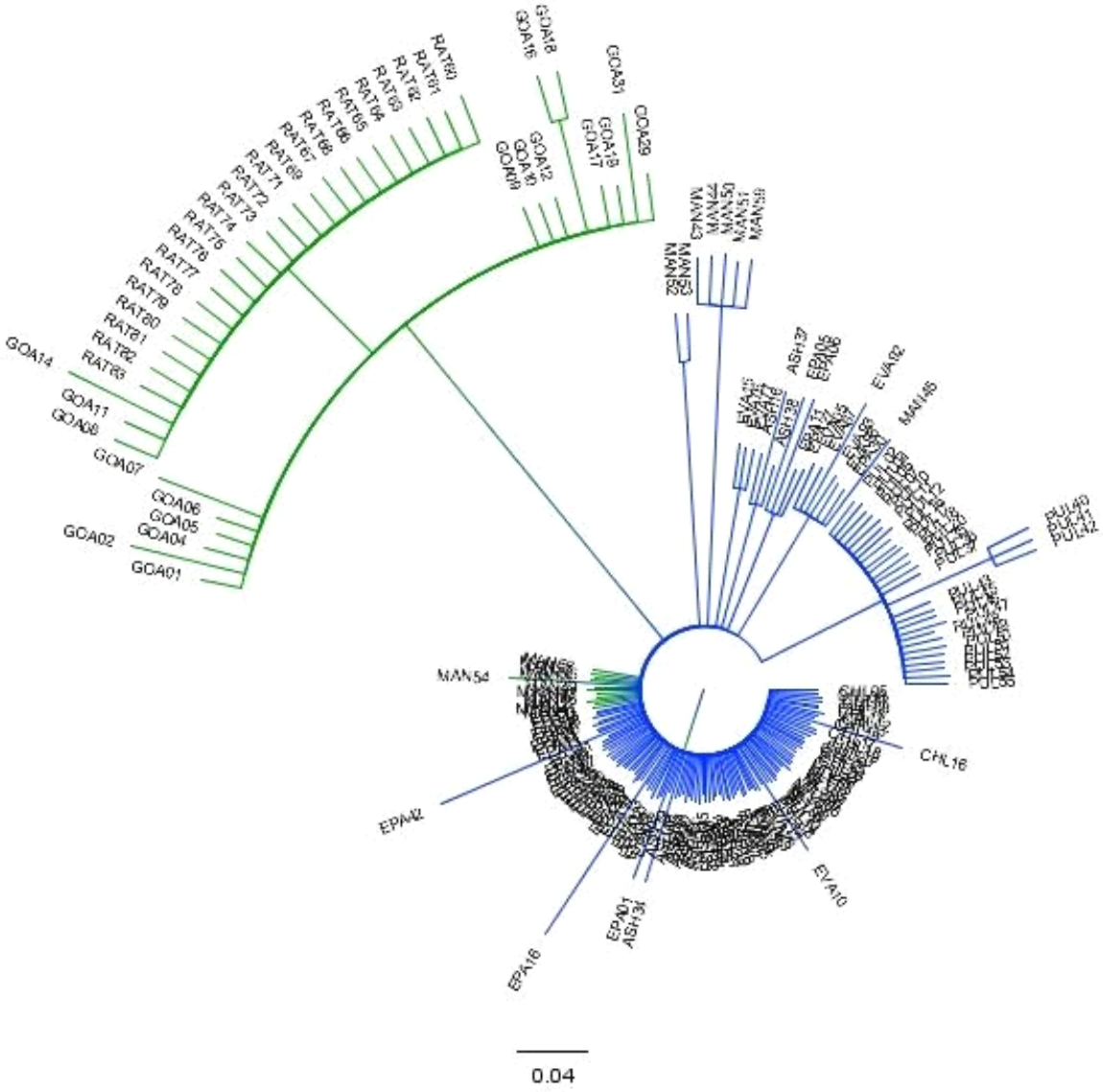


Full-sib families pearlspot cultured in hapas

POPULATION GENETIC STRUCTURE AND HISTORICAL DEMOGRAPHY OF PEARLSPOT FISH IN INDIAN WATERS

Etroplus suratensis (Bloch 1790) commonly known as pearlspot is the largest among the Etroplus species and distributed in the lagoons, brackishwater and backwater environment of southern peninsular India and Sri Lanka. It fetches higher price not only as a food fish but an ornamental fish too due to its delicacy and attractive coloration. Study on population genetic structure of the fish would be useful on conservation of intra-species diversity.

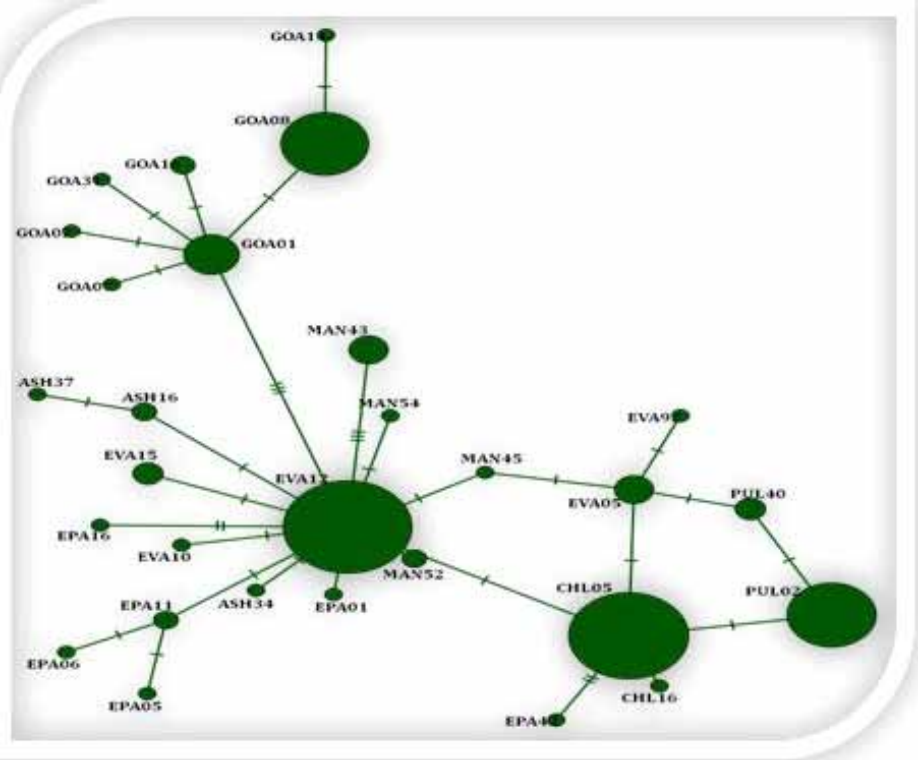
Sixteen tissue samples of *Etroplus suratensis* were collected from Ashtamudi Lake. ATPase 6/8 gene was PCR amplified, sequenced and included with the previously available data and reanalysed. The data includes Chilika (19), Nagayalanka(10), Pulicat (32), Vellayani (17), Ashtamudi (24), Vembanad (40), Mangalore (19), Goa (19) and Ratnagiri (23). AMOVA and FST based genetic differentiation were estimated



Phylogenetic tree reconstructed by Mrbayes for E.suratensis stocks

using Arlequin3.5.2.2. Mantel test for isolation by distance was carried out using ade library of R 3.5.1. Phylogenetic tree was reconstructed by UPGMA method using Mega7.0 and by Mrbayes 3.2.2 The best evolutionary model for the sequences was selected Using Bayesian information criterion implemented in Partition finder. Haplotype network was generated using PopART1.7.

The samples exhibited 31 polymorphic sites which include 16 singleton and 15 parsimony informative sites. The total haplotypes were 29 with the diversity of 0.85. Significant genetic differentiation (FST=0.75; P<0.01) was observed among all the stocks. Non-significant genetic differentiation was observed only between Chilika and Nagayalanka stocks. ATPase 6/8 gene revealed monomorphic pattern in Nagayalanka stocks. Mantel test (r = 0.46 P=0.025) suggests that the isolation by distance is non-significant. However, the positive correlation suggests smaller the differences between the nearer stocks than the farther one. The UPGMA tree established two haplo-groups; one of them includes Ratnagiri and Goa stocks and the second one consists of all the others. Non-significant Tajima's D (-1.47) and Fu's F statistic (-14.89) revealed there is no change in population size in the recent past.



Minimum spanning Haplotype network for the haplotypes of E.suratensis stocks

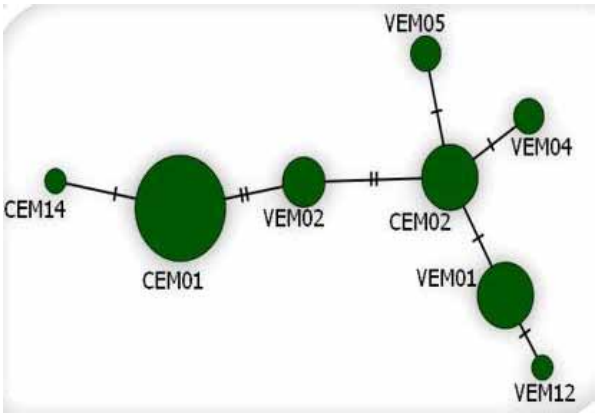
VEMPANAD AND PULICAT STOCKS OF ORANGE CHROMIDE (*ETROPLUS MACULATUS*)FISH ARE GENETICALLY DIVERGENT

Genetic diversity is the outcome of the evolutionary processes adapted by the species to the spatial and temporal environmental changes since its origin. Hence the studies on species diversity are of paramount important to the conservation programs. *Etroplus maculatus*, commonly known as Orange chromide is a euryhaline fish endemic to brackishwater streams, lagoons, estuaries and the lower reaches of rivers in peninsular India and SriLanka. It is mainly utilized as freshwater and brackishwater ornamental fish due to

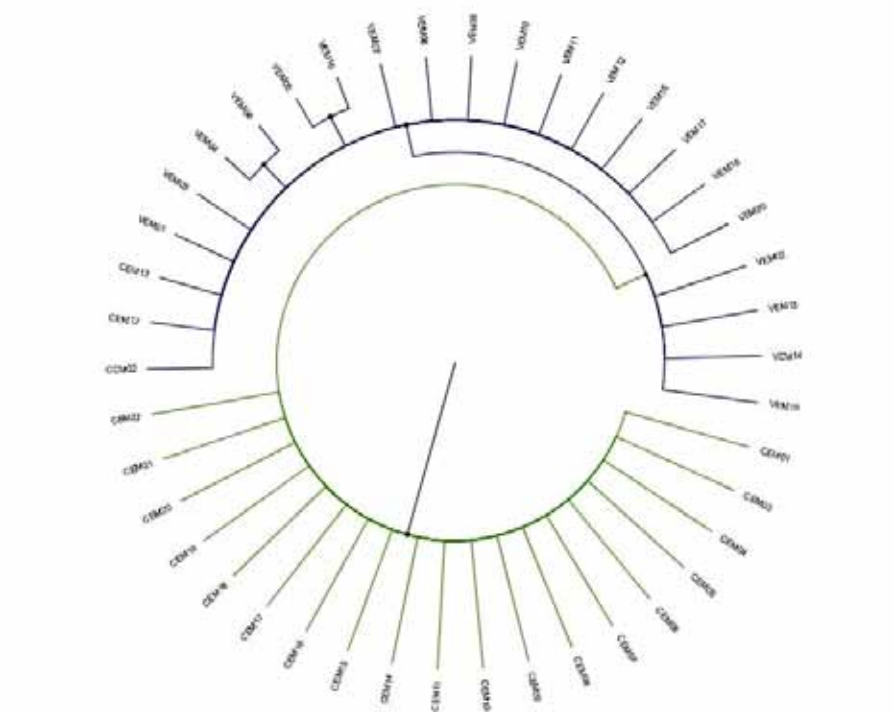
its attractive coloring pattern. The population genetic diversity of *Etroplus maculatus*, in southern Indian waters was studied.

Twenty samples each were collected from Pulicat (South-East) and Vempanad lake (South-West) coastal regions were utilised to study the genetic structure using an mtDNA gene ATPase 6/8. Haplotype and nucleotide diversity were generated by Dnasp6.0. Haplotype network was generated using PopART1.7 (Fig.4). AMOVA and FST based genetic differentiation were estimated using Arlequin3.5.2.2. Phylogenetic tree was re constructed by UPGMA method using Mega7.0 and by Mrbayes 3.2.2 (Fig.5). The best evolutionary model for the sequences was selected Using Bayesian information criterion implemented in Partition finder.

The sequences exhibited eight variable polymorphic sites which include one singleton and seven parsimony informative sites. The total haplotypes were eight with a diversity of 0.76. More and diversified haplotypes were found in Vempanad (six with the diversity of 0.82) compared to Pulicat stock (three with the diversity of 0.33). The phylogenetic tree constructed by both Bayesian and UPGMA methods revealed two separate clades. Non-significant Tajima's D (Pulicat:-0.63, Vembanad:-0.063), Fu's F statsitics (0.231) and bimodal mismatch distribution indicating stable population size historically. The genetic differentiation study (FST=0.42) imparted significant (P<0.001) difference between the stocks. The AMOVA revealed a variation of 42% between the populations and 58% within the populations.



Minimum spanning Haplotype network for the haplotypes of E.maculatus stocks



Phylogenetic tree reconstructed by Mrbayes for E.maculatus stocks

POPULATION GENETIC STRUCTURE OF INDIAN WHITE SHRIMP ACROSS INDIAN COAST USING MICROSATELLITE MARKERS

Indian white shrimp (*Peaneus indicus*) is one of the important commercial penaeid species. Studying the diversity pattern of the species is considered important. 155 individuals of *P.indicus* collected across Indian coast i.e. Chennai (49), Kanyakumari (09), Puri (37), Quilon (47) and Mangalore (13). Ten microsatellite loci were genotyped by fragment analysis method. The alleles and genotypes were generated using the Fragman package of R statistical tool. The genotypes were tested for null alleles using micro-checker. Due to the presence of null alleles and monomorphic pattern three loci data were not included and the study comprises of seven loci data only. The average number of alleles among the populations was 8.5 with a range from 5.4 (Kanyakumari) to 11.4 (Quilon). The mean observed heterozygosity ranged at sampled loci were high, ranging from 0.67 (Kanyakumari) to 0.76 (Puri). The analysis of molecular variance (AMOVA) revealed that 97% of the genetic variation was maintained within individual component, rather than shaped according to geographical regions. Pairwise FST (Table.2) (ranged from 0.01 to 0.053) estimates revealed Chennai and Quilon stocks differed significantly (P<0.01) with other stocks. However, Quilon did not differ from Mangalore stock. Bottleneck tests revealed all populations displayed a normal L shaped distribution in the mode-shift curve and the populations had no significant excess of heterozygosity for Wilcoxon's signed-rank test under the TPM model, which suggests the population did not undergo any reduction in the recent past. Mantel test indicated there was no significant correlation between genetic dissimilarity and geographic distance among populations (R= 0.0491; P =0.49). The above stock structure findings would be helpful in conservation and stock specific selective breeding.

Pairwise FST between the stocks

	Chennai (49)	Kanyakum (09)	Mangalor e (13)	Puri (37)	Quilon (47)
Chennai	--------				
Kanyakumar i	0.026**	----------			
Mangalore	0.050**	0.053*	--------		
Puri	0.347**	0.010^{ns}	0.011^{ns}	----------	
Quilon	0.011**	0.019*	0.010^{ns}	0.013**	----------

(**P<0.01; *P<0.05; ns-Non-Significant)

FIRST RECORD OF THE JAVANESE RICEFISH, *ORYZIAS JAVANICUS* (BLEEKER, 1854) (BELONIFORMES: ADRIANICHTHYIDAE) IN THE NATURAL WATERS OF INDIA

The distribution of *O. javanicus* (Fig. 1) in the natural waters of the Indian peninsula was confirmed for the first time from Muttukadu lagoon, Tamil Nadu, bringing the number of *Oryzias* species recorded from India to five (the others being, *O. dancena* (Hamilton, 1822), *O. melastigma* (McClelland, 1839) (currently in the synonymy of *O. dancena*), *O. carnaticus* (Jerdon, 1849), and the endemic *O. setnai* (Kulkarni, 1940).



Male (a) and female (b) Oryzias javanicus collected from the Muttukadu lagoon, India

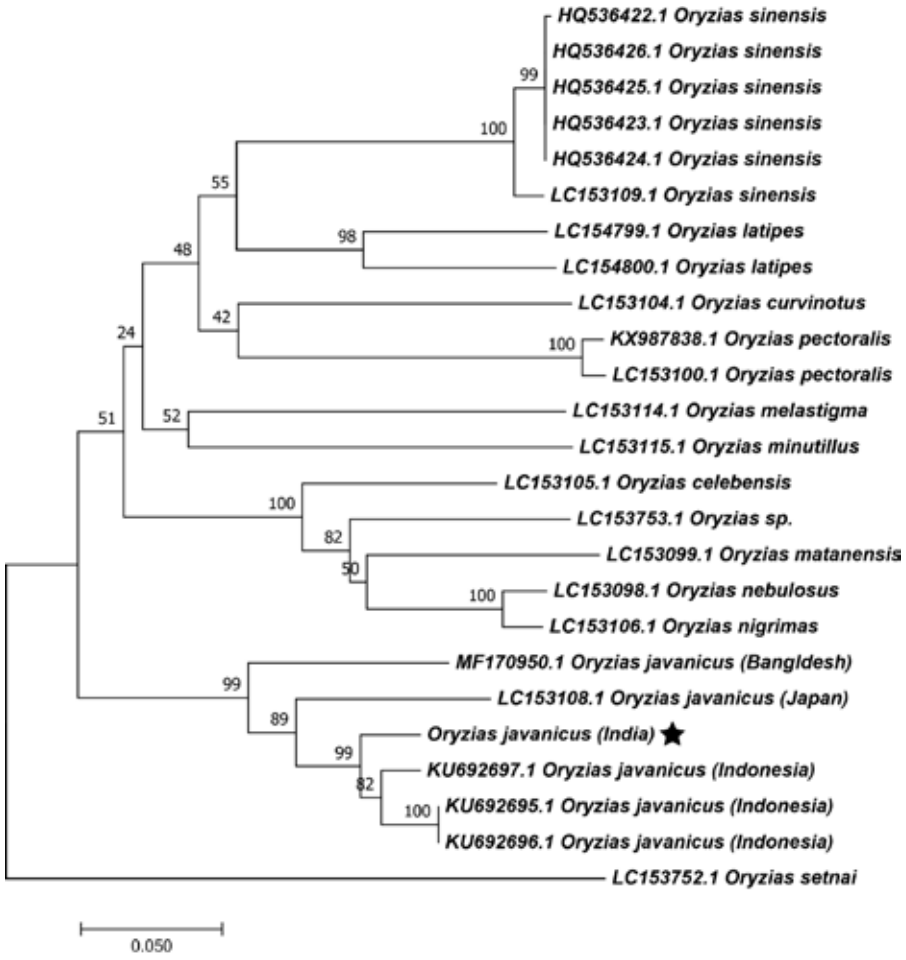
The species shows population-level variations in their meristic counts (Table 1). *Oryzias javanicus* is very similar to *O. dancena* and *O. carnaticus,* species that are native to the Indian subcontinent; *O. javanicus* can be easily distinguished from the Indian species, by the presence of yellowish sub-marginal bands on the dorsal and ventral sides of the caudal fin.

Comparison of meristic counts of *Oryzias javanicus*

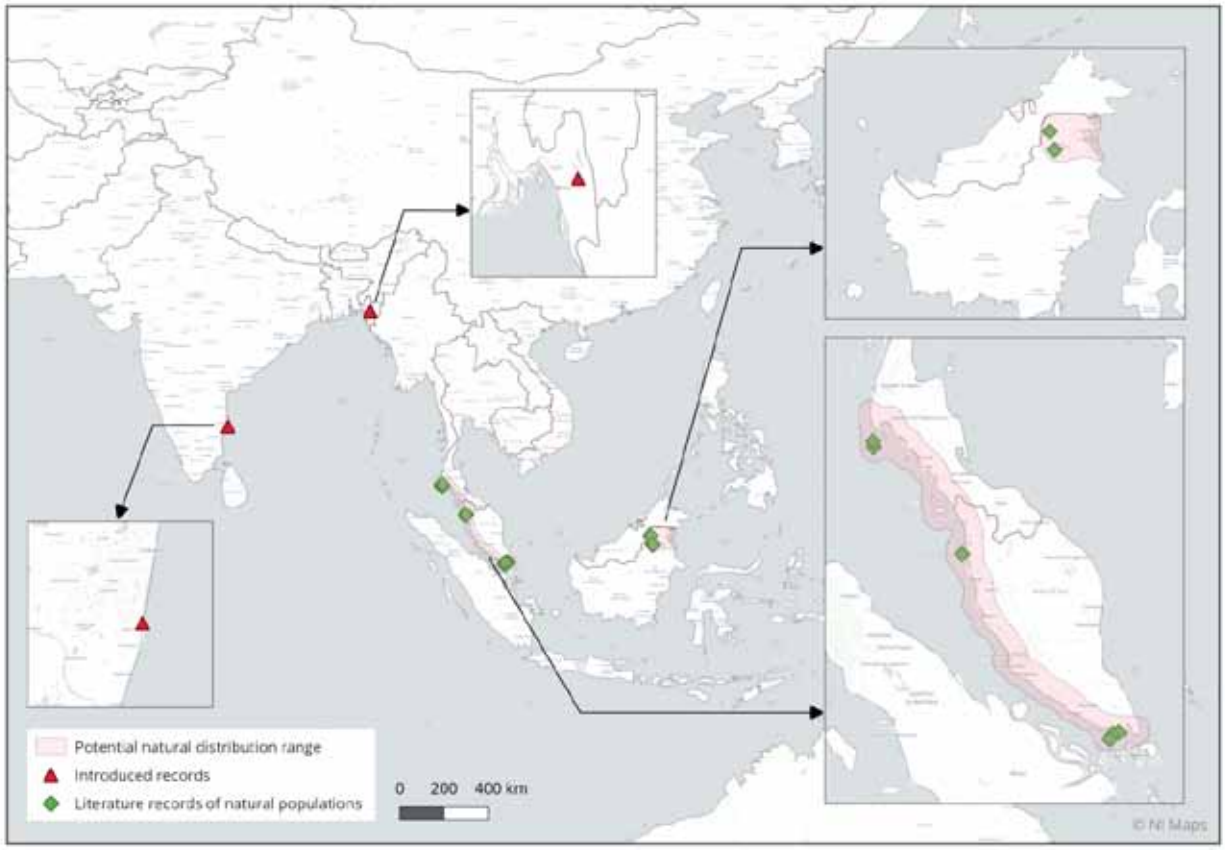
Meristic counts	Roberts (1998)	Parenti (2008)	Magtoon & Termvidchakorn (2009)	Yusof et. al., (2012)	Present study
Dorsal-fin rays	6-7	6-8	6-8	6	6
Anal-fin rays	21-25	18-25	22-26	21	20-21
Pelvic-fin rays	6	5-6	NA	6	6
Pectoral-fin rays	11	10-13	11-12	10-11	10-12
Principal caudal-fin rays[a]	5/6	i, 4/5, i	i, 4/5, i	i, 5/6, i	i, 4/5, i

Table adapted from Yusof et. al., (2012) with observations of the present study: [a] Rays of dorsal and ventral lobes are indicated separated by slash. Number of unbranched and branched rays is indicated by Roman and Arabic numerals, respectively.

The nucleotide genetic distance between the populations occurring in India and Indonesia was found to be indistinguishable, which showed the same evolutionary relatedness in neighbour-joining and maximum-likelihood analysis (Fig. 2)



Neighbour-joining tree based on mtDNA COI gene of different Oryzias species together with the sequence generated in the present study.



Map showing the native distribution range of Oryzias javanicus in South East Asia, and the new record from India

The water bodies around Muttukadu currently comprise the westernmost distribution range of this species (Fig. 3). The presence of considerable number of this species in the Muttukadu lagoon of ICAR-Central Institute of Brackishwater Aquaculture (CIBA), suggests that *O. javanicus* is well established in the present locality.

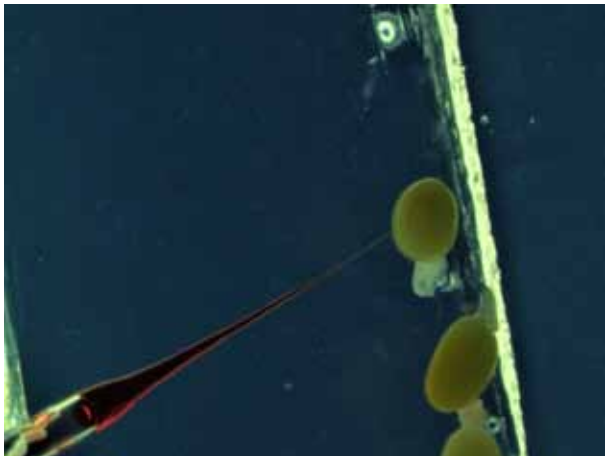
CRISPR-CAS9 MEDIATED GENOME ENGINEERING FOR GROWTH IMPROVEMENT OF *ETROPLUS SURATENSIS*

Currently, CRISPR/Cas9 is the most desirable tool for genome engineering. It efficiently introduces double-strand breaks (DSBs) in genomic DNA using cas9 and an appropriate guide RNA. For genome engineering, the myostatin gene of Etroplus suratensis has been characterized, and three different 20bp nucleotide sequences (target sequence) near to protospacer adjacent motif has been identified and synthesized. A standard PCR have done along with gene-specific oligos & constant oligonucleotide, to transcribe the target sequences into sgRNA using sp6 RNA polymerase enzyme. Three different stop codon cassette specific to each sgRNA were also designed and synthesized to include in CRISPR complex. 200ng/microliter sgRNA; 3 µM specific stop codon cassette, 600ng/microliter Cas9 Protein incubated at room temperature along with phenol red dye for 5 minutes to make CRISPR complex. About ten eggs of Etroplus suratensis were stacked one by one in an agarose gel, and each egg was injected with the injection mix @ 0.25µl using micromanipulator. Embryonic developmental stages and mortality of the eggs and larvae were documented.





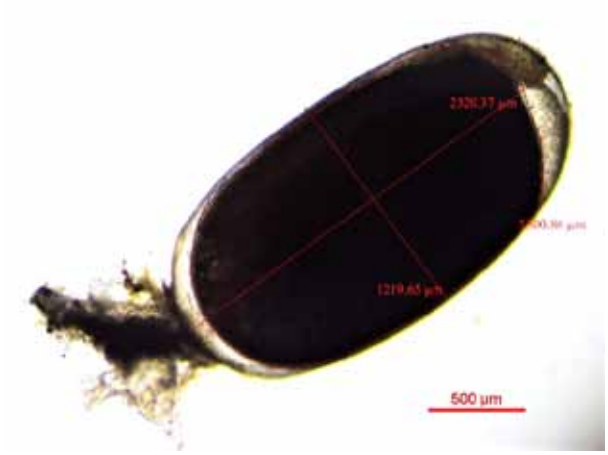
Etroplus suratensis breeding pair



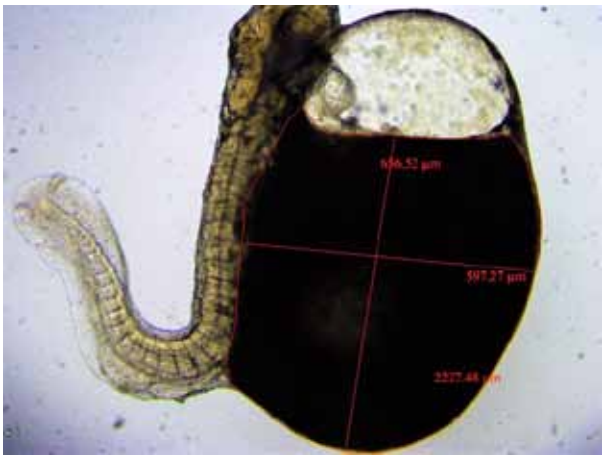
Microinjection



7hpf



24hpf



3dpf

AQUACULTURE ENVIRONMENT AND CLIMATE CHANGE

IMPLICATIONS OF TRENDS IN SURFACE WEATHER PARAMETERS FOR BRACKISHWATER AQUACULTURE

Trends in surface weather parameters with base line data obtained from IMD for the years starting from 1969 to 2009 for vulnerable coastal districts identified by ICAR-CRIDA have been analyzed. Coastal districts identified include Surat in Gujarat, Alappuzha in Kerala, Nagapattinam in Tamil Nadu, West Godavari in Andhra Pradesh and 24 Paraganas in West Bengal. Annual and seasonal trends for maximum temperature, minimum temperature, amount of rainfall and number of rainy days have been projected. Analysis has been carried out using 'esd' library under R Stats environment.

Summary of trends in surface weather parameters for five coastal districts of India

Coastal district Weather parameter	West Godavari	Nagapattinam	Surat	Alapuzha	24 Paraganas
Annual					
MaxT					
MinT					
Precip					
Seasonal – MaxT					
Winter					
Summer					
Monsoon					
Post-Monsoon					
Seasonal – MinT					
Winter					
Summer					
Monsoon					
Post-Monsoon					
Seasonal – Precip					
Winter					
Summer					
Monsoon					
Post-Monsoon					
Rainy days					
• 1 mm					
• 3 mm					

Increase No trend Decrease

Increased trends were observed for maximum and minimum temperature for almost all the districts except for 24 Paraganas. The increased trends in maximum temperature will impact pond water salinity and DO levels, whereas increase in minimum temperatures would be beneficial to brackishwater aquaculture to certain extent during winter crop. There is a decline in total rainfall over the years which will impact water availability for the aquaculture. There have been negative trends observed for number of rainy days beyond 1mm and 3mm rainfall per day, indicating that the number of rainy days coming down over the years and maximum rainfall occurs in fewer days. This trend will cause sudden drop in salinity, DO, and temperature which in turn cause stress to animals and make them susceptible to diseases.

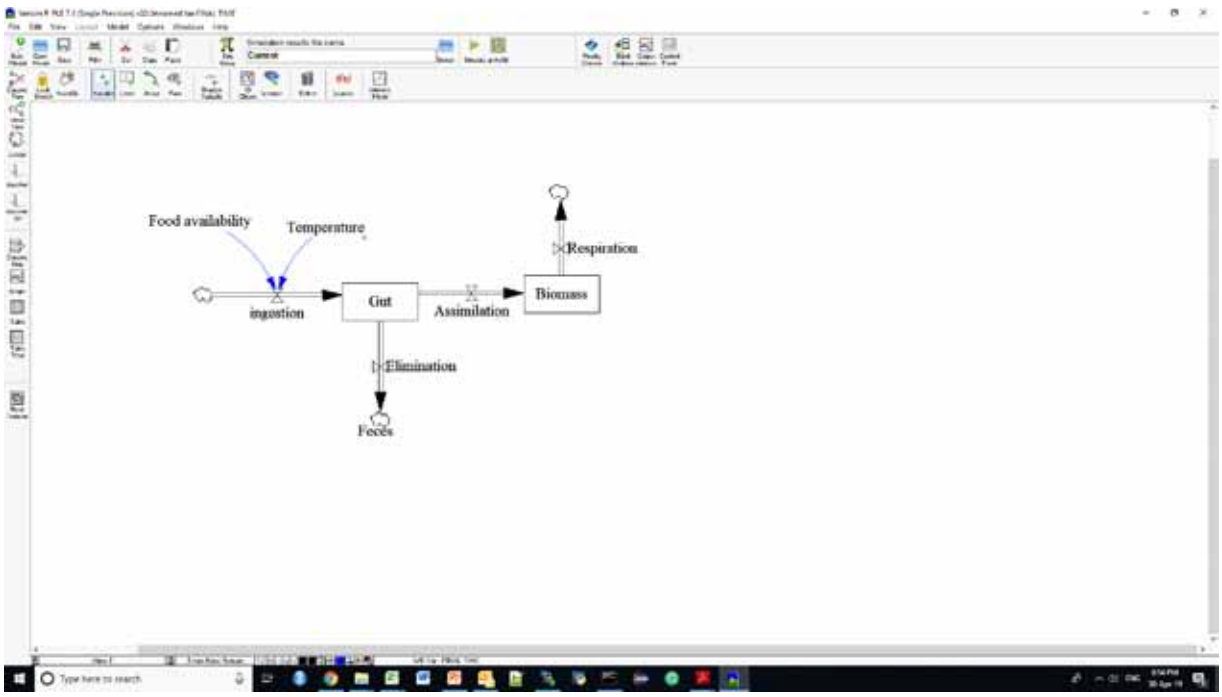
The annual average temperatures and total rainfall of base period were compared with multimodal climate change scenarios data obtained from IARI for RCP 4.5 of 2020s, 2050s and 2080s to project future values. Overall there has been around 2°C increase in the temperatures in 2080s compared to base period for all the districts under the study. There is a need to evaluate how these changes in surface weather parameters will actually impact brackishwater aquaculture through pond simulation models.

CHANGE IN CLIMATIC VARIABLES COMPARED TO BASE PERIOD.

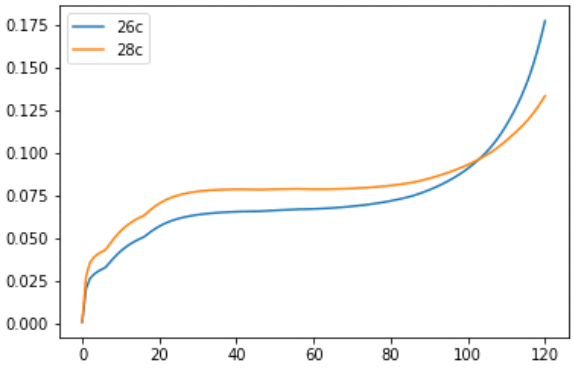
Coastal district	Weather parameter	Base period	2020s	2050s	2080s	Increase
West Godavari	tmax	32.63	33.29	33.94	34.35	1.72
	timin	23.26	24.06	24.75	25.17	1.91
	Rainfall	1126.7	1121.36	1161.97	1198.57	71.84
Nagapattinam	tmax	33.36	34.8	34.8	35.2	1.84
	timin	24.29	25.84	25.84	26.26	1.97
	Rainfall	1455.2	1555.25	1555.25	1613.65	158.4
Surat	tmax	33.09	33.89	34.68	35.15	2.06
	timin	20.99	22	22.89	23.38	2.39
	Rainfall	585.81	572.9	592.7	602.67	16.86
Alappuzha	tmax	29.6	30.42	31.06	31.46	1.86
	timin	20.53	21.44	22.12	22.53	2
	Rainfall	2927.8	2827.36	2915.96	2995.7	67.93
24 Paraganas	tmax	31.16	31.88	32.65	33.13	1.97
	timin	22.09	22.99	23.76	24.24	2.15
	Rainfall	1803.7	1806.77	1871.33	1919.26	115.6

SYSTEM DYNAMIC CLIMATE MODELS FOR SHRIMP AQUACULTURE

System dynamics models are simulation models to abstract individual processes involved in aquaculture through mathematical functions. The processes such as feed conversion, growth dynamics, biomass production, nitrogen dynamics, carbon dynamics and changes that affect growth of the animal due to several biotic and abiotic factors during shrimp culture period need to be captured in the model. Relational diagram was developed by considering all the processes involved in shrimp aquaculture. Different stock variables in the model include body weight, biomass, total N, plankton, microbial load, DO levels, salinity etc. In order to check the impact of temperature on gut content, a model involving feed ingestion, assimilation and elimination processes was constructed. Python module PySD and XMILE scripts are being used for building the models.



Sub process to estimate impact of temperature on gut content.



Impact of gut contents on dry weight basis due to changes in water temperature

DAMAGE TO SHRIMP FARMS DUE TO CYCLONIC STORM GAJA

The Cyclonic storm Gaja which had a land fall during the early hours of 17th November, 2018 and its associated floods have made substantial damage to shrimp farming area of approximately 1926 ha in Nagapattinam, Thanjavur, and Pattukottai districts of Tamil Nadu. About 50-60% of the farming area had a standing stock in the four districts and the crops were in the duration of 70-90 days. The average size of shrimps in the pond during the extreme event was 10-12 g. About 90% of the shrimp farms in the affected area were small and marginal to the tune of 2-3 ha. The wind speed of 120-140 kmph damaged the infrastructure (breach of farm bunds, store sheds, electrical lines, aerators, motors, pumps. etc) in the shrimp farms. In about 20% of the affected areas, the shrimp farms were in the low lying area and were totally inundated, shrimps escaped from the ponds and loss of production and infrastructure was 100% for those shrimp farmers. Many farmers were forced to go for distress harvests due to lack of electricity for providing aeration and disease outbreaks in the standing crop due to poor weather conditions and water quality deteriorations. The loss assessed by the State Fisheries Department was Rs. 711 lakhs, much less than the actual assessed damage. Farmers are demanding for separate relief package for shrimp farming to rebuild the farms and take up the farming in the coming season, a comprehensive insurance scheme to be developed and implemented for shrimp farming and support with an institutional credit scheme with a low interest rate to redevelop the infrastructure.



A



B



C



D

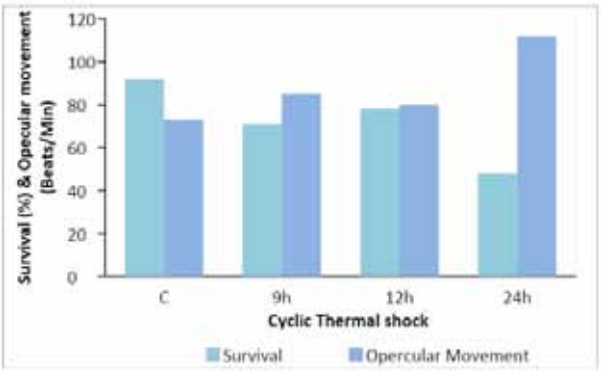
Gaja cyclonic storm damage to A. Electrical transformer B. Farm shed and aerators C. Pond dykes and D. Loss of stock due to power failure and water quality deterioration

EFFECT OF DIURNAL THERMAL SHOCK ON SEABASS JUVENILES

In the aim to mimic effect of heat waves shock *in vivo*, heaters were assembled in the fabricated environmental manipulation unit with automatic electronic timers. A 15 days experiment was conducted where diurnal heat shock (34°C) of different durations i.e. Control (RT), 9h, 12h and 24h (chronic) generated to assess the sea bass (TL - 7.5 cm; average body weight - 5.5 g) response towards cyclic heat shock versus chronic heat shock. It was found that seabass is more sensitive towards daily 9h heat wave, as survival (71%) was significantly less than 12h group. As a sign of heat sensitivity, seabass fry performed more opercular beating (85 beats/min) in 9h group compared to 12h group (80 beats/min), may be due to increased physiological need for oxygen under thermal stress. It is evident that sea bass is more stressed when 9h shock is given as it has less time to adapt physiologically. Minimum survival (48 %) and maximum opercular movement (112 beats/min) were found in 24h (chronic) heat shock. This study confirms elimination of agro-climatic zones having average water temperature of 34°C for more than 9 hours daily during summer months, as a nursery rearing area for seabass.



Automation in insitu environmental manipulation unit with electronic timers



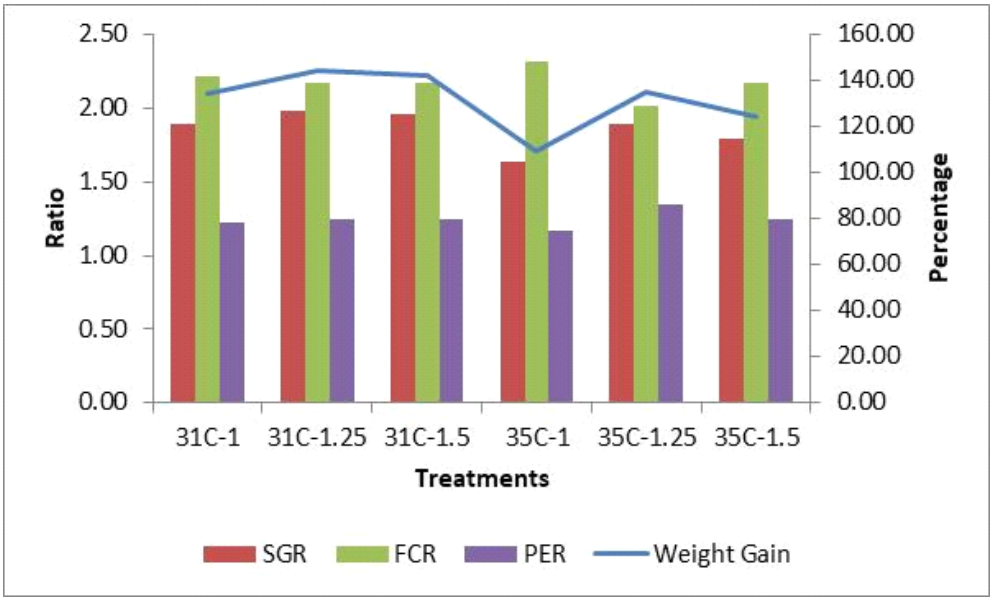
Survival and opercular movement of Seabass exposed to heat wave shock

EFFECT OF SUPPLEMENTATION OF PHOSPHOLIPID, SOYLECITHIN FOR AMELIORATION OF TEMPERATURE STRESS IN *P. VANNAMEI*

In our earlier studies on the effect of temperature on growth and nutrient utilization at 29, 31, 33 and 35 ^{0}C in *P. vannamei,* better survival and growth was observed between 31 and 33 ^{0}C. Yard experiments were carried out to study the effect of supplementation of higher level of phospholipid, soylecithin at 31 and 35 oC. Three experimental diets were prepared with varying levels of lecithin viz., 1, 1.25 and 1.50% and tested in the juveniles (2.62±0.12 g) of *P.vannamei* in a 45 day feeding trial. The supplementation of 25% higher lecithin has improved the weight gain (%) from 134.2 in control to 144.03 at 31 ^{o}C. At 35 ^{o}C, the weight gain values were 109.0 and 134.9 at 1 and 1.25% lecithin inclusion, indicating better improvement at 35 ^{o}C. The increase of lecithin level beyond 1.25% has shown negative effect at both 31 and 35 ^{o}C.

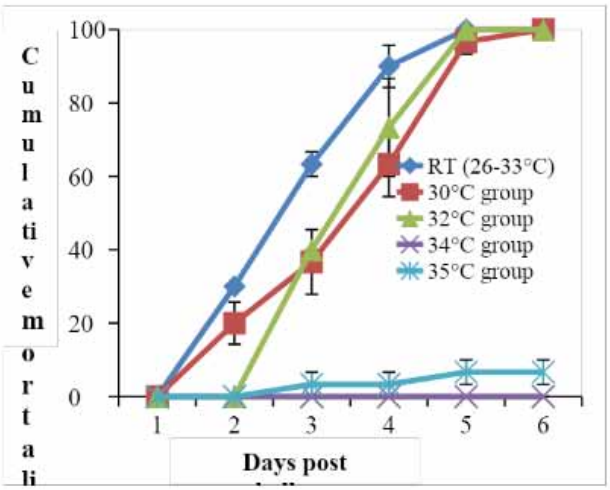
EFFECT OF REARING TEMPERATURE ON WSSV OUTBREAK IN SHRIMP

Regular monitoring for environmental parameters and pathogenic agents was carried out in two *P.vannamei* cultured shrimp farms in Pazhaverkadu area, Thiruvallur District. During the study period of 98 days of culture, the farm management kept environmental parameters ideal for farming and no pathogens were detected. In the month of November 2018, the region experienced heavy rain fall due to the cyclonic effect causing drop in water temperature (from 28-31 °C to 21-22 °C) and salinity. As a result, the shrimp farms in the region experienced WSSV outbreak resulting high mortality of the farmed shrimp. Customised environmental parameter controlled fish/shrimp rearing system was fabricated for studying the fluctuations in temperature and salinity on disease occurrence. P.vannamei were maintained in five groups, room temperature (26-33 °C), 30, 32, 34 and 35 °C for seven days and were challenged with WSSV (107 copies/L) for two hours by immersion



Effect of soylecithin supplementation for amelioration of temperature stress in P. vannamei



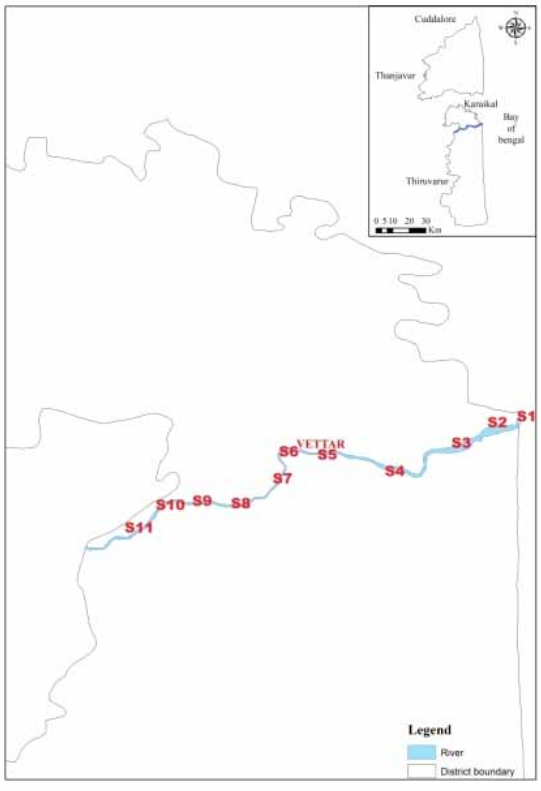


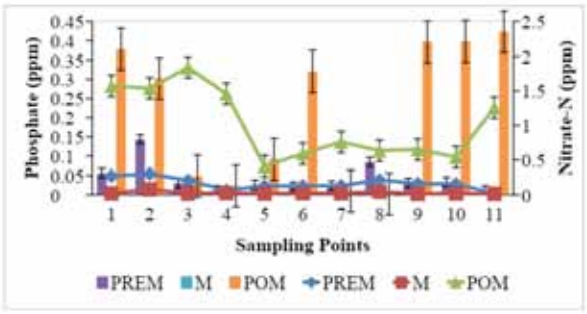
Influence of water temperature on shrimp mortality

and maintained at the respective temperature group to assess the infectivity and mortality rate. Shrimp in room temperature (RT), 30, and 32 °C experienced 100% mortality within 6 days post challenge and the dead/moribund shrimps tested 1st step positive by PCR. The shrimps reared in 34 and 35 °C experienced 0% and 7% mortality respectively and both were 2nd step positive. The study confirms the role of temperature on WSSV infectivity and mass mortality. Further study on the effect of diurnal variation in temperature and heat wave shock on disease outbreak will provide detailed insight into the role of weather parameters and climate change in induction of WSSV outbreak in shrimp farms.

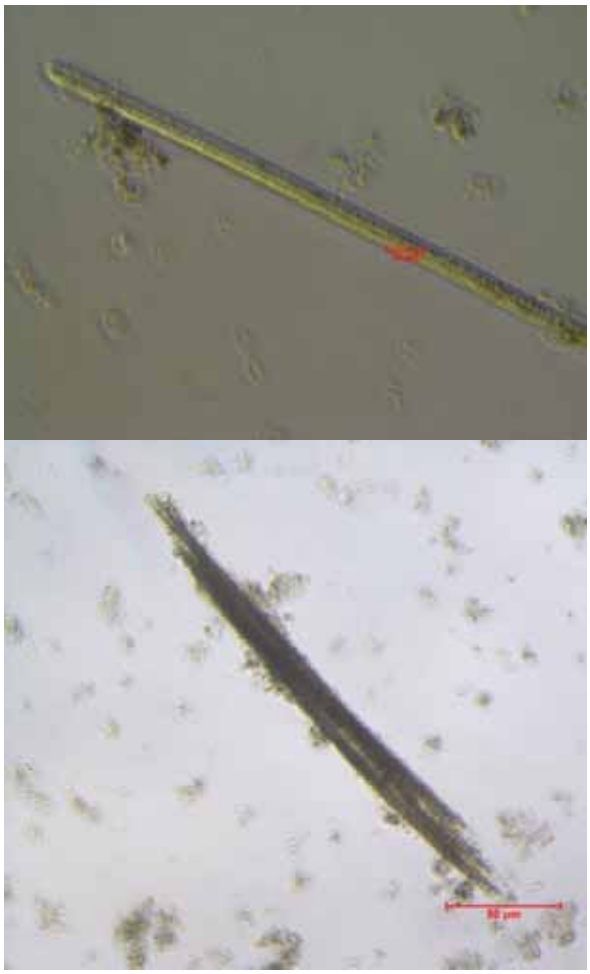
EFFECT OF SEASONAL CHANGES ON WATER QUALITY PARAMETERS AND CARRYING CAPACITY OF VETTAR ESTUARY

Water samples were collected from 11 different sites in Vettar Estuary, Nagapattinam District, Tamil Nadu during pre-monsoon, monsoon and post-monsoon to assess the seasonal changes on water quality and its carrying capacity. The salinity and pH ranged from 30-44, 8-30 and 32-54 ppt and 7.3-8.3, 6.9-7.5 and 7.5 – 8.1 during pre-monsoon, monsoon and post-monsoon, respectively. The eutrophic nutrients such as nitrate and phosphate were found to be highest during post-monsoon (0.955 and 0.218 ppm) followed by pre-monsoon (0.164 and 0.039 ppm) and monsoon season (0.0.029 and 0.016 ppm). Phytoplankton dominance also varied with the season. *Oscillatoria* sp was dominant during post monsoon and *Trichodesmium* sp was found to be dominant during pre-monsoon. The carrying capacity based on nutrients loading was found to be highest during the monsoon season with 133





Effect of seasonal changes on nutrients concentration of Vettar Estuary

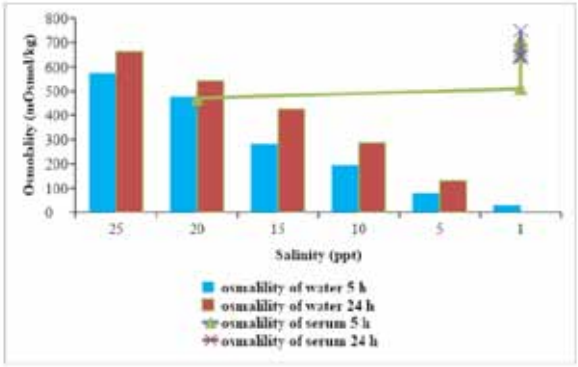


Dominant plankton species A. Oscillatoria sp. during post-monsoon and B. Trichodesmium sp. during pre-monsoon

kg/day followed by pre-monsoon (83 kg/day) and least during post-monsoon (64 kg/day). Nitrogen concentration was high during monsoon and pre-monsoon and during post monsoon season phosphate was the limiting nutrient which reduced the carrying capacity due to inflow of phosphate form the watershed area after the monsoon runoff.

ADAPTATION OF *P.VANNAMEI* TO CLIMATE CHANGE INDUCED SALINITY VARIATION

During extreme climatic events like flood, the salinity of shrimp pond water decreases sharply. To study the adaptation of *P.vannamei* under such sudden changes, the salinity of the water was reduced from 25 ppt to 20, 15, 10, 5 and 1 ppt in the yard experiment and the water and hemolymph were collected at 5 and 24 hours. Under the salinity variation of 25 to 5 ppt, water osmolality varied from 78-475 and 130-542 mOsmol/kg at 5 and 24 h respectively, whereas serum osmolality varied within a short range of 510-687 mOsmol/kg at 5 h and further narrowed and stabilized (639-665 mOsmol/kg) at 24 h. Shrimp survival was 95 % upto 5 ppt, only 20% in 1 ppt at 5 h and 0% at 24 h. Although *P.vannamei* is able to adapt quickly to changes in salinity due to its osmoregulatory capacity, it is unable to withstand the drastic change in salinity from 25 to 1 ppt. However, *P.vannamei* survived well even in < 1 ppt stable salinity in field and yard studies.

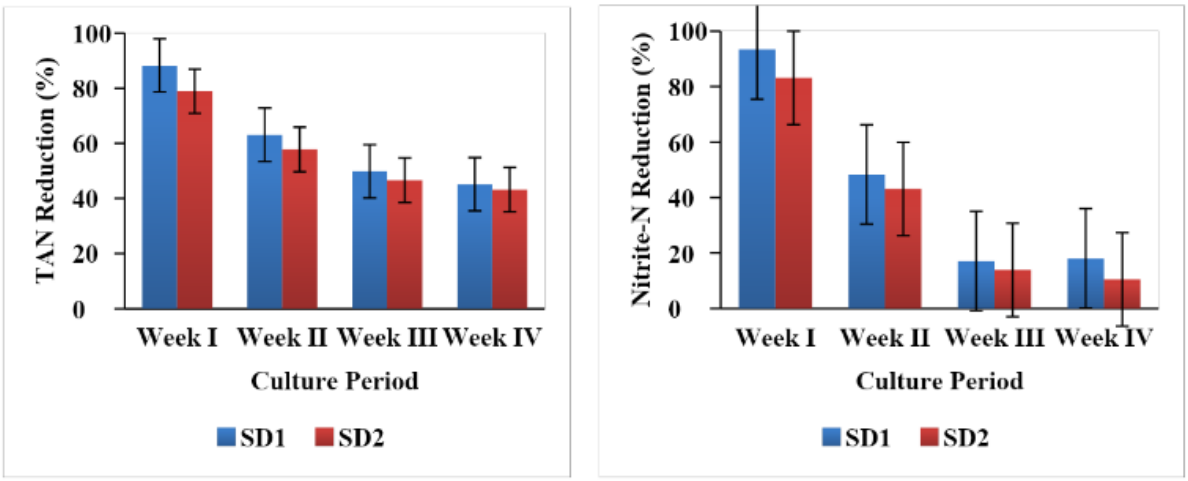


Influence of drastic water salinity on osmolality of serum and water at 5hs and 24hrs

EFFECT OF CLAY POLYMER ADSORBENT ON NITROGEN METABOLITES CONCENTRATION IN *P.VANNAMEI* CULTURE

In shrimp farming to overcome the problem of nitrogen metabolites viz., total ammonia nitrogen (TAN), and nitrite nitrogen (NO_2-N), application of adsorbents like zeolites, probiotics and water

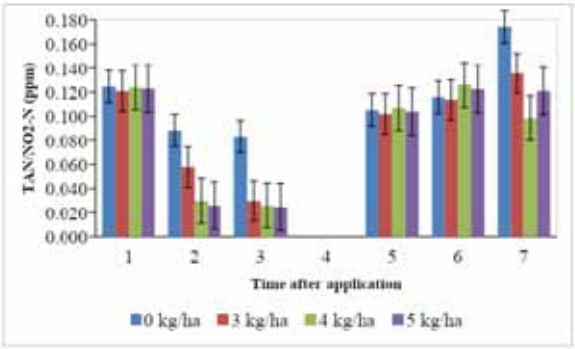
exchange, is the common practice. Clay-polymer based adsorbent was synthesized and evaluated for its effectiveness in the management of these metabolites. *P. vannamei* were stocked at two stocking densities (60 and 90 no/m^2) in100 L FRP tanks at 28 ppt salinity. The adsorbent was added at weekly interval @ 2.5g/ 100 l. The percent reduction of TAN was 88.3 and 78.9 during the first week and it reduced to 45.1 and 43.2 in the fourth week at lower and higher stocking density, respectively. Similarly, the NO_2-N level was reduced by 88.2 and 78.1, 18 and 10.5 percent during the first and fourth week at lower and higher stocking density, respectively. The efficiency of the adsorbent can be enhanced by raising the dose and frequency of application. The result indicates the use of synthesized adsorbent as an amendment for nitrogen metabolites management in shrimp culture.



Effect of clay polymer based adsorbent on percent reduction in TAN and Nitrite-N in P.vannamei rearing tanks at different stocking density

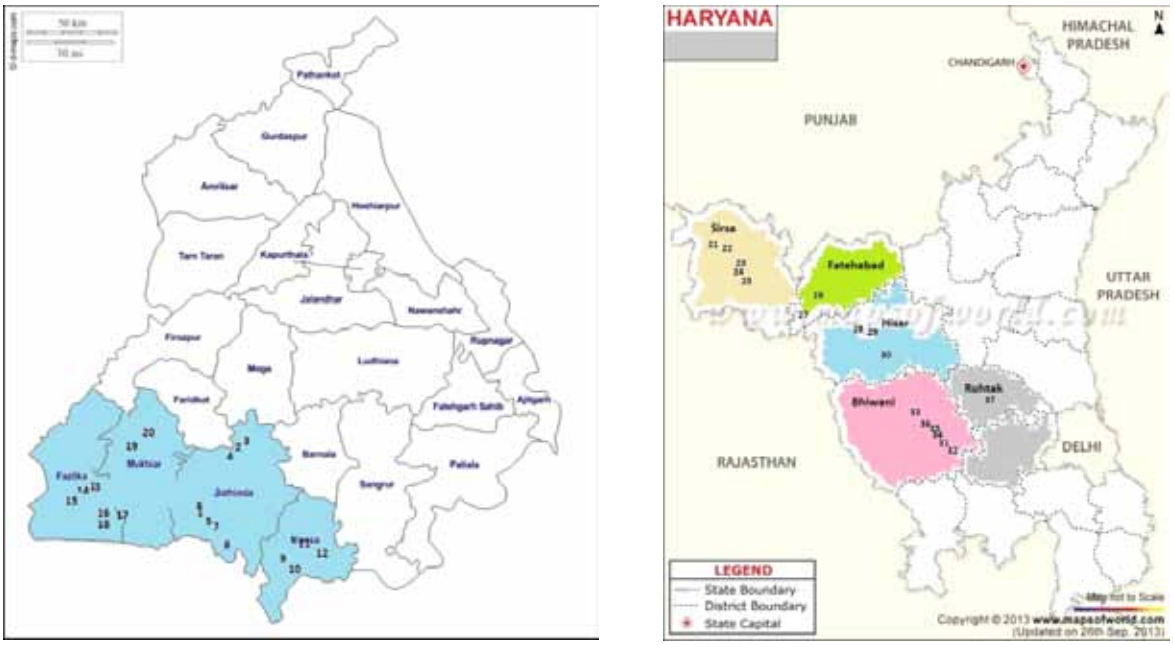
EFFECT OF OXYGEN RELEASING COMPOUND ON WATER QUALITY DURING SHRIMP CULTURE

To study the effect of developed oxygen releasing compound (ORC) on water quality, 3, 4 and 5 kg ORC was applied per ha and water quality parameters were monitored at different time intervals. ORC enhanced the dissolved oxygen level to 7.5, 9.2 and 12.1 ppm from initial value of 4.8 ppm at 3, 4 and 5 kg/ha, respectively. Apart from enhancing the dissolved oxygen levels, total ammonia nitrogen reduced to 0.025 ppm after 2 h of ORC application from the initial value of 0.125 ppm. Higher dose (5 kg/ha) of ORC resulted in the plankton crash. Based on the DO levels and other water quality parameters, the optimum dose was found to be 3 kg/ha.



ASSESSMENT OF SUITABLE SITES FOR INLAND SALINE AQUACULTURE IN PUNJAB AND HARYANA

In India, salt-affected soils are spread over 6.74 m ha and likely to increase to 16.2 m ha by 2050 (ICAR-CSSRI, 2019). Salt-affected soils concentrated in North western parts of India comprising Punjab, Haryana, Rajasthan and Gujarat. To assess the degraded land for inland saline aquaculture, soil (34) and water (33) samples were collected from selected districts of Punjab and Haryana. The salinity, pH, hardness and alkalinity ranged from 2-20 ppt, 7.2 to 8.3, 540-6570 ppm and 126-601 ppm respectively. The no. of samples with in the optimum range for critical water parameters indicated that 95, 52 and 37 per cent inland saline waters were deficient in potassium, magnesium and calcium that warranted for mineral supplementation.



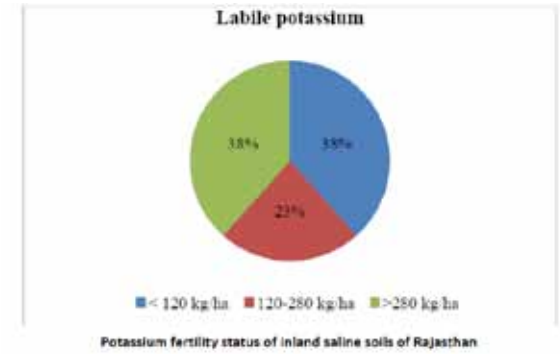
Sampling locations in Punjab and Haryana

Mineral profile and chemical properties of inland saline waters

Sl.No	Water Parameter	Range	Samples in optimum value (%)
1	pH	7.16-8.27	100
2	Salinity (ppt)	2-20	70
3	Total Alkalinity (ppm $CaCO_3$)	126-601	88
4	Total Hardness (ppm $CaCO_3$)	540-6570	79
5	Calcium (ppm)	72-1080	63
6	Magnesium (ppm)	88-1181	48
7	Potassium (ppm)	2.1-46.3	5

POTASSIUM SUPPLYING CAPACITY OF INLAND SALINE SOILS

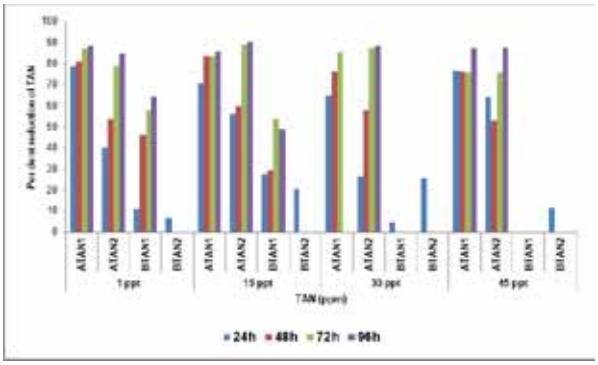
Inland saline waters are deficient in potassium and rich in calcium, and results in imbalanced ionic ratios. To rectify the skewed ratio, minerals should be applied externally. As soils could also be a source of potassium, potassium supplying capacity of inland saline soils of Rajasthan was evaluated by quantification of potassium fractions viz., water-soluble, exchangeable, non-exchangeable and total. The water-soluble, exchangeable, non-exchangeable and total potassium varied between 15 to 223, 27 to 814, 78-911 and 305 to 2275 kg/ha. Among the studied soils, 39% are low, 23% are medium and 38% are high in potassium fertility status based on labile K content. The soils from Jaitpura, Ajitpura, Jogni and Kishangarh were rich in labile potassium and could contribute to balance the skewed ionic ratio.



Potassium fertility status of inland saline soils of Rajasthan

MYCOTIC BIOREMEDIATION OF TOTAL AMMONIA NITROGEN IN VARYING WATER SALINITY

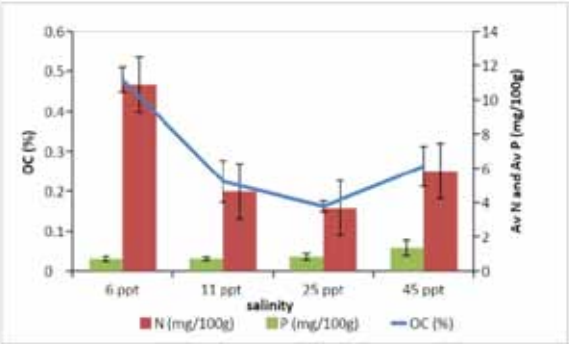
In vitro studies were conducted using the *Pleurotus erygnii* [A] and *Pleurotus ostreatus* [B] for remediating the nitrogenous metabolites. Both the species were applied @ fungal load of 10^4 CFU ml^{-1} in different salinity waters (1, 15, 30 and 45 ppt) spiked with total ammonia nitrogen concentration of 1 and 2 mg l^{-1}. Water samples were analyzed for TAN at periodic intervals 0, 24, 48, 72 and 96 h. TAN showed a reduction of more than 80% in 1, 15 and 30 ppt and less than 80% in 45 ppt within 72 h with *P. erygnii*. It was found that the *P. erygnii* has more potential to remediate total ammonia nitrogen in varying water salinities.



Effect of Pleurotus sps. on TAN in different salinities

CARBON DYNAMICS IN RELATION TO OTHER NUTRIENTS IN SHRIMP CULTURE PONDS

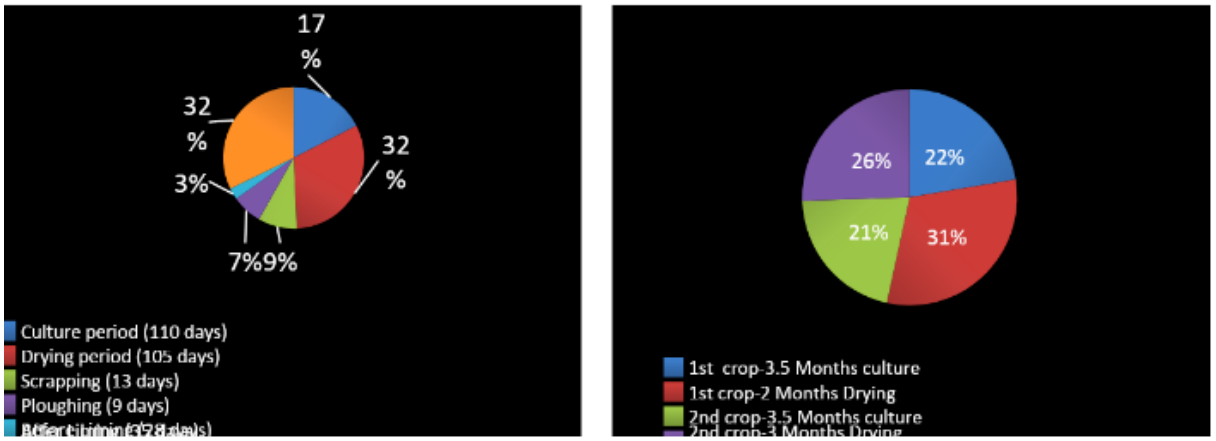
The variations in carbon concentration along with other nutrients like nitrogen and phosphorus in pond sediment of *P.vannamei* culture ponds varying in water salinity were studied. The shrimp culture ponds of varying salinity (6, 11, 25 and 45 ppt) were chosen in Elavur Village, Tiruvallur Distrct, Tamil Nadu within a perimeter of 5-10 km and carbon, nitrogen and phosphorus concentrations in the sediment during the culture period were determined. The average organic carbon content (0.48 %) in the sediments of low saline areas was found to be higher than that of high saline areas and decreases with increasing salinity, except at 45 ppt (0.26 %). Available nitrogen content varied from 3.6 to 10.8 mg/ 100 g and observed to follow the same trend as that of organic carbon. The available phosphorus content (0.7 to 1.3 mg/100 g) was observed to follow a reverse trend, an increase in concentration with increasing salinity. To further comprehend the changes in soil organic matter, water-soluble carbon (WSC) pool was studied. The WSC (mg/kg) was found to increase with salinity: WSC_{45} (2.5)> WSC_{25} (2.2)> WSC_{11} (2.1)> WSC_{6} (1.4).



Carbon, nitrogen and phosphorus content in pond sediment (average of 3 samples) under varying salinities

CONTRIBUTION OF CULTURE PRACTICES FOR GREENHOUSE GASES EMISSION IN SHRIMP FARMS

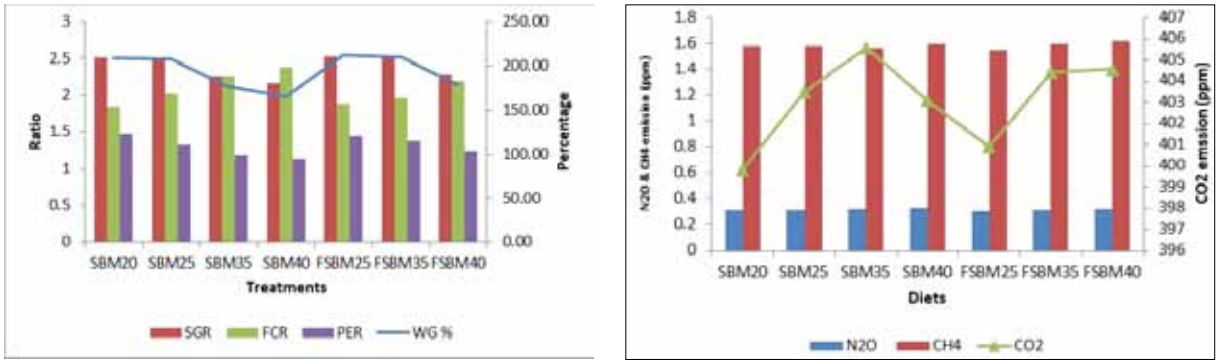
Studies were conducted in shrimp farms with single crop and two crops per year to assess the contribution of culture, fallow period and drying practices on GHGs emission. In the shrimp farms with single crop culture period of 110 days, the CO2 equivalent emission varied from 110-134 kg/ha. After harvest during the drying period, emission rate increased seven times (755 kg/ha) on the 3rd day of harvest compared to culture period and decreased gradually during fallow period. After scrapping and ploughing, GHGs emission increased thrice (360 kg/ha) and twice (282 kg/ha) compared to culture period. The highest CO_2 equivalent emission was recorded after liming, 13 times more (1304 kg/ha) compared to culture period. Single crop culture period of 110 days, drying period of 105 days, scrapping period of 13 days, and ploughing period of 9 days contributes 17%, 32%, 9 and 7% of total GHGs emission. In two crops per year, during the 1st crop, the CO_2 equivalent was 90 kg/ha on DOC 5 and increased gradually to 520 kg/ha on 90 DOC. After harvest emission increased 1.7 times (900 kg/ha) compared to culture period and decreased gradually to 216 kg/ha after 55 days of drying. During the second crop, CO_2 emission was 493 kg/ha on 90 DOC. During drying period, after one week of harvest, emission was 2.25 times more (1111 kg/ha) and decreased gradually to 113 kg/ha on the 80th day after harvest. The first crop culture period of 3.5 months, drying period of 2 months after 1st crop, second crop culture period of 3.5 months and drying period of 3 months after second crop in a year contribute to 22, 31 21 and 26 per cent of total CO_2 emission equivalent.



Contribution of culture practices on GHGs emission from shrimp farms A. Single crop per year B. Two crops per year

EFFECT OF SOLID STATE FERMENTATION OF SOYBEAN MEAL ON GREENHOUSE GASSES EMISSION IN P. VANNAMEI

The development of alternatives to fish meal should not compromise the production performance and also should not increase the emission of greenhouse gasses (GHGs) into the environment. In the present study, soybean meal was subjected to solid state fermentation using *Aspergillus niger*. Seven experimental practical shrimp diets were prepared by incorporating various levels of raw and fermented soybean meal viz., 20% raw soybean as control, and six treatments 25, 35 and 40% of raw and fermented soybean meal. These diets were fed to the juveniles of *P. vannamei* (3.88 ±0.062 g) for evaluation of growth and nutrient utilization in 500 L FRP tanks with three replications for each diet. After 45 days of growth trail, six shrimp from each replicate tank were transferred to 100 LFRP tank specifically designed for measuring the GHGs emission. The GHGs were measured once in three days for 12 days. Increase of raw soybean meal beyond 25% and fermented soybean meal beyond 35% has reduced the growth performance and nutrient utilization efficiencies. Among the three greenhouse gasses, nitrous oxide (N_2O) emission was significantly ($P<0.05$) different with dietary treatments. The fermented soybean meal inclusion has significantly ($P<0.05$) reduced the emission of N_2O at 40% soybean meal inclusion level. This may be due to the lower apparent dry matter and crude protein digestibility values of raw soybean meal (78.46 and 89.46%) compared to fermented soybean meal (91.71 and 95.49%), respectively. CO_2 and CH_4 emissions were not influenced by the dietary treatments.



Effect of varying levels of unfermented and fermented soybean meal in the diets of P. vannamei on A. Growth and nutrient utilization and B. Greenhouse gases emission

SOCIAL SCIENCE AND DEVELOPMENT

DATABASE MANAGEMENT ON INDIAN BRACKISHWATER AQUACULTURE : AQUASTAT INDIA 2018

ICAR-CIBA created a statistical compilation, the first comprehensive database on the world and Indian brackishwater aquaculture scenario. Aquastat consists of an updated database on aquaculture resources, production, trade, and consumption from 1991 to 2017. It also attempted to include economic loss due to important diseases, doubling of farmers income, and review for World, India, and States. This work is significant as ICAR-CIBA has been mandated to act as a repository of the database on brackish water aquaculture. The technical information provided in "Aquastat India 2018" would be useful for all fishermen, researchers, and other stakeholders.

This compilation is unique in nature, and technical information provided in "Aquastat India 2018" would be useful for all fishermen, researchers, and other stakeholders.

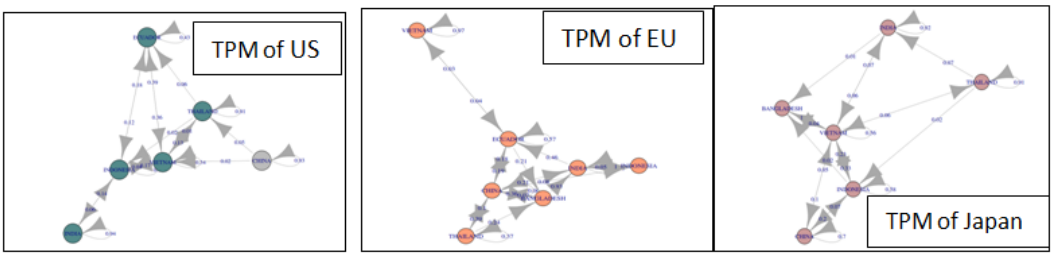


Cover page of Aquastat India 2018

INDIAN SHRIMP EXPORT PERFORMANCE FROM 2002-18

Methodology on Transition Probability Matrix using LINGO (Version 10) Package for shrimp exports was created to convert the data into a Linear Programming (LP), and Transitional probability matrix (TPM) values were estimated. The TPM indicated that India retained its share of 94%, and lost 6% to Indonesia in the US shrimp market. However, India gained 14 percentage of Indonesian share in the US shrimp market during the same period. China, and Thail, and retained their share of 93%, and 91% respectively, from 2002 to 17. Indonesia, Ecuador, and Vietnam lost their share of 30, 58, and 66 % to the other countries.

THE DIRECTION OF SHRIMP TRADE FROM THE US, EU, AND JAPAN: METHODOLOGY ON MARKOV CHAIN ANALYSIS: TRANSITIONAL PROBABILITY MATRIX (TPM) BY R SOFTWARE



TPM of shrimp imports

The trend of shrimp exports, and rejections from 2002-18

Country	Compound Growth Rate of exports/rejection						RCA		Instability index	
	2002-2010		2011-18		2002-18				2002-18	
	Exports	Rejections	Exports	Rejections	Exports	Rejections	2002-2010	2011-18	Exports	Rejections
US	-10.26	-23	25.59	2.71	13.84*	-1.1*	2.7	3.2	4.3	10.8
EU	6.52	-3.61	5.73	14.9	5.16*	-4.03*		4.74	6.6	11.6
Japan	-1.47	1.06$	2.71	-9.27	2.57*	23.8**	4.1	4.7	1.8	31.1

*Note: D*ata for rejection: Japan (2006-17)*, Indicate significance at 1% , and 5% respectively**

Over the period, India in US shrimp market gained an almost complete share of Indonesia, and Bangladesh shrimp market in the EU, and managed to retain half of its exports over the period (2012 to 17). Ecuador gained maximum Indian share (47%) of the EU market. Vietnam was able to maintain 97% of its quota, whereas Ecuador, Thail, and China retained 57, 37, and 6% of their shares, respectively. India kept 92% of its share of the Japanese shrimp market, losing marginally to Vietnam (7%), and Bangladesh (1%) throughout 2002-17. Thail, and China retained their share of 91 and 70% respectively, while Indonesia and Vietnam retained half of their share in the Japanese shrimp market during the same period.

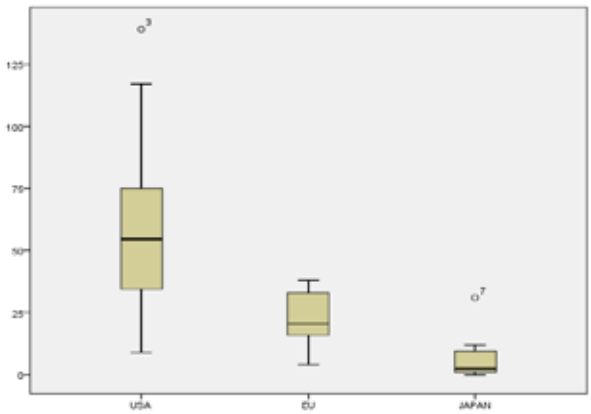
Compound Growth Rate of rejections of Indian shrimp exports to the US declined sharply by 23% in 2002-10, while it became -0.27 in 2011-17, overall period, the rejection rate remained at -2.42%. It may be seen along with the growth rate of exports by -10.26%, 26.40%, and 12.57% for the periods respectively. Similarly, Indian shrimp exports to EU grew from 4.55% (2007-10) to 18.36% (2011-17) while the rate of rejections increased from -3.61% to 3.34% in terms of CAGR during the same period. Indian exports to Japan grew marginally by 2.46% with higher rejections CAGR of 28.10%. However, during the first half of the study period, Indian shrimp exports to Japan declined by 1.47%, and rejections grew by 1.06% while in the second half of the period of study, exports grew by 2.56%, and rejections declined by 9.27%.

Analysis of instability in Indian shrimp exports, and rejections during the study period revealed higher variations in rejection by Japan while exports stayed relatively stable (2.48%). Exports to the US, and EU, and their denials remained steady at 6.90%, and 7.48% for exports, and 11.89%, and 12.14% for rejections respectively.

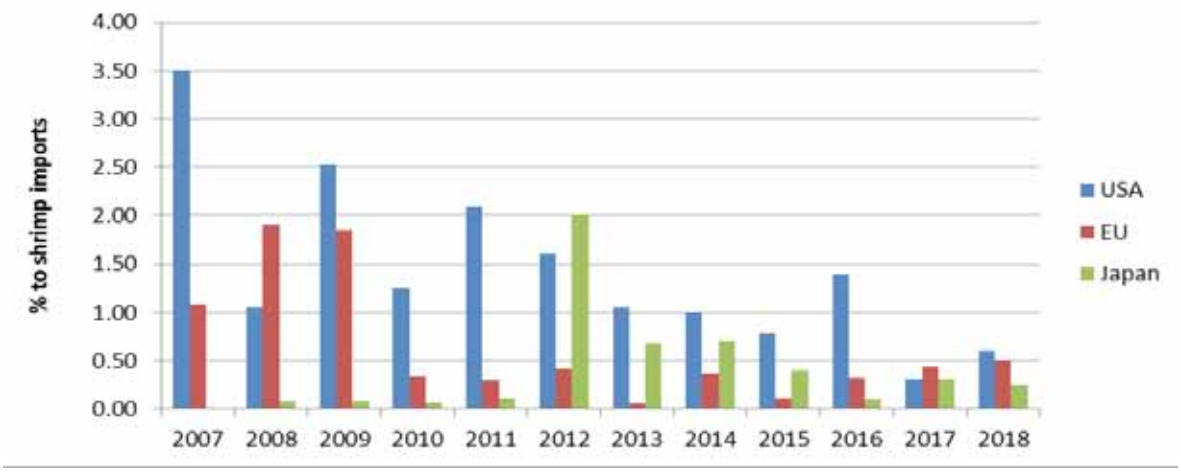
DATABASE MANAGEMENT ON SHRIMP EXPORT REJECTION BY THE US, EU, AND JAPAN FROM 2002 TO 2018

The export rejection database collated from trade portals of India, USA, EU, and Japan on shrimp products for the year 2002-2018, revealed Indian shrimp export rejections by the US, EU,

and Japan were 83, 20, and five respectively. Box plot analysis of Indian shrimp export rejections to US, EU, and Japan showed that higher quantum of rejections was from upper quartile for the US while rejection distribution for EU and Japan situated at lower quartile.



Box plot analysis of Indian shrimp export rejections



Box plot analysis of Indian shrimp export rejections

INDIAN SHRIMP EXPORTS REJECTION SHARE IN TOTAL EXPORTS FROM 2007 TO 2018

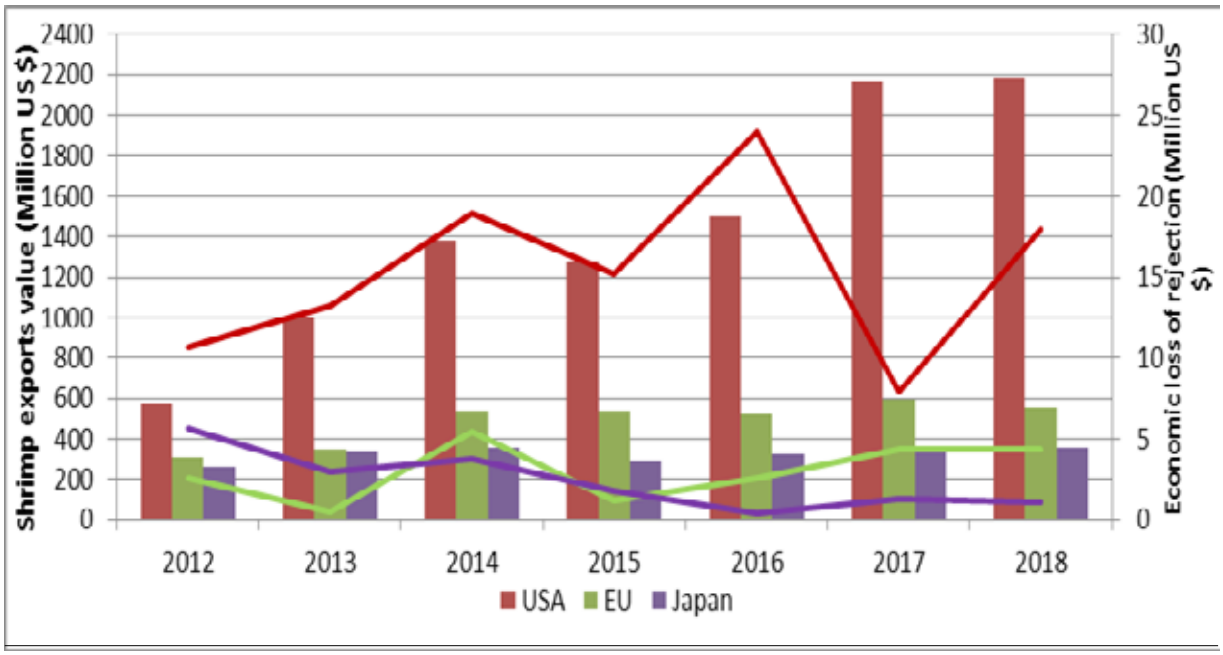
In the USA, the rejection percent was 3.5 in 2007 and consistently reduced to 0.6 in 2018, which showed affirmative compliance of Indian shrimp exports. The share was very high during 2004 (6.1%). In EU, the rejection share was 1.08% in 2007 and significantly reduced to 0.49 during 2018 whereas, in Japan, the percentage was very high in 2012 (2%), and afterward it had decreased to 0.25 during 2018.

THE ECONOMIC LOSS OF INDIAN SHRIMP EXPORT REJECTION BY US, EU, AND JAPAN

Estimated financial loss due to shrimp export rejection by the US was between Rs.7.5 crores to Rs.158 crores. Value of shrimp exports to the USA was 363 million $ US in 2002, and significantly increased to 2186 million USD during 2018 whereas the economic loss was 11 million $ US in 2012 and rose to 24 million USD in 2016, and during 2018, which had significantly decreased to 18 million USD, and showed an improvement in compliance performance and adoption of Better Management Practices (BMP) by the shrimp processors.

ECONOMIC LOSS OF INDIAN SHRIMP EXPORT REJECTION

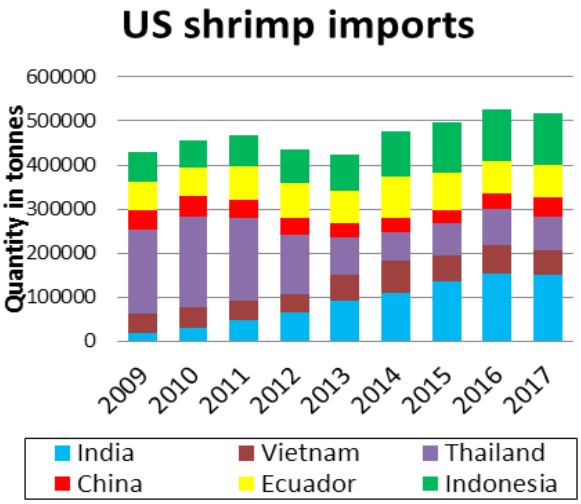
The European Union has more stringent food safety standards. In the EU, the value of Indian shrimp exports was 305 million $ the US and



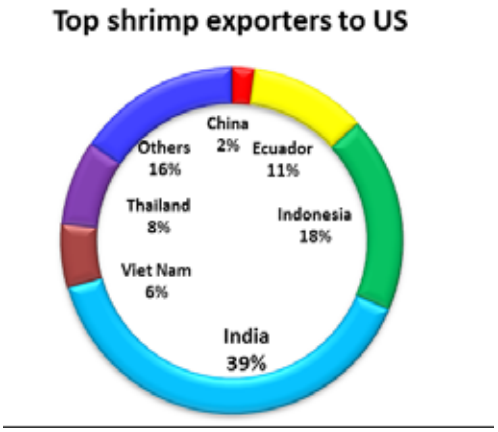
increased to 550 million $ US, and economic loss also significantly rose from 2.9 in 2012 to 4.4 million $ US in 2018. In Japan, the value of shrimp exports has been increased sharply from 258 million USD to 353 million USD from 2012 to 2018 whereas the economic loss had decreased from 5.61 million USD to 1.1 million $ US except during 2012 when the loss was 3.7 million USD. Japan has been traditionally importing Jumbo tiger shrimps for making ethnic dishes like tempura, and shush. There were incidents of rejections of shrimp imports from India during 2012-2014 for the presence of anti-oxidants.

PANEL DATA REGRESSION: GRAVITY MODEL APPROACH ON US SHRIMP IMPORTS FROM INDIA, AND OTHER EXPORTERS

Panel data methodology for US shrimp imports from India, and other major exporters used and based on the results of the Hausman test, and Breuch Pagan Lagrangian multiplier test, the random effects model, adopted. LM test clearly showed that there is a significant difference among various regions, and panel effect between different shrimp exporting countries to the US.



US Shrimp imports quantity from 2009 to 2017



Top shrimp exporters to the US in 2017

ECONOMIC ANALYSIS OF BRACKISHWATER AQUACULTURE TECHNOLOGIES IN INDIA

An analysis of cage culture of pearl spot was carried out in a single cage of 4x4x3 m undertaken by KVK Alleppey, with the technological backstopping of CIBA Chennai, and KVK Ernakulam. The results indicated that the survival rate was 80% for 1000 fingerlings, the yield was 200 kg. Out of the total cost of Rs.37000, Rs. 10000 (25%) was incurred for feed, and Rs.8000 (21.6%) for the labor. Seed cost accounted for only 5.4 %. The gross return was Rs.80000, and the net profit was Rs.43000/crop, and the realized BCR was 2.16.





Pearl spot farming in brackishwater resources of Alleppey district in Kerala

ECONOMICS OF RE-CIRCULATORY AQUACULTURE SYSTEM

To study the economy of Recirculatory Aquaculture System (RAS) practiced at farmer's level, a survey sheet was prepared, and data were collected to do the economic analysis of existing RAS. Modification of RAS design could be done to reduce the cost of production, optimize the production volume for economic viability (Break-even analysis) of RAS.

RAS designed to study the reproductive performance of penaeid shrimps in comparison with flow-through the system. Preliminary trials of water quality analysis of shrimp maturation in flow-through system revealed that the Total Ammonia Nitrogen (TAN) was above the recommended limit (1 ppm) in all the tanks with 100% water exchange per day at a stocking density of 2 shrimps/m2. To overcome the disadvantages of the flowthrough, a new RAS system is designed, and modified to improve water quality, subsidize water usage, preserve pheromones, and also ensure biosecurity in shrimp maturation. The shrimp broodstock RAS is designed based on the capacity, biomass, water flow rates, biofilter sizing, oxygen delivery, etc. The estimated capacity was to stock five shrimps/m2. Broodstock RAS is modified as follows: Tank bottom is raised to 40 cm – to accelerate gravity flow, central drainage with slope- easy sludge removal, two-step swirl separation- removal of settleable solids (large, and fine solids), and bio ball filter aeration piping design- made adequate to provide fluidization of bio-balls. A further modification is possible to improve the capacity of RAS by replacing the media. The biomass and animal stocking density was calculated based on the carrying capacity of the RAS concerning the solids removal rate of mechanical filter, TAN removal rate of biofilter, Oxygen addition rate, etc. The flow rate required to maintain the optimum concentration of TAN, TSS (Total Suspended Solids), and DO (Dissolved Oxygen) in the RAS, and sizing of biofilter was calculated using the spreadsheet.

To summarize, RAS is designed to grow shrimp from its post-larvae stage to maturity. The system is proposed to have the capacity to grow 500 PL/m3. The study is being conducted to optimize the stocking density, and system carrying capacity, and analyze the water quality, and efficiency of the system.

TECHNO-ECONOMIC VIABILITY OF THREE-TIER CAGE FARMING OF ASIAN SEABASS FISH IN OPEN BRACKISHWATER BODIES

Fingerling size fish (8-10g) is the stockable size in pre-grow out cages, and generally small size fry will not survive in running waters. Although fingerlings can be purchased from the nurseries operated by farmers, the cost is extremely high, and it is economically unfeasible. Therefore nursery rearing to raise fish fry to fingerling size is the better option, and a critical phase to get the fingerling stock for the cages. The group carried out four cycles of nursery rearing to raise fingerlings, and the weekly growth rates of fish fry stocked in hapas are given in the Table. The average survival in the four cycles was 40%, and the mean growth rate in eight weeks duration was 7.3 cm (7-8 g). It was noted that nursery rearing in hapas in open waters did not give better survival when the water current was more than 10 cm/sec. Therefore it is suggested that nursery rearing unit need to be set up in a pond based system.

Growth rate, and weekly survival in nursery rearing

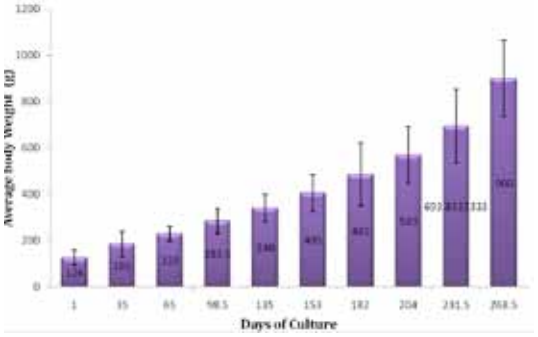
Nursery cycles	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Mean± SD
Initial Length (mm)	2.5	2	3	4	2.9±0.8539
Final Length (cm)	6.5	6.8	7.5	8.5	7.3±0.8884
The average survival in %					
Week 1	80.0	74.0	73.0	85.0	78.0±5.5976
Week 2	63.0	69.0	69.0	72.0	68.3±3.7749
Week 3	58.0	55.0	58.0	66.0	59.3±4.7170
Week 4	54.0	50.0	55.0	57.0	54.0±2.9439
Week 5	49.0	46.0	51.0	52.0	49.5±2.6458
Week 6	45.0	42.0	49.0	46.0	45.5±2.8868
Week 7	42.0	39.0	48.0	42.0	42.8±3.7749
Week 8	39.0	36.0	46.0	40.0	40.3±4.1932

Rearing of fish fingerlings (7-8g) to a juvenile size (900-100g) was taken up in pre-grow out cages for 90-105 days. The average growth of fingerlings in pre-grow-out, and mean body weights were measured in fortnightly intervals, and the results are presented in the Table. The average daily growth was found to be one gram in pre-grow out stage, and at the end of 100 days, the fingerlings were grown to juvenile fishes with an average size of 126 g.

Average body weight, and length of fish in pre-grow out phase

Day of Culture	ABW (g)	Mean length (cm)
1	4.9±1.6	6.9±0.84
15	13.6±1.9	9.8±1.20
30	28.0±2.9	11.9±1.54
45	40.6±4.1	13.2±1.28
60	52.7±6.5	14.3±2.96
75	75.4±6.8	15.8±3.18
90	101.6±17.3	17.9±3.48
100	126.0±37.2	19.6±3.89

In the grow-out phase, the fish juveniles of 100-150 g size were transferred from pre-grow out cage into a larger grow out cage for rearing them to an adult size of around one kg. At 270 days of culture, the mean body weight of the fish was 900g. It was observed that the cages acted as fish aggregating devices, and fishers had good catch around the cage farming site. As the water quality was good in moving waters, and fishes were in the ideal rearing environment, the quality and taste of the fish was very good and fetched a premium price in the market. The Fisher group was linked with the Tamil Nadu Fisheries Development Corporation (TNFDC) the marketing arm of the Department of Fisheries, Govt. of Tamil Nadu, and they bought the fish at the cage site. Due to this market linkage, the Fisher group received a better price for their produce.



MEAN GROWTH RATE OF FISH IN GROW OUT PHASE

The seabass fish were sold @ Rs.380-400/kg at the cage site itself. The fishers obtained a monthly income of Rs.8000, Rs.4900, and Rs.8500 respectively in nursery rearing, pre-grow out, and the grow-out farming. This shows that cage farming has provided them an alternative livelihood, and doubled their income. With proper management of cage erected at an ideal location in brackishwater can yield production of 20-25kg/m^3 with various species of fishes. Since all the three phases require hardly two man hours per day to manage the system, the fishers could take up cage farming as an additional occupation. With proper planning, four cycles of nursery rearing, and two cycles of pre-grow out culture can be taken up in a year. Nursery rearing can provide eight months of employment in a year for four people. Two persons in the group can take care of pre-grow out farming, and an average one member can spend one hour in the morning, and one hour in the evening for feeding the fishes. All together for the 90 days of duration, 180 hours of manpower was required for one cycle of three months. Two cycles can be done in a year. Four fisher youth of the team can take up grow out farming. On average, one member can spend one hour in the morning, and one hour in the evening for feeding the fishes. All together for 300 days totally 600 man hours of manpower they need to spend for one total cycle. With the installation of one more grows out the cage in the site, two full cycles of the three-tier system could be taken up in a year.

The group members may subdivide among themselves to take up the nursery, pre-grow out, and grow out phases as this segmentation might provide interim returns to them, and they need not wait for the cycle to complete. In the subsequent culture, they could inter-change their portions among themselves. Since the water bodies are common property resources

THREE TIER SYSTEM OF CAGE FARMING WITH FORWARD AND BACKWARD LINKAGES



group of fishers of their families could jointly take up this system of farming. Nursery rearing can be taken up by fisher womenfolk as it requires smooth handling, and grading once in 4-5 days to avoid sibling cannibalism. For effective adoption of aquaculture technologies by the poor, and new entrants in the developing countries, the use of participatory rather than technology-driven approaches are highly convincing (Edwards, 2000). The fisheries departments of the states should promote cage aquaculture in suitable locations by developing suitable schemes with an inbuilt subsidy to establish cage infrastructure. Location-specific cage designs using locally available materials could minimize the investment.

POLYCULTURE OF MILKFISH, PEARL SPOT, AND MUD CRAB FARMING AT SADARASKUPPAM BACK WATERS, KANCHEEPURAM DISTRICT, TAMIL NADU

Polyculture of milkfish, pearlspot, and mud crabs was conducted in the open water system pen structure (size of 150 m2) among five tribal families (10 nos.) of Sadraskuppam, Kancheepuram district, Tamil Nadu. A total of 100 milkfish (avg. wt 49 g), 750 pearl spot (3 to 15 cm) size, and 125 mud crab (18. 5 kg; 95 to 250 g) were stocked in pen. After 60 DOC, due to obstruction at the bar mouth of Sadraskuppam backwater area followed by less water exchange to the pen structure, heavy mortality of mud crab was noticed. Mud crabs were harvested with 30 % of survival range from (225 to 685 g) size, and fish culture is in progress.

INSTALLATION OF FISH WASTE PROCESSING UNIT, AND DEMONSTRATION FOR PREPARING PLANTONPLUS, AND HORTI^{PLUS}

ICAR-CIBA, Chennai has adopted fishermen villages viz., Srinivasapuram, Nambikkai Nagar, Mullikuppam, and Mullimanagar located near CIBA Headquarters in Chennai. This village cluster





Harvested Mud crab at Sadaraskuppam backwaters, Kancheepuram district, Tamil Nadu





Culture of milkfish, and pearl spot at Sadaraskuppam backwaters, Kancheepuram district, Tamil Nadu

has about 4500 persons in 2000 households. Their main occupation is fishing, and selling of fish in the lighthouse fish market, which is located nearby these villages. In this fish market, fish waste is not properly disposed or recycled. Mostly fish trimming wastages are dumped nearby seashore. In this backdrop, "Fish Waste Processing Unit" was established for recycling of fish waste to high value-added products in the Nambikkai Nagar, Pattinapakkam, Chennai, Tamil Nadu based on the need, and interest shown by the Nambikkai Fish Farmers Group, Nambikkai Nagar, Pattinapakkam. After installation ICAR-CIBA staff has given a demonstration about the protocol for recycling of fish waste to value-added products to Nambikkai Fish Farmers Group, Nambikkai Nagar, Pattinapakkam, Chennai during February, and March 2019. Impact of this initiative, the group has produced 520 Kg of Planton^{plus}, and 65 Kg of Horti^{plus} during March 2019 , and received Rs. 16120/-. The group is processing the fish waste continually and producing Planton^{plus}, and Horti^{plus} as an alternative livelihoods activity. This initiative is not only cleaning, and hygienic disposal of fish market waste which is abundantly available in the village cluster but also will help to produce wealth from waste as a concept of the circular economy. This user-friendly technology will help in improving the environment in addition to enhancing their livelihood.



Fish Waste Processing Unit at Nambikkai Nagar, Pattinapakkam, Chennai



Protocol for recycling of fish waste to Plankton^{plus}, and Horti^{plus}, Nambikkai Fish

ORNAMENTAL FISH FARMING FOR PROFITABLE INCOME GENERATION, AND COMMUNITY DEVELOPMENT AMONG COASTAL FAMILIES OF KOVALUM VILLAGE, KANCHEEPURAM DISTRICT. TN.

Homestead backyard pearl spot seed rearing unit as a livelihood support activity was established for the clam collecting coastal families at Kundrakadu village, Kovalum, Kancheepuram district. TN. Pearlspot (*Etroplus suratensis*) 2000 Nos, with the average size of 1.0 cm to 2.0 cm was stocked in 4 concrete tanks @ 500 nos – each (in a hatchery shed of 200 sq.ft (20x10ft.). After 52 days of culture, the fish attained the average size of 0.6g in size ranging from 2.5 cm to 3.13 cm, with the survival rate of 93.3%. A total of 1865 nos. of pearlspot was harvested from all the tanks indicating the successful nursery phase rearing. These beneficiaries earned Rs. 8000-12,000/- approx. per trial or month. These beneficiaries saved their profit money earned from this intervention by opening a joint bank savings account.







Homestead backyard pearl spot seed rearing unit







Pearl spot seeds for stocking being received by beneficiaries from Shri. Chhabilendra Roul, Special Secretary, DARE, Govt. of India & Secretary, ICAR in the presence of Dr. K.K.Vijayan, Director -CIBA

MILK FISH FARMING WAS DEMONSTRATED IN VACANT SHRIMP PONDS FOR COASTAL SHRIMP FARMER'S FAMILY AT TIRUVALLUR DISTRICT, TAMIL NADU.

Two tier Milkfish (*chanos chanos*) farming in brackishwater pen culture system was demonstrated as fish farming in an open water pen erected in the brackishwater body among the tribal families under Tribal Sub Plan. 0.5g milkfish fry stocked in the nursery pond @2 nos/m^2 attained an average body weight of 12 g with a survival rate of 70% in 43 days. Subsequently, these 12g size milkfish fingerlings were transferred to a pen culture enclosure erected in Pulicat lake area and stocked @ 2.5 nos/m2 in a 400 m2 pen system. After 55 days of grow out culture, the fish attained an average body weight of 125g - 180g with a survival rate of 70%.







HARVEST MELA OF MILKFISH IN KANAVANTHURAI VILLAGE OF TIRUVALLUR DISTRICT

A harvest mela was conducted on 23rd October 2018, at Kanavanthurai village A production of 60 kg milkfish was harvested. Bank accounts were opened , and the tribal beneficiaries deposited Rs.25,000/- the profit earned from this intervention in their bank account — officials from CPCL Company, local villages heads, bank manager & Govt. School children participated in this program. The present demonstration showed that milkfish farming in open water systems is technically feasible, economically viable, environmentally sustainable in providing livelihood to the tribal families, other communities with access to water bodies.



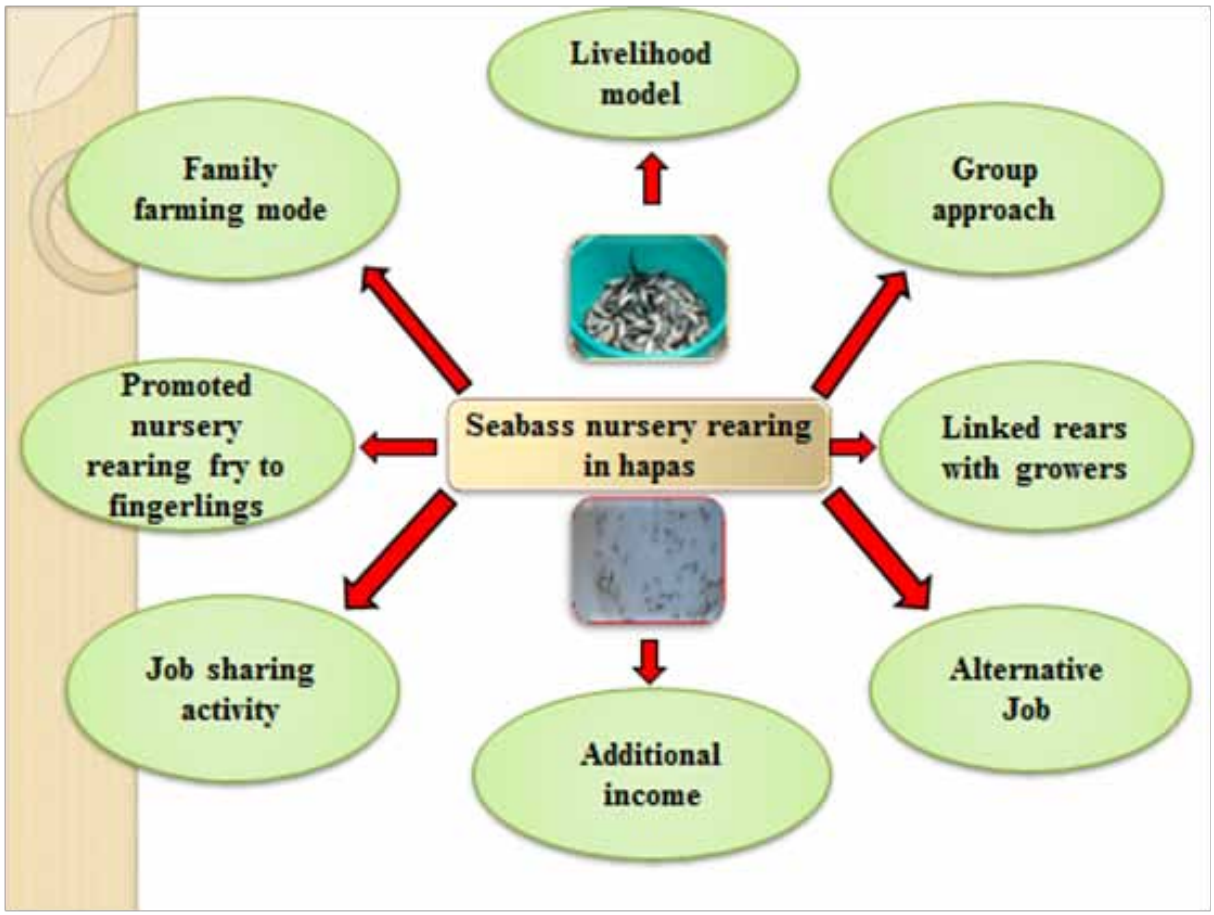


Pearlspot integrated with crab farming (in tide fed ponds) was demonstrated among Irular tribal families of Kulathumedu village, Tiruvallur District. TN. (in tide fed ponds)

TECHNOLOGY TRANSFER MECHANISMS FOR IMPROVING THE LIVELIHOOD SECURITY OF COASTAL FAMILIES.

Hatchery produced seabass fish fry of size 1.8-2.0 cm was stocked @ 500 no. Per hapa , and four trials were conducted in Koovathur village of Kancheepuram district in Tamilnadu. CIBA seabass nursery ^{Plus} with 45% CP, and 12% lipid was used as feed. Feeding was done twice a day at 08.00hrs, and 16.00hrs. Grading of the fry and cleaning of the net was carried out once in 4-5 days. The nursery rearing was continued for 60 days. The total realized production was 2500, 2520, 2523, and 2850 fingerlings out of 5000 fries stocked in each trial. At the end of nursery rearing, an average total length size of 6.8, 7.1, 7.0 & 8.4 cm was harvested — survival of 50-57% in open waters.

The net income from four cycles was Rs 1,14,000/-, and each member got an average income of Rs.7000 /- per head/ per cycle. It was an additional income, job-sharing employment which could be taken up throughout the year as a livelihood activity. Regular supply, and uniform size of fry, site specification, calendar of operation, standardization of transport mode, stocking density depending on the availability of feed, feeding frequency, and demand based marketing were the suggestions given by the farmers regarding technology refinement.



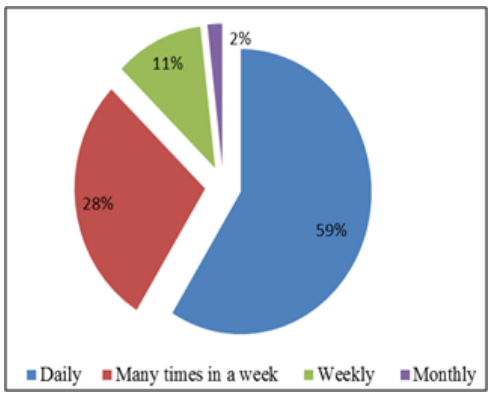
Farmers feedback on nursery rearing of seabass in hapas in open brackishwater sources

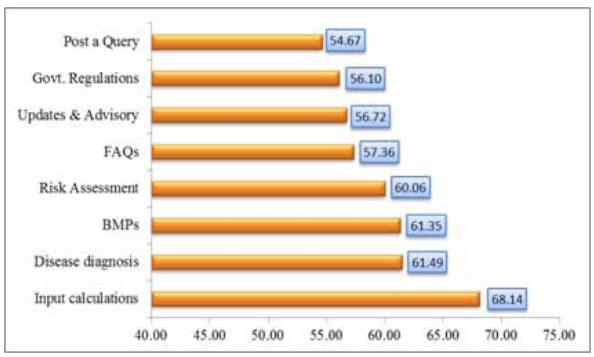
EFFECTIVENESS OF MOBILE APP IN TECHNOLOGY DISSEMINATION ON SHRIMP FARMING

ICAR-CIBA launched a mobile application Vanami Shrimpapp in 2017 a platform to disseminate technical knowledge to the aqua farmers, and extension workers. The app has been regularly updated with new information as per the field requirements, and extensively consulted across the countries. As on date, it has more than 15300 downloads across the worldwide with 4.5/5.0 rating. India is the major user with 80% of downloads. A study was undertaken with 180 vanami shrimpapp users to assess its effectiveness in terms of the usefulness of its modules to the end users. It was noted that 85% of the respondents conveyed that it was a reliable source of information, and a farmer can decide on his farm using this app.

Similarly, 87% of them opined that it was a notable contribution by the institute to the sector. Majority of the app users referred to the app every day (59%), and 28% consulted on alternate days (28%). The users ranked input calculations; disease diagnosis, BMPs, and risk assessment were the most used modules. Based on the suggestions, the app was updated with additional modules, and in vernacular languages viz. Tamil, Telugu, Bengali, and Hindi, and renamed as CIBA Shrimpapp , and launched during the National Brackishwater Aquaculture Farmers Conclave-2019 on 22 January 2019 at CIBA campus.







Usability of mobile app

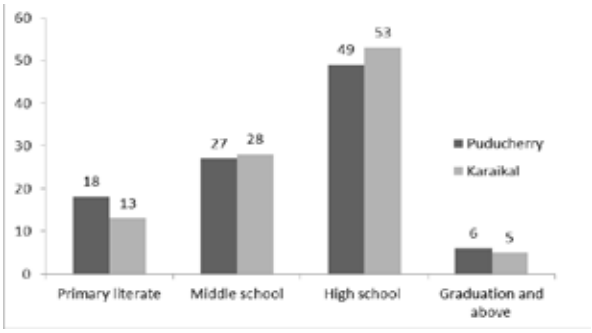


CIBA Shrimpapp launch

CAGE AQUACULTURE IN BRACKISHWATER OF PUDUCHERRY, AND KARAIKAL REGIONS OF PUDUCHERRY UNION TERRITORY

A feasibility study on Socio-economic status of coastal fishers Puducherry, and Karaikal region revealed the following:

Majority of the fisher families in Puducherry (69%) , and Karaikal (60%) were of a nuclear type, and the family sizes were also small with four members or less (66% , and 60%).



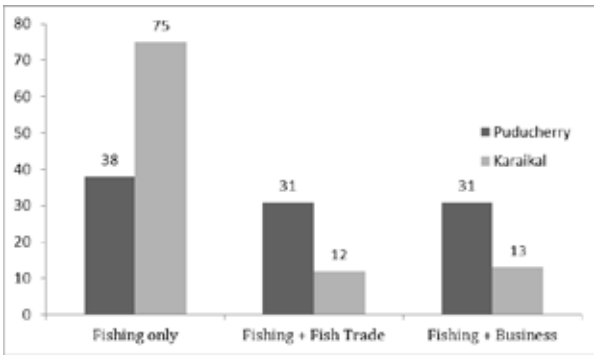
Education status of the Fisher folk

However, about 30-40% of fisher families still live as joint families as this important in case of fishing avocation is concerned, and it shows that the family relationships were intact, and they help mutually one another during the needed situations. Almost half of the respondents in Puducherry (49%), and Karaikal (53%) were educated up to high school.

It is interesting to note that the majority of Puducherry (64%), and 37% of Karaikal fisher families had more than one source of income mainly through fish marketing. However, the majority of the fishers of Karaikal (63%) mostly depend on fishing for their livelihood, and they may be receptive to any fisheries development programs. This is explicitly indicated by the occupation status of the respondents wherein 75% of the Karaikal fishers were full-time fishers , and fishing was their only occupation.

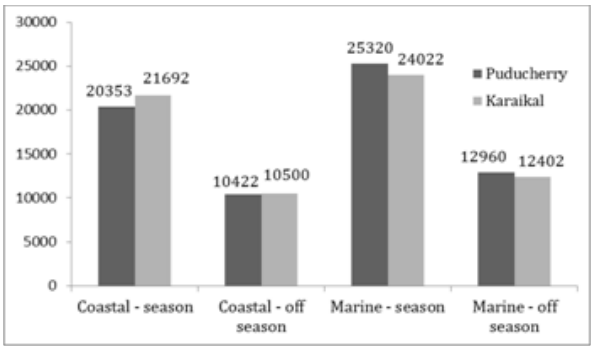
In terms of contact with the Fisheries Department, which is the nodal agency for their welfare, the majority of Karaikal respondents

(65%) had contacted the Department officials for one or the other purpose. However, in case of Puducherry, one-third of respondents had monthly to occasional (28-33%) contacts with Fisheries Departments, and one-third of them (37%) had contacted the officials of the Fisheries Department. This may be because the Karaikal fishers were mostly dependent on fisheries for their livelihood, and they need to contact with fisheries department for getting advisories, and information about the scheme, etc.



Occupational status of the Fisher folk

The average monthly income realized by the coastal fishers was Rs.20,353-Rs.21692 while the marine fishers could realize Rs.24, 022 –Rs.25,320 during the fishing seasons. However, during the off-seasons, their monthly income was respectively Rs.10, 422-10,500, and Rs.12,402 -12,960 for the estuarine, and marine fishers. During the off season, their monthly income was reduced by 50% but their effort on fishing was the same.



Average Income of Coastal and Marine Fishermen based on the seasons

THE LIVELIHOOD ASSESSMENT OF COASTAL FISHERS PUDUCHERRY, AND KARAIKAL REGIONS:

The livelihood assessment has indicated that the average livelihood score of coastal fishers was 70%. The mean livelihood score of Puducherry fishers was 67.50 %, and the fishers of Karaikal region had an average livelihood score of 72.50% However, about 40% of the Puducherry, and Karaikal fishers were in the category of below the average livelihood score. These results indicated the respondents needed support in the form of assets, capacities, and activities to improve their livelihood status. The statistical analysis carried out showed that there is a significant difference in the livelihood scores of Puducherry, and Karaikal fishers and both the samples are not belonging to the same set of the population ($p \leq 0.01$). Further, the analysis shows that Karaikal fishers (mean rank 87.80) had an edge in terms of their livelihood levels than their Puducherry (mean rank 62.55) counterparts.

ASSESSMENT OF WATERBODIES FOR THEIR SUITABILITY FOR AQUACULTURE

Assessment of waterbodies considering the physical, chemical, and environmental conditions using geospatial analyses has indicated that Malattaru estuary, a portion of Chunnambar river in Puducherry , and Arasalaru creek in Karaikal regions were identified as relatively suitable for taking up culture-based fisheries. However, tourism and recreation were found to hamper the fisheries and initiating culture based alternative livelihood for the fishers in Puducherry.



Collecting onsite water quality parameters



Collecting soil samples

DEVELOPMENT OF DECISION-MAKING TOOL FOR AQUACULTURE DEVELOPMENT AT ADYAR CREEK, AND ESTUARY

Web-based Adyar Creek and Estuary Information System based on Decision Making Tool was developed for the development of aquaculture in the water bodies. The system permits end users to fast, and easy access to large amounts of analyzed data which are collected in different sample locations, and details of culture practices which are suitable for the different sample locations for the development of brackishwater aquaculture. It has been developed using MySQL database management system, and PHP scripting language. In this tool, an information system was designed into different modules namely, about Adyar creek, and estuary, System needs, and objectives, Sample location, Water parameters, Soil parameters, phytoplankton, zooplankton, and culture practices. The season wise, location-wise, month-wise, year-wise, salinity-wise, phytoplankton class/genus-wise, and/or zooplankton group-wise information is used for deciding to develop the aquaculture activities in the water bodies. Although illustrations are based on the six sample locations, the system is general and can act as a model to elaborate for the entire Adyar creek water bodies.



Front page of a decision-making tool for aquaculture development at Adyar creek, and estuary

DEVELOPMENT, AND EVALUATION OF THE EFFECTIVENESS OF WEB-BASED KNOWLEDGE CENTRE IN BRACKISHWATER AQUACULTURE

Web-based Knowledge Centre in brackishwater aquaculture was developed using Drupal content management software (CMS) based on the ADDIE model of Instructional System Design (ISD), including Analysis, Design, Development, Implementation, and Evaluation. This system is built-up with PHP, and MySQL for the design of pages, and database, respectively. The effectiveness of the centre was evaluated using a structured questionnaire consists of six categories such as related to contents; presentation of modules; interactivity, visual design, and accessibility; user friendliness; module applicability; and general assessment of the unit. For the pilot study, the questionnaire was distributed to twenty-five randomly selected users of Village Knowledge Centers (VKCs), MSSRF, Chennai, and their responses were analyzed for checking its reliability by Alpha-Cronbach test.



FLOW DIAGRAM OF WEB-BASED KNOWLEDGE CENTRE INSTRUCTIONAL SYSTEM DESIGN

The results showed that the questionnaire was reliable since the alpha score produced was over 0.7 for each category of the questionnaire. After the pilot study, this tested evaluation questionnaire was used for evaluating the effectiveness of the centre by recording the responses of 30 sample ICT users, VKC, MSSRF, Chennai. A five-point rated scale was used where a respondent was asked to indicate their response to their statements on the centre. The possible scores were 1 for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree, and 5 for strongly agree. The average score was obtained by adding the multiplication of frequencies with the respective weights and dividing them with a total number of respondents. The evaluation results revealed that the items related to contents produced, visual design, accessibility, and presentation style had good responses. Future provides a knowledge base which goes beyond the traditional approach of storing and retrieving of information of various aspects of brackishwater aquaculture as racks of hard copies or in removable media storages. This also safeguards the valuable information gathered on shrimp, crab, finfish, and policies over some time.

RELIABILITY, AND EVALUATED RESULTS FOR WEB-BASED KNOWLEDGE CENTRE

Criteria	Reliably result (Alpha value (α))	Evaluated results (Average score)
Contents of the centre	0.85	4.1
Presentation, and Interactivity of the centre	0.78	3.3
Visual design, and accessibility of the centre	0.81	4.4
User friendliness, and motivation of the centre	0.73	3.3
Module applicability	0.82	2.9
General assessment	0.84	3.6

Human Resource Development (HRD)

Training, Capacity Building and Skill Development

Training attended by Individuals

International

Dr. Aritra Bera, Scientist, attended the International Training Course on Fish Culture Development at Egyptian International Centre for Agriculture (EICA) & World Fish at Arab Republic of Egypt during 01.10.18 – 15.12.2018



National

Dr. Debasis De, Principal Scientist attended the Training Programme on "Empanelled members in the evaluation committee under NPOP" organized by APEDA, New Delhi during 21-23 May 2018

Dr. M. Muralidhar, Principal Scientist attended the National Dialogue on "Artificial Intelligence and IoT applications in Agriculture" organized by ICAR – NAARM, Hyderabad during 1-2 June 2018

Dr. R. Geetha, Scientist attended the Training programme on "Advanced statistical methods and computational software for fisheries research and management" organized by Extension, Information & Statistics Division, ICAR-CIFT, Kochi during 17-26 July 2018

Dr. R. Ananda Raja attended the "Two Days Regional Workshop cum Training Programme for Nominees of CPCSEA" at Conference Hall, Madras Veterinary College, Vepery, Chennai- 600 007, Tamil Nadu during 19-20 July, 2018

Dr. Debasis De, Principal Scientist attended the Training programme on "Research Excellence in Organizations" organized by Administrative Staff College of India, Hyderabad during 8-10 August 2018

Shri T. Sivaramakrishnan, Scientist attended the Training Course on "LC-Ms based Proteomics" organized by CSIR – CCMB, Hyderabad during 3-13 October 2018

Dr. P. Kumararaja, Scientist attended the Training programme on "Winter School Climate Change impacts and resilience options for Indian marine Fisheries" organized by ICAR-CMFRI, Cochin during 8-29 Nov. 2018

Shri T. Sathish Kumar, Scientist attended the Workshop on "Basic course in Bio-Statistics for medical professionals and non-medical researchers" during 10-14 December, 2018 at NIE, Chennai

Dr. Krishna Sukumaran, Senior Scientist attended the "Training of Master Trainers" organized by Agricultural Skill Council of India during 7-9 January, 2019

Dr. T. Ravi Sankar, Principal Scientist attended the Incubator Manager Training Programme organized by American Corner, St. Francis College for Women, Uma Nagar, Begumpet, Hyderabad during 28-29 January 2019

Dr. J. Raymond Jani Angel, Scientist attended the Training Programme on "Bioinformatics for metagenome data analysis (NGSDAT 2019) Organized by ICAR-Indian Institute of Species Research, Kozhikode, at Kerala during 19-22 March 2019

Dr. T.N. Vinay, Scientist attended the Training Programme on "Bioinformatics for metagenome data analysis (NGSDAT 2019) Organized by ICAR- Indian Institute of Species Research, Kozhikode, at Kerala during 19-22 March 2019

Technical Staff

Dr. Sivagnanam, CTO attended the Training of Trainers programmes under Skill Training Programme organized by ATARI Kanpur during 17-19 December 2019

Shri S. Rajamanickam, ACTO attended the Training of Trainers programmes under Skill Training Programme organized by ATARI Kanpur during 17-19 December 2019

Dr. Joseph Sahayarajan, ACTO attended the Training Course on "Molecular Cloning & Protein Expression" organized by CSIR – CCMB at Hyderabad during 19 June to 13 July 2018

Dr. A. Nagavel, ACTO attended the Training Programme for Technical Personnel on "Experimental data analysis" organized by IASRI, New Delhi during 27 August 1 Sept 2018

Shri S. Prabhu, Technical Assistant attended the Training programme on Green Buildings organized by IGBC, Chennai during 14-15th February 2019

Administrative Staff

Shri S. Pari, AAO (C&B) attended the Training programme on PFMS & FMS organized by ICAR- NAARM, Hyderabad during 10-12th September 2018

Shri A. Sekar, Assistant attended the Training programme on PFMS & FMS organized by ICAR- NAARM, Hyderabad during 10-12th September 2018

Supporting Staff

Shri V. Kishor Kumar, SSS attended the Training programme on PFMS & FMS organized by ICAR- NAARM, Hyderabad during 10-12th September 2018

Trainings Programmes Organized

Headquarters

Sl. No	Name of the Training /FGD	Duration	No. of participants
1	Training Course on "Skill Enhancement in the marine sector (SEMS) for Sustainable Export Opportunities"	7-11 May, 2018	16
2	Training course on "Sustainable crustacean farming in brackish water systems"	14-19 May, 2018	9
3	Skill Development Training programme on "Recent Advances in Soil and Water Management in Brackishwater Aquaculture"	25 - 30 June 2018	20
4	Customized training on Identification, isolation and pure culture of microalgae from sea and brackishwater	11-13 July 2018	
5	NFDB Sponsored Training Progamme on "Seed Production and farming of brackishwater finfish species"	30 July – 3 August 2018	
6	Training Programme on "Hatchery production and farming of milkfish and mullets"	16-20 August 2018	10
7	Customized Training Programme on "Water and Soil Treatment Applications in Aquaculture"	27-28 August, 2018	7
8	Hands-on training on "Aquaculture Genomics and Bioinformatics"	27 August to 1 September, 2018	11
9	NFDB sponsored training on Recent advances in farming of pacific white shrimp	10-14 September, 2018	8
10	Training Programme on Seed Production and culture of Brackishwater Finfishes	18-22 September 2018	2
11	Hands-on Training on "Waste to wealth: Recycling of fish and domestic waste to value added products" at Srinivasapuram, Pattinapakkam, Chennai, Tamil Nadu	28 September 2018	70
12	Hands-on training to women self-help group on recycling of fish waste to value added products at Muttukadu Experimental Station, Muttukadu, Tamil Nadu	1 October 2018	14
13	Customized training on Aqua feed	30 Oct.- 3 Nov.	4

	Processing and Quality Control	2018	
14	Training cum demonstration on "Waste to Wealth" by recycling of fish waste to value added products at Nambikkai Nagar, Pattinapakkam	22 December, 2018	30
15	Customized training on aqua feed processing and quality control	1-5 February 2019	2
16	Advanced Training in Aquaculture Nutrition and Feed Technology	19-28 February 2019	12
17	Hands on Training on Nursery rearing of Seabass (*Lates calcarifer)*	25-27 February 2019	6
18	Hands-on Training on "Waste to wealth: Recycling of fish waste to value added products" at Nambikkai Nagar, Pattinapakkam, Chennai, Tamil Nadu	4-7 March 2019	12
19	National Workshop-cum-Training Programme on "Biofloc Technology for Nursery and Grow-out shrimp aquaculture"	12-16 March 2019	20

Kakdwip Research Centre

Sl. No	Name of the Training /FGD	Duration	No. of participants
1	Training programme on "Seed production and farming technology of brackishwater catfish, Mystus gulio"	2-7 July 2018	25
2	Training Programme on "Advances in Brackishwater Aquaculture"	23-28 July 2018	13
3	Training Programme (Training of Trainer) on "Advances in brackishwater aquaculture practices"	20-24 August 2018	11
4	Training programme on "Brackishwater fish, shrimp and crab culture with feed formulation and feed management "	10-15 September 2018	15
5	Training-cum-awareness programme on integrated farming of Fish and Livestock for the livelihood improvement of tribal people of Sundarban region, organized at Mundapara, Manmathapur, South 24 Parganas.	9 October 2018	50
6	Need based training for IFB Technical Staff on Advances in Brackishwater Aquaculture Practices	26-28 December 2019	19
7	Skill development training for Shrimp	5-29 March	20

	farmers	2019	

Navsari Gujarat Research Centre

Sl. No	Name of the Training /FGD	Duration	No. of participants
1	Training Programme on "Seabass Nursery and Pre Grow out Rearing in happas as a livelihood activity" to Nursery Self-help group beneficiaries (No.s) of Nivati and Redi Villages, Taluka-Vengurla District-Sindhudurg, Maharashtra	17 May, 2018	48
2	Training Programme on "Brackishwater finfish cage culture models as livelihood opportunities for rural folks"		80

Workshops/Seminars/Meetings

SCAFi-CIBA lecture series: GPS and Natural System Research



Dr. K.K. Ramachandran, Scientist & Head, Central Geomatics Lab, ESSO, delivered a presentation on GPS and Natural System Research at ICAR-CIBA on 20th April 2018. He elaborated the different techniques used in and advancement made in the field of GPS and imaging. He also highlighted the applications of GPS in daily life and resource mapping. More than 100 participants comprising scientists, technical officers, research scholars and other staff of CIBA attended the interesting presentation.

CIBA-SCAFi Lecture Series: Technological Advances in Global Shrimp farming (1st May, 2019)



Dr. George Chamberlain delivered a invited talk on technological advancements in global shrimp farming on 1st May, 2019. In his talk he highlighted the importance of seafood and production scenarios and related challenges. He said, being one of the leading producers of farmed shrimp, He said, India has a major role to play in keeping the sustainability in production. He further pointed that, India can achieve newer heights in shrimp production, through the adoption of new technologies, new investments and new markets.

Skill enhancement programme for Fisheries officials



Export Inspection Council (EIC), Govt. of India, in coordination with ICAR-CIBA, conducted a five day 'trainers-training' course on 'Skill enhancement in the marine sector (SEMS) for sustainable export opportunities: during 7-11 May, 2018 at ICAR-CIBA Chennai. A batch of 16 fisheries officials from the states of Andhra Pradesh, Tamil Nadu and Puducherry participated in the programme. The participants were trained on the quality requirements in the primary production chain, processing centres and standards enforced by the major importing nations.

World Environment Day was celebrated on 5th June, 2018



ICAR-CIBA in association with the Society of Coastal Aquaculture and Fisheries (SCAFi), organized an interaction on the occasion of World Environment Day with a theme "Beat Plastic Pollution" on 5th June, 2018 at CIBA headquarters, with a lead talk delivered by Dr.E.Vivekanandan, National Consultant, Bay of Bengal Programme an Inter-Governmental Organization. The talk brought to the focus on "Human Interventions in Coastal Environment" emphasizing that people should strive to change their everyday lives to reduce the heavy burden of plastic pollution.

World Ocean Day was Celebrated on 8th June 2018



Society of Coastal Aquaculture and fisheries (SCAFi) and ICAR-CIBA jointly celebrated "World Ocean Day' on 8th June 2018 at CIBA. On this occasion, Dr. R.

Venkatesan, Head, Ocean Observation Systems, National Institute of Ocean Technology (NIOT), Ministry of Earth Sciences, Chennai has delivered a lecture on "India's Ocean Observation Programme - Relevant to the Society". In his lecture he related the Indian subcontinental ocean research and its relevance vis-a-vis the global counterparts as "WE SEE MORE SEA THAN OTHERS SEE".

Inauguration first CIBA's Regional Research Centre on the West Coast in Gujarat



ICAR-CIBA has inaugurated its Navsari-Gujarat Research Centre (NGRC) in Navsari Agricultural University (NAU) campus, Navsari, on 7th June, 2018 by Dr. J.K. Jena, Deputy Director General (Fisheries), ICAR, in the presence of Shri. R.C. Patel, Member of Legislative Assembly, Navsari, Dr. C.J. Dangaria, Vice Chancellor, NAU and Dr. K.K. Vijayan, Director, ICAR-CIBA, Chennai. Shri. R.C. Patel, Member of Legislative Assembly, Navsari, in his presidential remarks, expressed his happiness on establishing CIBA's centre in Navsari and sought the help of CIBA to bring the technologies for quality seed, cost-effective and quality feed and diseases management products to the shrimp farming sector of Gujrat, so that the cost of production can be reduced.

Dr. J.K. Jena, Deputy Director General (Fisheries) in his inaugural address thanked Vice Chancellor and all the officers of NAU for hosting the NRGC in Navsari Agricultural University campus. Dr. C.J. Dangaria, Vice Chancellor of NAU underlined the opportunities in working together of CIBA and NAU in addressing the needs of the aquaculture farmers, also called for the cost-effective technologies for the benefit of the farmers.

High lighting the importance of CIBA centre in the west coast, Dr K.K. Vijayan, Director, CIBA articulated that CIBA has the expertise in quality seed production, feed technology and aquatic animal health and underlined the importance of having partnership between fisheries college of NAU and CIBA in extending the technological support to the aqua farmers in the region.

During the occasion, Dr. C. Gopal, Member Secretary, Coastal Aquaculture Authority, Govt. of India, Chennai, Dr. Pravin Puthra, Assistant Director General (Fisheries), ICAR and Dr. N.H. Kelawala, Dean, Veterinary College, gave their facilitations and offered support for the newly established centre.

Fourth international Day of yoga celebrations at ICAR-CIBA



The fourth international day of Yoga was celebrated on 21st June 2018 at Central Institute of Brackishwater Aquaculture Chennai. Two guest speakers of eminence have been invited for the program. Dr Saravanan Palaniappan from MIOT hospital, Chennai and Yoga guru and Reader from Government Yoga and Naturopathy Medical College, Dr Indiradevi Subramaniam gave lecture on Lifestyle modifications and cardiac ailments and different types of yoga respectively

Skill development training programme on Recent Advances in Soil and Water Management in Brackishwater Aquaculture

A six-day hands-on training programme on "Recent Advances in Soil and Water Management in Brackishwater Aquaculture" was organized by Environment Section of Aquatic Animal Health & Environment Division (AAHED) during 25 - 30 June 2018.



National Fish Farmers Day with the costal fishers of Puducherry



ICAR-CIBA celebrated the National Fish Farmers Day on 10th July, 2018 with the costal fishers of the Puducherry. Scientist of CIBA, sensitized fishers and other villagers from the coastal areas of Puducherry. Thiru. K. Deivasigamani, Additional Director of Fisheries, Puducherry presided over the interaction. Dr.S.Vasanthakumar, Additional Director of Agriculture and Head, KVK, Puducherry expressed that efforts should be made to enhance the production and income levels of the fishers by adopting the viable technologies developed by ICAR institutions such as CIBA.

ICAR Foundation Day as 'Aquaculture Start-up Day'



Startup initiatives are common in sectors other than aquaculture, and hence an aquaculture startup day has been organized on the occasion of 90th ICAR-foundation at CIBA on 16th July 2018, to infuse innovations and attract entrepreneurship in aquafarming. A Brainstorming workshop on "Startup India programme on aquaculture sector" brought the outgoing students from Fisheries Colleges of Andhra Pradesh, Karnataka, Kerala, and TamilNadu together on the startup platform at CIBA. Shri.Ruban Hobday, Additional Director, FICCI, Chennai was the Chief Guest and he assured that FICCI will give the best possible support for the startups in aquaculture sector. About 70 participants including officials from State Fisheries Departments, Development Agencies like NFDB, MPEDA, MSME, CII, FICCI, Investors, Startups, Professors and students from State Fisheries Universities attended the workshop and participated in the panel discussions.

Independence Day Celebrations at ICAR-CIBA, Chennai

ICAR-CIBA celebrated the Independence Day with colourful illumination of the campus symbolizing the growth and prosperity of the country. Dr K K Vijayan, Director of the institute hoisted the tricolour flag and delivered the speech. In his address he remembered the great sacrifices made by the great leaders and freedom fighters for getting the Independence and highlighted that it is the duty of every Indian citizen to protect the same and to strive hard for sustainable growth and prosperity of the country.



Training programme for state fisheries officials



A need based training programme for the Kerala State fisheries officials on "Hatchery production & farming of milkfish and mullets" from 16th to 20th August 2018. Dr. Baskaran Manimaran, former Vice chancellor, Tamil Nadu Fisheries University inaugurated the training. He appreciated the holistic efforts of CIBA in developing technologies for seabass, milkfish, mullet, pearlspot and other ornamental fish breeding and culture in the development of brackishwater aquaculture in the country.

Skill development programme on Water and Soil Treatment Applications in Aquaculture



A customized training program on "Water and Soil Treatment Applications in Aquaculture" during 27-28 August, 2018 to a group of seven technical persons from Grasim Industries Ltd - Aditya Birla Group. The focus of the training was on application of chemical and biological products in improving aquaculture pond water and soil environment.

MOU signed with Govt. of Gujarat for the Brackishwater Aquaculture Development in the state

ICAR-CIBA, Chennai and the Department of Fisheries, Gujarat have signed a Memorandum of Understanding for the sustainable development of brackishwater aquaculture in Gujarat on 5th September, 2018. Dr. K. K. Vijayan, Director, ICAR-CIBA, Chennai and Shri. Mohammed Shahid (IAS), Commissioner of Fisheries, Department of Fisheries, Gujarat signed the MOU in the presence of Shri. R. C. Faldu, Hon'ble Cabinet Minister for Agriculture, Rural Development, Fisheries, Animal Husbandry and Transport, Government of Gujarat.



Inauguration of Community Development Centres under Corporate Social Responsibility (CSR)



ICAR-CIBA in collaboration with the Karam Chand Thapar (KCT) group established Community Development Centre for Learning, Livelihood and Research (CDC-LLR) at Bhimavaram, West Godavari district, Andhra Pradesh (AP). The farmers community centre and state-of-the-art aquaculture diagnostic laboratory, the second in AP was inaugurated on 12th September 2018. Shri.P.Koteeswara Rao, Additional

Director of Fisheries, Govt. of Andhra Pradesh, Shri.Ramakanth V.Akula, CEO, the Waterbase Limited (TWL), Ms. Shomasree Dey, Head of CSR, KCT group graced the event.

Training-cum-awareness programme on integrated farming of fish and livestock in Sundarban region



Kakdwip Research Centre (KRC) of ICAR-CIBA has organized day training-cum-demonstration programme on integrated farming of Vegetables, Fish and Livestock at Mundapara, Manmathapur, South 24 Parganas for the livelihood improvement of tribal people on 9th October 2018. The training was attended by 50 farmers along with local Gram Panchayat representatives, Pradhan and social activists. In the interaction meeting Dr. Ananta Das, Veterinary Officer, Kakdwip block sensitized the people about the practices and problems of animal husbandry.

Mahila Kisan Divas with Irula Tribal Women

ICAR-CIBA celebrated Mahila Kisan Divas on 15th October, 2018 at Karathittu village, Vayalur Panchayat of Kancheepuram district of Tamil Nadu to recognize the contribution of women in fisheries and aquaculture. About 60 tribal women from the village participated in the programme. Two successful women farmers from Thirividanthai village who have successfully adopted CIBA's Pearlspot fish larval rearing technology shared their experiences the way the technology provided them a viable livelihood option.



Interaction meeting of the second sub committee of parliament on official language



The second sub-committee of Parliament on Official Language had interaction meeting with officials of Central Institute of Brackishwater Aquaculture, Chennai on 4th October, 2018. The meeting was convened by Honorable Dr. Prasanna Kumar Patasani, Member of Parliament (Lok Sabha) and Convenor of the second sub-committee of Parliament on Official Language. The other honorable members of this committee were Dr. Sunil Baliram Gaikwad, Member of Parliament (Lok Sabha), Shri Prataprao Ganpatrao Jadhav, Member of Parliament (Lok Sabha), Shri Pradeep Tamta, Member of Parliament (Rajya Sabha), and Mr. Harnath Singh Yadav, Member of Parliament (Rajya Sabha). The interaction meeting, was attended by Dr P. Praveen, Assistant Director General (My.F.), ICAR, New Delhi, Shri M.L Gupta, Deputy Director (Official Language), ICAR, New Delhi, Mr. Manoj Kumar, ACTO, ICAR, New Delhi. Dr. M. S. Shekhar, Principal Scientist and Officer, In-charge Hindi Cell.

Milkfish harvest mela in Pulicat, Tamilnadu



ICAR-CIBA has successfully demonstrated an innovative two-tier milkfish farming, nursery rearing and grow-out in an open water pen erected in the brackishwater body, as a livelihood initiative for the benefit of tribal families. The harvest mela was conducted on 23rd October 2018 at the demonstration site Kanavanthurai village, Tiruvallur district, Tamil Nadu. Around 100 participants including village panchayat president, progressive farmers, tribal families, officials from Chennai Petro Chemicals Ltd., who are partnering with CIBA in supporting the coastal families for their economic improvement elsewhere under corporate social responsibility (CSR) scheme, officials from Bank of India (BOI), participated in the function.

Annual review meeting of Consortium Research Platform (CRP) on vaccines and diagnostics

The Annual Review Meeting (2017-18) of the Consortium Research Platform on Vaccines and Diagnostics was held at ICAR-CIBA during 30-31, October, 2018 under the chairmanship of Dr. Joykrushna Jena, Deputy Director General (Fisheries) and DDG in-charge Animal Sciences, ICAR. Dr. Ashok Kumar, ADG (AH), ICAR, Dr. K. K. Vijayan, Director, CIBA, Dr. Aniket Sanyal, Co-ordinator, CRP on V & D, sectoral coordinators and all Principal investigators under CRP on Vaccines and Diagnostics participated in the event.



CIBA-SCAFi Lecture Series: Emotional Quotient and You



Prof. (Dr) Mohan Joseph Modayil, Former ASRB Chairman, Ex-Director CMFRI delivered invited talk on 15th November, 2018, at CIBA, Chennai. Prof. Modayil cited the importance of balanced Intelligence Quotient (IQ) and Emotional Quotient (EQ) in with a balance in personal life and career. The anecdotes on the attributes to be acquired by citing the 'Ant Philosophy' and 'Fish philosophy' was very captivating. The meeting was coordinated by the office bearers of Society of the Coastal Aquaculture and Fisheries (SCAFi).

World fisheries day with fishers of coastal village



ICAR-CIBA celebrated the World Fisheries Day with the coastal fishers at Karathittu village in Vayalur Panchayat of Kancheepuram district of Tamil Nadu. About 60 fishers' including, tribals and rural youth participated in the programme. The participants were sensitized about the importance of sustainable fishing, impact of habitat destruction and conservation of bio-diversity and opportunities for livelihood and income through the technologies developed by CIBA.

ICAR-CIBA distributed "soil and water heath cards" during world soil day



On the occasion of celebration of World Soil day, ICAR-CIBA organized Brackishwater Aquaculture Farmers Meet at B.Mutlur, village, Cuddalore District, Tamil Nadu on 5th December 2018 under the National Innovations in Climate Resilient Agriculture (NICRA) Project. On this occasion, 104 farmers participated in the meeting, and received Soil and Water Health Cards (SWHC), on a Public Private Partnership (PPP) initiative by CIBA. During the meeting, 55 SWHCs were distributed to aqua farmers from the shrimp farming belt in the presence of Dr. M. Srinivasan, Director and Dean, Faculty of Marine Sciences, Annamalai University, Parangipettai, Shri C. Subramanian, Assistant Director of Fisheries, Parangipettai, Shri Babu, RGCA (MPEDA).

Kisan Diwas with fishers and tribal farmers of Tamil Nadu

National Farmers Day or Kisan Diwas is celebrated every year on 23rd December in the honour of Chaudhary Charan Singh who was the fifth Prime Minister of India. ICAR-CIBA celebrated the Kisan Diwas with the fishers and tribal farmers of the Sadraskuppam village, Kancheepuram district, Tamil Nadu.



ICAR-CIBA Foundation and Annual day





ICAR-CIBA celebrated its Foundation and Annual Day on 29th December, 2018. On this occasion the institute observed "Open House" by making the laboratories open to the graduate and post graduate students of city colleges and the public to visit the state-of-the-art research facilities. The exhibition of brackishwater live fishes, shrimp and crab species, and an array of ornamental fishes, has been the main attraction.

The annual day was celebrated in the evening where Dr. M. A. Atmanand, Director, National Institute of Ocean Technology (NIOT), Chennai graced the occasion as Chief Guest. On the occasion, Dr. Atmanand appreciated the efforts and achievements of CIBA, and specially appreciated the efforts in bringing the green concepts to the CIBA campus. He appreciated the CIBA's lead role in the frontier areas of aquaculture and emphasized the necessity for the active co-operation between institutions such as CIBA and NIOT to pave the way for sustainable aquaculture. Dr K. K. Vijayan, Director, ICAR-CIBA, in his welcome address, briefed about the progress of the Institute during the past year.

The Brackishwater Aquaculture Farmers Conclave -2019



ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) in collaboration with Society of Coastal Aquaculture and Fisheries (SCAFi) has organized the Brackishwater Aquaculture Farmers Conclave – 2019 on 22 January, 2019 a pan-Indian assembly of brackishwater aquaculture farmers in connection with the World Brackishwater Aquaculture Conference (Braqcon-2019). Dr.M.S. Swaminathan, the doyen of Indian agricultural research and education has inaugurated the Farmers Conclave in the presence of Thiru. D. Jayakumar, Hon'ble Minister for Fisheries, Personnel and Administrative Reforms, Govt. of Tamil Nadu, Dr. K. Gopal, IAS, Principal Secretary, Animal Husbandry, Dairying & Fisheries, Govt. of Tamil Nadu, Dr. B. Meenakumari, Chairperson, National Biodiversity Authority (NBA), Dr. J.K. Jena, Deputy Director General (Fisheries), Indian Council of Agricultural Research, Shri. N. Vasudevan, Additional Principal Conservator of Forest, Mangrove Foundation, Govt. of Maharashtra, Dr. K.K. Vijayan, Director, CIBA and Convener, Braqcon-2019. Dr. Swaminathan in his address highlighted the importance of fisheries in food and nutritional security, doubling the income of fish farmers and environment friendly aquaculture. Thiru.D. Jayakumar, Hon'ble Minister for Fisheries, Personnel and Administrative Reforms, Govt. of Tamil Nadu who is the Chief Guest of the programme released the diagnostic kits, publications, mobile smarts apps and inaugurated the Aquaculture Expo and Seafood court arranged in the CIBA campus. About 1200 participants including 950 aqua farmers representing all the coastal states, Haryana, Punjab and Rajasthan participated in the conclave. During the farmers' conclave 30 innovative farmers from all the coastal states and Haryana presented their innovative approaches and success stories in brackishwater aquaculture during the technical session on farmer presentations.

World Conference on Brackishwater Aquaculture (Braqcon-2019)



The World Brackishwater Aquaculture conference BRAQCON2019 was held at ICAR-CIBA, Chennai between Jan 23rd and 25th Jan, 2019. Dr. Trilochan Mohapatra, Secretary, Department of Agricultural Research and Education and Director-General, ICAR inaugurated World Brackishwater Aquaculture Conference (Braqcon-2019) on 23rd January in the presence of Dr. J.K. Jena, DDG, Fisheries and Animal Sciences, Dr. S.K. Saxena, Director, Export Inspection Council, GOI, Dr. K.K. Vijayan, Director, CIBA and Convener of Braqcon-2019. In his address he highlighted that seafoods exports contributed about 5 billion USD for the national income. In order to develop this sector on a sustainable basis, concerted efforts by research and development organizations need to be strategically planned and implemented in coordination with the private sectors, farmers and other related stakeholders. In the research angle, in addition to species diversification, nutrition and input supply, long term breeding programmes need to be evolved for improving the productivity of brackishwater aquaculture species need to be thought of. He emphasized that gene editing would be key for breeding of shrimps and fishes with specific characteristics like disease pathogen exclusion, faster growth and meat quality. Dr.J.K.Jena, Deputy Director General (Fisheries), ICAR emphasized the importance of fisheries and aquaculture in India and the technology support rendered by the ICAR institutions. About 700 fishery scientists including 30 international fisheries experts presented their research achievements in the conference.

BRAQCON 2019 has come to the end in the evening on 25 Jan, 2019 with the valedictory function presided by Dr.Modadugu Vijay Gupta, the World Food Prize Laurate. In his address, Dr.Gupta congratulated ICAR-CIBA and Society of Coastal Aquaculture and Fisheries (SCAFi) for organizing this world conference on Brackishwater Aquaculture at appropriate time. Dr. S.D.Tripathi, former Director Central Institute of Freshwater Aquaculture and Central Institute of Fisheries Education, presented the recommendations of BRAQCON 2019. He highlighted recommendations on major issues in brackishwater aquaculture related to diversification of species and rearing system, fish nutrition, biotechnology, aquatic animal health, aquatic environment and climate change, ecosystem & biodiversity conservation, and socio economic issues



Republic day celebrations



ICAR-CIBA celebrated republic day on 26th Jan, 2019 with CIBA scientist, staff and their family members. Dr K K Vijayan, Director of the institute hoisted the national flag and delivered the speech.

Inauguration of fish waste processing unit-an initiative under circular economy in fisheries & aquaculture

On 18th February,2019 ICAR-CIBA inaugurated a "Fish Waste Processing Unit" at Nambikkai Nagar, Pattinapakkam, Chennai, Tamil Nadu established by the institute which will be operated by a Self Help Group (SHG) of Nambikkai Nagar for recycling of fish waste to high value added products as an initiative towards Circular economy in fisheries and aquaculture.



National Productivity Week Celebrations





National productivity week was celebrated at ICAR-CIBA, Chennai from 12th to 18th February, 2019 in aligning with the theme of Circular Economy for Productivity & Sustainability". The celebrations were initiated by imparting hands on training to fisherwomen of Srinivasapuram village on 'converting fish waste to value added products' on 12th February, 2019.

Workshop Cum Training On “Biofloc Technology



ICAR-CIBA conducted a five-day National workshop cum training programme on “Biofloc Technology for Nursery and row-out Aquaculture” between 12th and 16th March, 2019 at Chennai. The training programme was inaugurated on 12th March 2019 by Dr. A. K. Munirajan, Professor & Head, Department of Genetics, University of Madras, Chennai.

Awards and Recognizations

ICAR National Team Award For Nutrition And Feed Biotechnology Won By CIBA Scientists

ICAR-CIBA Nutrition team was awarded with Nanaji Deshmukh ICAR Award for outstanding interdisciplinary team research in Agriculture and allied sciences 2015-16 in the category of Animal and Fisheries Sciences. The nutrition team comprising of Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. K.P. Kumaraguru Vasagam, Late Shri. S. Stanline, Dr. P. Nila Rekha, Dr. Debasis De, Shri. Sandeep, K.P., Dr. T.K. Ghoshal and Dr. K.K. Vijayan. The team leader, Dr. K. Ambasankar, Principal Scientist received the award from Dr. T. Mohapatra, Hon'ble secretary DARE and Director General ICAR, on the occasion of Pusa Krishi Vigyan Mela organized at ICAR- IARI New Delhi on 5th March 2019. The Award carries a citation and cash prize of INR 5 Lakhs.







Dr.M.Kumaran, Principal Scientist, Social Sciences Division, ICAR-CIBA has been conferred with **Swami Sahajanand Saraswati Outstanding Extension Scientist Award-2017** (Individual category) of the ICAR on 16th July, 2018 for his outstanding and impactful contribution in the field of Brackishwater Aquaculture Extension

Research, Capacity enhancement and Technology Transfer through innovative approaches.

ICAR-CIBA received Certificate of Appreciation from DG, ICAR on 4th December 2018 for proactively implementing ICAR-Research Data Management Guidelines and uploading more than 700 publications in KRISHI portal.



भारतीय कृषि अनुसन्धान परिषद
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
भा.कृ.अनु.प. में ज्ञान संवर्धन के लिए अनुसंधान आंकड़ों का कोष
ICAR Research Data Repository for Knowledge Management

CERTIFICATE OF APPRECIATION

प्रशंसा पत्र

यह प्रशंसा पत्र **भा.कृ.अनु.प. - केन्द्रीय खारा जल जीवपालन अनुसंधान संस्थान, चेन्नई** को भा.कृ.अनु.प. अनुसंधानिक आंकड़ों के प्रबंधन दिशानिर्देशों के सक्रिय क्रियान्वयन एवं कृषि पोर्टल में कृषि पोर्टल में 700 से अधिक **प्रकाशन** अपलोड करने के लिए प्रदान किया जाता है।

This certificate of appreciation is awarded to **ICAR- Central Institute of Brackishwater Aquaculture, Chennai** for proactively implementing ICAR Research Data Management Guidelines and uploading more than 700 **Publications** in KRISHI Portal.

(नरेन्द्र सिंह राठौड़)
उपमहानिदेशक (कृषि शिक्षा)
(Narendra Singh Rathore)
DDG (Agricultural Education)

(के. अलगुसुन्दरम)
उपमहानिदेशक (प्राकृतिक संसाधन प्रबंधन)
(K. Alagusundaram)
DDG (Natural Resource Management)

दिनांक : 04 दिसंबर 2018

Date: 04 December 2018

Dr. R.Ananda Raja and team got the best oral presentation award for the paper entitled "Fatty liver syndrome in pearlspot, *Etroplus suratensis*" in the "Fourth National Agricultural Science Tamil Research Conference" organized by Agricultural Scientific Tamil Society, New Delhi at The Directorate of Research, TNFU Campus, OMR, Vaniyanchavadi, Chennai during 10-20 November, 2018

Dr.M.Kailasam, Principal Scientist received best Scientist Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018

Dr. Shyne Anand, Scientist received best Scientist Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018

Dr.Joseph Sahaya Rajan, Asst. Chief Technical Officer received best Technical Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018

Late Mr. Stanline, Technical Officer received best Technical Award posthumously for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018

Mrs. Mary Desouza, Assistant received best Administrative Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29th December 2018

Mr. Pichandi & Mr, Jeevanandam received best Supporting Staff Award for the year 2017-18 by ICAR-CIBA & SCAFI in the CIBA Foundation cum Annual Day held on 29 December 2018

Dr. G. Biswas, Senior Scientist received the Best Oral Presentation Award (First Place) for the paper entitled "System Diversification in Brackishwater Aquaculture of India: Research Support on Fish Culture Options for Sundarban Producers" presented in the International Congress on Engineering and Life Science (ICELIS 2018) held during April 26-29, 2018 at Kastamonu, Turkey.

Dr. K.P. Jithendran, Principal Scientist received Springer Nature–Indian Virological Society Award for the best paper published in Virus Disease on Aquatic Virology during Virocon-2018, PGIMER, Chandigarh, India during 10-14 November 2018

Shri T. Sathish Kumar, Scientist awarded with best oral presentation in the Fourth National Agricultural science Tamil research conference" Nov 19-20, 2018 at TNJFU, Chennai for the oral presentation on "Rapid and specific loop mediated isothermal amplification detection of Enterocytozoon hepatopenaei (EHP)'' in Tamil.

Dr. M. S. Shekhar, Principal Scientist received the Best poster award for for the paper entitled "Understanding the course of infection: determining gene expression changes with time in *Penaeus vannamei* infected with white spot

syndrome virus" in the World Brackishwater Aquaculture Conference (BRAQCON, 2019) during 23-25 January, 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai

Dr. M. Makesh, Principal Scientist received the Best Oral Presentation Award for the paper entitled "Development of Inactivated oral NNV Vaccine for Asian Seabass, *Lates calcarifer*"

Dr. S. N. Sethi, Principal Scientist received the Best Poster Presentation Award in the field of Brackishwater/Marine Biodiversity and Conservation in World Brackishwater Aquaculture Conference (BRAQCON, 2019) during 23-25 January, 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai

Dr. Krishna Sukumaran, Senior Scientist received the Best Poster Presentation Award for the poster entitled "Growth and reproductive parameters of two geographical groups of grey mullet *Mugil cephalus*" in World Brackishwater Aquaculture Conference (BRAQCON, 2019) during 23-25 January, 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai

Dr. K. Vinaya Kumar, Senior Scientist received the Best Oral Presentation Award for the paper entitled "The applications of genomics and proteomics in Aquaculture, Fisheries and Marine biology (omicsAFM 2018)" at the National Symposium on ', Sathyabama Institute of Science and Technology, Chennai, 20th and 21st of June 2018.

Dr. K. Vinaya Kumar, Senior Scientist received the Best Poster Presentation Award in the International conference on World Brackishwater Aquaculture Conference (BRAQCON 2019) held during 23-25 January 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai.

Dr. Prem Kumar, Scientist received the Best Poster Presentation Award for paper entitled "Larval development, rearing and digestive tract ontogeny of Indian shad, *Tenulosa ilisha*" in the International conference on World Brackishwater Aquaculture Conference (BRAQCON 2019) held during 23-25 January 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai.

Shri Jose Antony, Scientist received the Best Poster Presentation Award for paper entitled "….."in the International conference on World Brackishwater Aquaculture Conference (BRAQCON 2019) held during 23-25 January 2019 organized by ICAR-CIBA & SCAFI at ICAR-CIBA, Chennai.

PhD obtained



Shri S Sivakumar, was awarded PhD degreree by University of Madras, for his doctoral thesis, "Development of Cell culture system from crustacean and insect cell lines and adaptation of white spot syndrome virus (WSSV). The research work was carried out under the supervision of Dr N. Kalaimani, Retired Principal Scientist, ICAR-CIBA

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.

Consultancies, Technology Development and Transfer

Institute Technology Management and Agri Business Incubation Unit (ITMU) & (ABI)

Institute Technology Management Unit and Agri Business Incubator have been functioning with ICAR-National Agricultural Innovation Fund at ICAR-CIBA. The Performance has been consistently good and CIBA is generating revenue of Rs.25 lakhs and above every year from commercialization of various technologies developed by ICAR-CIBA. In total CIBA has signed 112 MoUs and Rs.168 crores of revenue have been generated. In addition, CIBA also made partnership with various national and state level institutions, farmers and other stakeholders of the brackishwater sector for backstopping sustainable brackishwater aquaculture in the country.

MOUs Signed in 2018-19

A total number of Twenty one MoUs have been signed during April 2018 to March 2019. A total amount of Rs.24.00 Lakhs (Rupees Twenty Four lakhs) was generated as one time license fee. Revenue share and royalty of 3 to 10% is expected to be received by the institute in the event of good crops in this year. Two patents have been granted and one patent application has been filed.

Technologies transferred /commercilaized

Strategic alliance with ‘The waterbase Ltd’ in the promotion of brackishwater aquaculture in the country



The Waterbase Ltd, one of the pioneering Indian company that manufactures high-quality shrimp feed signed a Memorandum of Understanding (MoU) on 10th April 2018, for a collaborative programme of eco-friendly shrimp feed technology. The collaboration programme will cover technical collaboration and partnership in the development of ecofriendly shrimp feed, the Vanami Ecoplus

Partnership with Corporate Social Responsibility (CSR) initiatives of KCT



The KCT group signed a memorandum of understanding (MoU) at Thapar House in Delhi on 10th April 2018, as a knowledge partner. This collaborative effort is targeted to benefit aqua farmers in Nellore region for their needs with regard to testing and diagnostic services related to soil & water quality of aquaculture ponds, seed quality, DNA-based screening of disease causing microbial pathogens and feed quality.

First shrimp feed mill Dr Attar Aqua Feed, Haryana in Northern India



A cost effective and quality shrimp feed using indigenous feed ingredients for vannamei farming was developed and the feed is promoted as the ‘Vanami Plus’. The technology is transferred to Dr Attar Aqua feed, Haryana. Dr Attar Aqua feed commissioned a new feed mill at Bhiwani, Haryana by adopting Vanami Plus feed technology of CIBA, through an MOU. It is a first of its kind in Northern India, which will be a great advantage for shrimp farmers in inland saline regions of Punjab, Haryana and Rajasthan, where the feed is brought from the southern states

Technology transfer of indigenous shrimp feed



Vanami *Plus'* feed technology was transferred to Pranita Marines, Andhra Pradesh on 14th August 2018. The company envisaged to produce shrimp feed with the CIBA's technical guidance. The feed will meet the demand of aquaculture farmers in and around Bhimavaram which is expected to benefit the shrimp farmers, and to increase the profitability.

Technical partnership with Ministry of Earth Sciences (ESSO)-NIOT in the promotion of aquaculture in the country



Technical partnership with Ministry of Earth Sciences (ESSO)-NIOT in the promotion of aquaculture in the country was initiated on 25th September, 2018 through an MoU. The MOU will help to contribute towards the roadmap conceived by the MoES 'Farming the Oceans for the Future' to promote India's blue economy. Partnership of NIOT with its blend of engineering expertise in finfish cages and CIBA with its proven technologies in hatchery, farming and feed biotechnology for candidate finfish species such as Seabass, would help in expanding the finfish cage culture operation, in the depths from 5 m to 100m.

Technology Transfer of Seabass Fish Hatchery Technology



Hatchery technology developed for the production of seabass seed and nursery rearing technology for the fingerlings, has been transferred to a young entrepreneur, Mr. Nishanth Reddy from Nellore, Andhra Pradesh through an MOU on 30th October 2018, at CIBA Headquarters, in the presence of Dr. J K Jena, DDG (Fy. Science), ICAR, New Delhi.

Transfer of formulated fish and shrimp feed technology to promote brackishwater aquaculture development in the West coast of India



Strategic alliance was made with Aditi Enterprise, Porbandar, Gujarat by transferring Shrimp and Seabass Feed Processing Technologies to spread its feed biotechnology footprints in the West coast of the country. The feed will cater to the need of aquaculture farmers of West coast of the country, particularly the small and marginal farmers, who cannot afford the high cost feed. The proposed concept of 'factory to farm' promoted by CIBA would help the farmer to source the feed directly from the feed mill, enabling the farmers to save the usual marketing cost also.

Transfer of "CMH MINERAL, AMMONIA, NITRITE & DO Technology



Maintenance of water quality parameters in optimum level is critical for successful aquaculture operations. It is essential to monitor pH, dissolved oxygen (DO) and the toxic metabolites like, ammonia and nitrite which are critical for the survival of aquatic animals. Different kits have been developed for detection of these parameters in hatcheries and grow-out farms will help in taking up immediate measures for preventing the economic loss. These kits was transferred the New Bio Science Company, Mysore on the 24th day of January, 2019 by signing MoU.

Transfer of "CIBAMOX"- Water Probiotic Technology



ICAR-CIBA has developed a water probiotic "CIBAMOX" which has the innovative combination of ammonia oxidizing bacteria, nitrite oxidizing bacteria and denitrifying bacteria. The technology is being transferred to Rallis India Limited, (Tata Enterprise), Mumbai for up-scaling and commercial production. In this regard, CIBA signed the MoU on 15th February 2019.

Technology transfer on fish feed processing and production



Institute has developed fish feed processing and production technology and transferred the fish feed technology for commercial production to various clients. The technology was licensed to Sanvika Feeds, Ernakulam, Kerala on 16th day of March 2019 by signing a MoU.

Collaborative Programme with Aquaculture Development Cooperative Society (ADCOS), Payyanur, Kerala- For Capacity Development and Transfer of Location Specific Brackishwater Aquaculture Technologies

Aquaculture Development Cooperative Society (ADCOS), Payyanur, Kerala inked a MoU on the 25th March, 2019 to train the aqua farmers of the ADCOS and dissemination of CIBA technologies suitable for the agro-climatic situation of the west coast. Under the agreement CIBA will partner with the farmers group to provide technical guidance for the adoption of brackishwater technologies suitable for the region.

Evaluating the utility of Krill meal in shrimp diet



M/S. Aker Biomarine private Limited, Mumbai made an alliance to harness the nutritional potency of Krill meal in shrimp and fish feeds on 28th March 2019. Aker Biomarine is a Oslo based Norwegian fishing and biotech company providing krill meal and value added products through a fully regulated and sustainable value chain, from the Antarctic region. As the major supplier of krill to the salmon farming industry, the nutritional superiority of the krill meal in salmon feeds has been proven. Aker Biomarine India Private Limited, Mumbai is a subsidiary of Norwegian company taking up the operations in India and wanted to promote krill mill as a functional component in shrimp and fish feeds with, which would benefit the Indian feed Industry and aquaculture sector.

Partnership with Farmers

Biofloc based Shrimp Nursery Technology demonstrated by ICAR-CIBA



Frontline Demonstrations on Biofloc based Nursery rearing Technology for Pacific white shrimp *Penaeus vannamei* have been conducting in different parts of the country with support from the Department of Biotechnology, Govt. of India. The genesis of this demonstration was initiated with the MOU signed with one progressive farmer (Dandapat Aquatics) on 10th July, 2018 in presence of Hon'ble Member of Parliament Mr Rabindra Jena.

Technical Support and Partnership farming for Adoption of Periphtyon based milkfish Grow-out culture Model



MoUs were signed for technical support and Partnership farming for Adoption of Periphtyon based milkfish Grow-out culture Model with Sri. Animesh Das and Sri Krishnendu Gayan, Shibgobindapur - South 24 Parganas, Pin-743371, West Bengal on 28th June 2018

Government Department

Sustainable development of brackishwater aquaculture



Memorandum of understanding was signed for the sustainable development of brackishwater aquaculture between Govt. of Gujarat and CIBA for the Brackishwater Aquaculture Development in the state on 5th September 2018. The MoU is for the development, refinement and transfer of technologies by CIBA in brackishwater aquaculture for the state of Gujarat and refine localized brackishwater aquaculture solutions on a partnership mode for farmers and entrepreneurs in Gujarat.

Meeting Organized

ICAR Foundation Day as 'Aquaculture Startup Day' to promote innovations and entrepreneurship in Indian aquaculture Sector



Startup initiatives are common in sectors other than aquaculture, and hence an aquaculture startup day has been organized on the occasion of 90th ICAR-foundation at CIBA on 16th July 2018, to infuse innovations and attract entrepreneurship in aquafarming. A Brainstorming workshop on "Startup India programme on aquaculture sector" brought the outgoing students from Fisheries Colleges of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu together on the startup platform at CIBA. About 70 participants including officials from State Fisheries Departments, Development Agencies like NFDB, MPEDA, MSME, CII, FICCI, Investors, Startups, Professors and students from State Fisheries Universities attended the workshop and participated in the panel discussions.

Start-Up Meet 2019

As a part of the conference a Start-Up Meet was organized on 24th January 2019, chaired by Dr Sanjeev Saxena, ADG IPTM, ICAR, New Delhi, in which about 70 participants including scientists, business entrepreneurs, Start-Up entrepreneurs, prospective Start-Up personnel, Senior officials from NABARD, Patent Office, State Department officials from Tamil Nadu, Andhra Pradesh and Odisha, Oriental Insurance, faculty students from fisheries college have participated in the group-discussion meet on opportunities, problems and prospects of the Start-Ups in aquaculture sector





Agri Start-up conclave



Young entrepreneurs of ICAR-CIBA at Agri Start-up conclave on 16 & 17th October 2018 at NASC complex, New Delhi

Revenue Generated during 2018-19

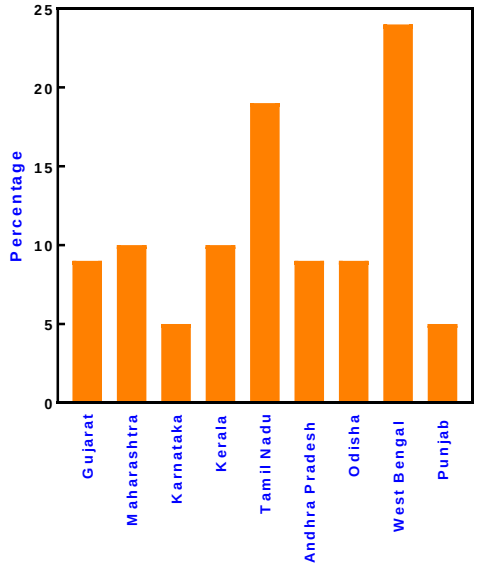
The Revenue earned from different types of activities and revenue from onetime payment and royalty/revenue share obtained in the total revenue generated.

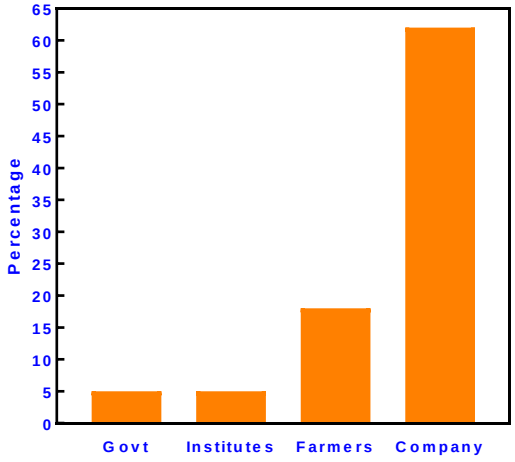
Revenue Generated

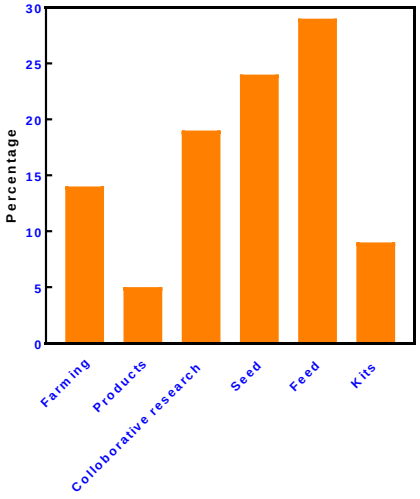
Client Name	Revenue Generated
The Water Base Ltd, Chennai 600 008.	2,36,000
Dr.Attar Aqua Feed, Haryana.	1,10,000
Mr.Suryakumar Boriah-CEO, Hitide Seafarms, Tamil Nadu	50,000
Shri. Anjan Kumar Dandapat, M/s. Laxmi Narayan Feeds, Odisha	88,500
Sri Krishnendu Gayan, West Bengal.	20,000
Sri. Esukapalli Nagaraju, M/s. Pranita Marines, AP	1,18,000
Sri Aniruddha Das, West Bengal	20,000
Shri. Nishanth Reddy, AP.	2,36,000
Shri. Keshav Odedara, M/s.Aditi Enterprises, Gujarat.	7,08,000
Mrs.B.Aarthi, New Bio Science Company, Mysore.	2,50,000
Dr. R. Singaravel, Coastra Biosolutions Pvt. Ltd.,Chennai.	1,47,500
Rallis India Limited, Mumbai.	2,36,000
Shri Alok Kumar Choudhury, Sri Jagannath Foods &Aquaculture Odisha	1,50,000
Oriental Insurance	27,000
Total	**23,97,000 (inclusive of tax)**

CIBA's MoU with different Stakeholders

Nature of organizations which signed MoU with ICAR-CIBA







RESEARCH & ADMINISTRATIVE MEETINGS

Research Advisory Committee (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F.No.18-3/2016-ASR-I dated 06.12.2016) for a period of three years with effect from 01.01.2017:

Chairman	Dr. K. Gopakumar
Members	Dr. V.V.Sugunan Dr. K.M.Shankar Dr. G.Gopakumar Dr. S.N. Mohanty Dr. Aparna Dixit Dr Pravin Puthra Dr.K.K.Vijayan
Member Secretary	Dr. Subhendu Kumar Otta

The 24th meeting of the Research Advisory Committee (RAC) of CIBA was held on 2nd March 2019 at CIBA Headquarters, Chennai.



Institute Research Council (IRC)

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. P. Balasubramanian

Dr. S.V. Alavandi
Dr. G.Gopikrishna
Dr. M. Kailasam
Dr. C.V.Sairam
Dr. M. Muralidhar
Dr. K. Ambasankar
Principal Investigators of all the projects

Member Secretary — Dr. Subhendu Kumar Otta

The 35th IRC Meeting was held on 26-27th April 2018 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. Sudhansu Sekhar Mishra, Principal Scientist, ICAR- CIFA, Bhubaneswar
Dr. V.R. Suresh, Principal Scientist, ICAR-CIFRI, Barrackpore, West Bengal
Dr. Vindhya Mahendra, Principal Scientist, ICAR-NBFGR, Lucknow
Dr. Shekarnath Ojha, Principal Scientist, ICAR-CIFE, Mumbai
Commissioner of Fisheries, Govt. of Tamil Nadu, Chennai
Commissioner of Fisheries, Govt. of Gujarat, Gandhi Nagar
The Dean, FCRI, TANUVAS, Thoothukudi

Member Secretary
Dr. T. Ravisankar, Principal Scientist & Head of Office

Co-opted Members
Dr. S. K.Otta, Principal Scientist, OIC, PME Cell
Dr. M. Jayanthi, Principal Scientist & OIC Engg. Cell
Shri R.K.Babu, Finance & Accounts Officer
Shri. R. Kandamani, AAO (Stores)
Smt. V. Usharani, AAO (Estt.)
Shri S. Pari, AAO & DDO
Shri. P. Srikanth, Junior Accounts Officer

Non-Official Members

Sh. S. Satish Kumar, Farmers' Representative
Sh. R.P. Venkatachalam, Farmers' Representative

The 50th IMC meeting held on 3rd September, 2018

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 R.K.Babu, Finance & Accounts Officer
	Smt. V. Usharani, AAO (Estt.)

Staff Side

Secretary	Shri A.Manoharan, Assistant
Members	Shri N.Jagan Mohan Raj, Sr. Technical Asst Shri K.Paranthaman, Technical Asst. Smt. E.Mary Desouza, UDC Shri M.Sakthivel, Skilled Support Staff Shri C.Raghu, Skilled Support Staff

Grievance Committee

The composition of the Institute Grievance Committee (reconstituted by CIBA vide Office Order F.No.48-16/2010-Admn. Dated 06.06.2016) is as follows:

Chairman	**Dr. K.K.Vijayan**

Elected Members

Scientific Member	Dr. J. Shyam Dayal, P.S & Dr. Nila Rekha, P.S
Technical Member	Dr. A. Nagavel, Senior Technical Officer
Administrative Member	Mrs. Usha Rani, A.A.O
	Shri P. Srikanth, J.A.O
	Shri. A. Manoharan, Assistant
Staff Member	Shri. M. Pichandi, Skilled Support Staff

Women Complaint Committee

Women Complaint Committee has been constituted as follows:

Chairman	**Dr. R. Saraswathy, Principal Scientist**
Members	Dr. Prasanna Kumar Patil, Principal Scientist Dr. P.Nila Rekha, Principal Scientist Shri N.Jagan Mohan Raj, Sr. Technical Asst Smt. E. Mary Desouza,

External Member Dr. A. Sumathi, Asst. Prof. & Head–in-Charge, Dept. of Biomedical Sciences , Sri Ramachandra Medical College, Porur, Chennai

Women Cell

Women Cell has been constituted as follows:

Chairman	**Dr. D.Deboral Vimala, Principal Scientist**
Member	Dr. R.Saraswathy, Principal Scientist
	Smt. B.Amudavalli
	Smt. K.Subhashini, PA
	Smt. M.Mathuramuthubala
Member Secretary	Shri R. Kandamani, AAO

SERVICES AND ASSIGNMENTS

Services in Committees

Dr.K.K.Vijayan, Director

- Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai.
- ICAR Regional Committee No.VIII
- Executive Committee member - National Centre for Sustainable Aquaculture (NaCSA)
- Coastal Aquaculture Authority
- Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur.
- Scientific Advisory Committee for Dr.Perumal Krishi Vigyan Kendra
- State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Department of Animal Husbandry & Veterinary Services, Government of Tamil Nadu, Chennai.
- Board of Management of Tamil Nadu Fisheries University, Nagapattinam.
- Board of Management of Tamil Nadu Veterinary and Animal Sciences University, Chennai.
- Academic Council of Central Institute of Fisheries Education, Mumbai.
- Board of Management of Central Institute of Fisheries Education, Mumbai.
- National Committee on Introduction of Exotic Aquatic Organisms into Indian waters, constituted by the Ministry of Agriculture & Farmers Welfare, DAHDF, Govt. of India, New Delhi.
- Advisory Committee on Hilsa Conservation and Research
- Governing Body of State Fisheries Resource Management Society (FIRMA), Thiruvananthapuram.
- Advisory Board for Fisheries Sector Development, constituted by Special Chief Secretary (Planning), Planning Department, Govt. of Andhra Pradesh.
- Society of Coastal Aquaculture and Fisheries
- Society for Fisheries Technologists
- Marine Biological Association of India
- Project Monitoring Committee for monitoring the project works related to setting up of the Specific Pathogen Free Shrimp Seed Multiplication Centre at Mulapolam Village, Sompeta Mandal of Srikakulam District in Andhra Pradesh under the chairmanship of Chief Executive, National Fisheries Development Board, constituted by the Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Govt. of India, New Delhi.
- Technical Committee to examine as to whether the concepts and designs provided by MHKL for setting up Multiplication Centre for SPF *P.monodon* could be used for any alternative species of shrimp, constituted by the Department of Animal Husbandry Dairying and Fisheries, Ministry of Agriculture, Govt. of India.
- Member of Faculty in the Board of Studies of Cochin University of Science and Technology (CUSAT), Kochi.

- Selection Committee - Tamilnadu Scientist Award (TANSA) constituted by Tamil Nadu State Council for Science and Technology.
- High Power Society "Society for Promotion of Shrimp Farming in Punjab", headed by Additional Chief Secretary, Government of Punjab, Department of Animal Husbandry, Fisheries & Dairy Development, constituted by Department of Fisheries, Punjab.
- Selection Committee for the selection of the University Officers of the Tamil Nadu Dr J Jayalalitha Fisheries University, Nagapattinam.
- State-wise Coordination Committees for doubling Farmer's income by March, 2022, constituted by Secretary, DARE & Director General, ICAR, New Delhi.
- Kerala State Council for Science Technology and Environment, Thiruvananthapuram.
- Expert committee to study on Vembanad, Astamudi and Sasthamkotta lakes, constituted by Office of the Director of Fisheries, Govt. of Kerala, Thiruvananthapuram.
- Steering Committee for the Asian Pacific Aquaculture 2019 (APA 2019) event to be held on 18-21 June 2019 in Chennai.
- Sub-Committee to work out modalities for engaging Consultants in Coastal Aquaculture Authority.

Scientists

- Acted as External examiner to evaluate the Ph.D. thesis at CIFE and at Madras University - Dr. K. Ambasankar
- Acted as Expert member in the discipline of Fish Nutrition in the departmental selection committee for promotion of ARS scientist At CIFE, Mumbai - Dr. K. Ambasankar
- Member of Entrepreneurship Development and Innovation Institute (EDII), Chennai, constituted by Govt. of Tamil Nadu - Dr. K. Ambasankar
- Member of the Steering committee of the TN fisheries Department on 03.10.2018 - Dr. K. Ambasankar
- Participated as a Chief Guest in the inaugural Function of one year Diploma Programme in Industrial Aquaculture Technology on 27.10.2018 - Dr. K. Ambasankar
- Acted as Member of the Abstract and Poster Management committee for the XIV Agriculture Science Congress, New Delhi during 20-23 February, 2019 - Dr. K. Ambasankar
- Acted as observer in the ICAR's 23rd AIEEA – 2018-19 on 22-23rd June, 2018 at Mullai Infotech, 3/148, SBI building, 1st floor, Mount Poonamalle High Road, Ramapuram, Chennai – Dr. R. Ananda Raja
- Member Secretary in the Institutional Animal Ethics Committee (IAEC) – Dr. R. Ananda Raja
- Member in the Institutional Biosafety Committee (IBSC), Annual Physical Verification Committee, Library Advisory Committee, and job training for security guards for fire safety – Dr. R. Ananda Raja

- Acted as an expert with Coastal Aquaculture Authority (CAA) to inspect the hatchery located at Prakasam, Guntur and Krishna districts of Andhra Pradesh on 4th and 5th October, 2018 – Dr. R. Ananda Raja
- Observer in ARS/NET Exam- 2018 during 9-10 April, 2018 held at Chennai Centre – Dr. Debasis De
- Observer for the Renewal audit of Karnataka State Organic Certification Agency (KSOCA), Bengaluru under National Programme for Organic Production (NPOP) held during 9 -11 July, 2018 - Dr. Debasis De
- Member, ICAR Regional Committee No. II. - Dr. T.K. Ghoshal
- Member, Scientific Advisory Committee of Ramkrisahna Ashram Krishi Vigyan Kendra, Nimpith Dr. T.K. Ghoshal
- Member, Scientific Advisory Committee of Sasya Shyamala Krishi Vigyan Kendra, Narendrapur - Dr. T.K. Ghoshal
- Acted as Expert Member in the assessment committee for staff of Ramakrishna Ashram Krishi Vigyan Kendra, Nimpith on 21.04.2018 and 27.07.2018 - Dr. T.K. Ghoshal
- Acted as External Examiner for evaluation of answer sheet and viva- voce of PG and Ph.D. students of Animal Nutrition of NDRI on 30.10.18 at NDRI-ERS, Kalyani - Dr. T.K. Ghoshal
- Acted as Member of Assessment Committee for scientist under CAS at ICAR-NINFET, Kolkata on 22.03.19 - Dr. T.K. Ghoshal
- Acted as an Organizing Committee Member for the International Congress on Engineering and Life Science (ICELIS 2018) held during 26-29 April 2018 at Kastamonu, Turkey - Dr. Gouranga Biswas
- Acted as a Member (Outside expert) in the Selection Committee Meeting for selection of JRF under a DBT funded project held on 4 August 2018 at ICAR-CIFA, Kalyani Field Centre, Kalyani, West Bengal - Dr. Gouranga Biswas
- Reviewer for Journal of Indian Society of Coastal Agricultural Research - Dr. T.K. Ghoshal
- Editorial Board Member for Menba Journal of Fisheries Faculty, Kastamonu University, Turkey - Dr. Gouranga Biswas
- Editorial Board Member for Marine Science and Technology Bulletin, Turkey - Dr. Gouranga Biswas
- Associate Editor, Journal of Fisheries and Life Sciences, Mangaluru, India - Dr. Gouranga Biswas
- Reviewer for various international journals, such as Aquaculture, Aquaculture Research and Fish Physiology and Biochemistry - Dr. Gouranga Biswas
- Acted as member in the State level monitoring committee for Tilapia aquaculture, at Department of Fisheries, Govt. of Tamil Nadu for approving Tilapia farms for the farmers of Tamil Nadu after screening the documents on 21.3.2019 – Dr. M.Kailasam
- Nodal person - State-of-the-art Community Development Centre for Learning, Livelihood & Research (CDC-LLR) Laboratories in Nellore, Bhimavaram and Surat by KCT with CIBA as technical partner - Dr. M. Muralidhar

- Expert member of Committee constituted by Coastal Aquaculture Authority to suggest suitable recommendations for amending the CAA Rules, 2015 and guidelines issued there under to facilitate implementing them at field level - Dr. M. Muralidhar
- Expert Member of 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 - Dr. M. Muralidhar
- Expert member for Inspection of hatcheries applied for permission to import brood stock of SPF *L.vannamei* and its seed production - Dr. M. Muralidhar
- Expert Panel member to develop strategies for holistic development of marine and island fisheries of Andaman & Nicobar Islands - Dr. M. Muralidhar
- Expert member for interviewing the candidates for the post of "Subject Matter Specialist, Agricultural Extension" at RASS KVK, Tirupati, Andhra Pradesh on 18th August 2018 - Dr.P.Mahalakhsmi
- Expert member for conducting "Departmental Promotion Committee meeting for Technical Staff" at ICAR-NRC for Banana, Tiruchirappalli on 16 October 2018 - Dr.P.Mahalakhsmi
- Jury member for holding "Smart India Hackathon (SHS) 2019: software" at Sri Sivasubramaniya Nadar College of Engineering, Chennai, Tamil Nadu during 2-3 March 2019 - Dr.P.Mahalakhsmi
- Member, Doctoral Committee for a research scholar in School of Information Technology, VIT University, Vellore - Dr.P.Mahalakhsmi
- Reviewer for various international journals, such as Review of research papers from Aquaculture, aquaculture research and Indian Journal of Fisheries - Dr. Prem Kumar
- Programme Committee member in International Conference of Virology on Global Viral Epidemics: A Challenging Threat, Chandigarh, India – Dr. M.Poornima
- Doctoral Committee Member in Sathyabhama University, Chennai – Dr. M.Poornima
- External expert to set question papers for master degree examinations Madras Veterinary college, TANUVAS, Chennai – Dr. M.Poornima
- External examiner for comprehensive viva voce examination, VELs University, Chennai – Dr. M.Poornima
- Lead Invited Speaker for the Krishi Sammridhi Mela 2018 at CODISSIA Trade Complex, Coimbatore during 24-26th August 2018 – Dr. C V Sairam
- Observer for ICAR AIEEA-2018 (UG/PG/SRF) held on 22-23 June, 2018 – Dr. Sherly Tomy
- Doctoral committee member in Presidency College, Chennai - Dr. Sherly Tomy
- Nodal officer, Data Management of ICAR-CIBA - R. Saraswathy
- Acted as Co-chairman of session entitled 'Role of Muscle Food Safety and Human Health' of the 8th Conference of Indian Meat Science Association and International Symposium on Technological Innovation in Muscle Food

Processing for Nutritional Security, Quality and Safety during 22-24 November 2018 at West Bengal University of Animal and Fishery Sciences, Kolkata - Dr. Sanjoy Das

- Acted as Evaluation Committee Member under National programme for organic production (NPOP) Committee member with APEDA – Shri T. Sathish Kumar
- Served as Assessment panel expert member for approving cold storage with EIA - Shri T. Sathish Kumar
- Served as Inspection committee member for inspecting hatcheries with CAA- Shri T. Sathish Kumar
- Member in IMC of CIFA, Bhubaneswar – Dr. S.K.Otta
- Examiner to conduct PhD viva, TNFU, 27th November 2018 - Dr. S.K.Otta
- Member of 'Technical and Inspection Committee' constituted by the DAHD&F, Ministry of Agriculture and Farmers' Welfare for the purpose.

Attracting and Retaining Youth in Agriculture (ARYA): An initiative to attract youth to brackishwater aquaculture

Farming in land and water is the noble occupation and farmers consider it as their way of life. In India, we have a self sufficient and self reliant food production system. However, most farmers do not want their next generation to be in agriculture, as income from agriculture is not sufficient, and quality of life is not that appreciative. Minds of youth are creative and socially networked and they are capable of handling risk factors such as climate changes using various technologies. At this context, Govt. of India initiated a new scheme ARYA and it is launched by ICAR.

More than 450 school / college students from 20 educational institutions visited CIBA HQ and MES Muttukadu and learned about brackishwater aquaculture technologies. In Government School at Pakkam village, in Tiruvallur district of Tamil Nadu, an ornamental fish unit was established under CPCL project. The unit is being maintained by high school children under the guidance of their teachers. The National Science Day was organized at Corporation School Mylapore, in which importance of science and brackishwater aquaculture farming in Indian agriculture were inculcated among the school children









Mera Gaon Mera Gaurav

Under the flagship programme of the Honourable Prime Minister of India, Mera Gaon and Mera Gaurav (MGMG), ICAR-CIBA organised 65 visits by a team of scientists, 28 meetings and 8 training programmes; Under the patronage of the MGMG programme,33 demonstrations were conducted, 812 mobile advisories have been extended, 10 literature were distributed, in addition to the completion of 31 campaigns. The total number of activities conducted were 221 and 3428 fish/shrimp farmers benefitted out of it. These activities were taken up to hasten lab to land programmes and to create awareness among farmers about the organisations and the programmes related to the farming sector.

Technological Interventions

- ICAR-CIBA's technological interventions such as three-tier system of cage aquaculture and nursery rearing of Seabass (*Lates calcarifer*) in open brackishwaters, family farming initiatives, homestead backyard Pearl spot larval rearing techniques, demonstration of "Waste to Wealth: Recycling of Fish and Domestic Waste" were demonstrated to the coastal families of MGMG villages for livelihood support and the security of communities and for doubling their income.

Lessons Learnt

- The lessons learnt out of the technological interventions were the development and successful implementation of appropriate policy guidelines for optimal utilization of open brackishwaters involving coastal fishers, technical empowerment of coastal communities in pen and cage culture of milkfish and mud crab, skill development of fisherwomen in the recycling of fish and domestic waste, providing opportunities to improve the livelihood of coastal women and their families and provision of alternative and additional income during the lean period.

Linkages Developed

- The fishers were linked with the Tamil Nadu Fisheries Development Corporation, CRRT, Department of Fisheries, Govt. of Tamil Nadu, and private fish farmers for procurement and marketing of seabass fingerlings as well as research institutes such as ICAR-CIBA and Kolathur ornamental hub, Chennai, for marketing.



Hand-on training on Waste to wealth: recycling of fish waste to value added products at MES of CIBA, Tamil Nadu



Demonstration of recycling of fish waste to value added products at Nambikkai Nagar, Srinivaspuram, Chennai, Tamil Nadu



Inauguration of Fish waste Processing Unit at Nambikkai Nager, Srinivaspuram, Chennai, Tamil Nadu





Homestead backyard Pearl spot hatchery Unit





Nursery rearing of Finfishes

Swachh Bharat Mission

The Swachh Bharat or Clean India Mission was conceived by the Hon'ble Prime Minister, Sri Narendra Modi to motivate and galvanise Indian citizens from all walks of life to achieve by 2019 Mahatma Gandhi's dream of a clean India. In response to the noble call, Swachh Bharat Mission, the following Swachhta Hi Seva and Swachhta Pakhwada programmes were conducted at ICAR-CIBA, Chennai and Kakdwip Research Centre (KRC) of CIBA, Kakdwip, West Bangal, and Navsari Gujarat Research Center (NGRC) of CIBA, Navsari, Gujarat with due gravity and purposefulness during 15th September to 1st October 2018 and December 16-31 2018 respectively.

- Awareness campaign among the school children and villagers about the importance of hygiene and health aspects with displaying of sentences related with cleanliness and hygiene and importance of reducing open defecation and water management to the children at Panchayat Union Primary School, Keelarkollai village, Kanchipuram District, Tamil Nadu, on 20th September 2018.



Displaying of cleanliness and hygiene related sentences at Panchayat Union Primary School rallies, Tamil Nadu, ICAR-CIBA, Chennai

- Swachhta Hi Seva 2018 programme at Kannavandurai village, Tiruvallur district, Tamil Nadu, on 21st September 2018 to create awareness on cleanliness, hygiene and sanitation among the villagers and removal of waste from the village and coastline premises.



Cleaningof Kannavandurai village coastline Tamil Nadu, ICAR-CIBA, Chennai

- Navsari Gujarat Research Center of CIBA organized the Swachhata pakhwada programme at Matwad village, Navsari district, Gujarat, on 25th September 2018 to create awareness on cleanliness, hygiene and sanitation among the villagers, door to door meeting and removal of waste from the village premises.



Cleaning of village premises - Matwad, Navsari district, Gujarat - ICAR-CIBA, Chennai

- Kakdwip Research Centre of ICAR-CIBA cleaned village road and market place at Dakshin Lakshminarayanpur village, Patharpratima Island, South 24 Parganas, West Bengal on 27th September 2018.



Cleaning of village roads - - Dakshin Lakshminarayanpur, South 24 Parganas, West Bengal - ICAR-CIBA, Chennai

- Swachhta workshop on "Waste to Wealth" by recycling of fish and domestic waste under Swachhata pakhwada programme on 28th September, 2018 at Srinivasapuram, Mullikuppam, Mullimanagar fishermen villages cluster located near CIBA headquarters in Chennai.



Demonstration of fish waste to value added products - Srinivasapuram, Adyar creek and estuary, Tamil Nadu – ICAR-CIBA, Chennai



Hand on training on composting of domestic waste in three steps - Srinivasapuram, Adyar creek and estuary, Tamil Nadu – ICAR-CIBA, Chennai

- Awareness programme on cleanliness, usage of toilet, health aspects hygiene and sanitation among the villagers and removal of waste from the village premises at Karathittu village, Kancheepuram district, Tamil Nadu on 29th September 2018.



Cleaning of Karathittu village, Kancheepuram district, Tamil Nadu - ICAR-CIBA, Chennai

- Kakdwip Research Centre of ICAR-CIBA organized cleaning of plastics and garbage from the village road and market activities at Ganeshnagar village, Namkhana, South 24 Parganas, West Bengal on on 1st October 2018.

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Cleaning of road and market Ganeshnagar village, Namkhana, South 24 Parganas, West Bengal - ICAR-CIBA, Chennai

- Hand-on training to women self help group on recycling of fish waste to value added products at Muttukadu Experimental Station, Muttukadu, Tamil Nadu on 1st October 2018.



Recycling of fish waste to value added products at Muttukadu, Tamil Nadu – ICAR-CIBA, Chennai

- Cleaning activities at three different places such as (1) Public pathway, (nearby ICAR-CIBA) Santhome High Road, R.A.Puram, Chennai, Tamil (2) Public pathway (near by

Adyar creek and estuary) Srinivasapuram, Chennai, Tamil Nadu and (3) Oyalikuppam village road, Kancheepuram district, Tamil Nadu on 2nd October 2018.



Public pathway, Santhome High Road, R.A.Puram, Chennai, Tamil Nadu - ICAR-CIBA, Chennai



Oyalikuppam village road, Kancheepuram district, Tamil Nadu

- Awareness campaign and collecting of wastes at Kakdwip Buddhapur Road, Kakdwip Ramkrishna Mission and Sundarban School, Kakdwip on 16th December 2018.



Cleaning and collecting of wastes - Kakdwip Buddhapur Road, West Bengal

- Awareness on cleanliness, hygiene and sanitation among the villagers; door to door meeting and removal of waste from the households activities on 18th December 2018 at Keelarkollai village, Kancheepuram district, Tamil Nadu.



Awareness meeting, Keelarkollai village, Tamil Nadu, ICAR-CIBA, Chennai



Cleaning of village premises, Keelarkollai village, Tamil Nadu, ICAR-CIBA, Chennai

- Awareness programme on cleanliness, hygiene and sanitation among the villagers and removal of waste from the households activities at the Kuvathur MGMG village, Kancheepuram district, Tamil Nadu, on 19th December 2018.



Cleaning of MGMG village premises, Kuvathur, Tamil Nadu, ICAR-CIBA, Chennai



Collecting of wastages from MGMG village, Kuvathur, Tamil Nadu,

- Awareness programme about the importance of utilization of homestead fallow land by converting to kitchen garden for cultivation of horticultural crops that provide extra incomes, meet up domestic needs for vegetables and nutrition, and create clean and esthetic surroundings of a house at Mundapara- Manmathapur, South 24 Parganas, West Bengal on 21st December 2018.



Kitchen Gardening at Tribal Village, Mundapara-West Bengal

- Demonstration cum hand-on training on “Waste to Wealth” by recycling of fish waste to value added products under Swachhta Pakhwada on 22nd December, 2018 at Srinivasapuram village, Pattinapakkam, Chennai.



Demonstration of recycling of fish waste to value added products- Srinivasapuram, Adyar creek and estuary, Tamil Nadu



Hand on training on waste to wealth- Srinivasapuram, Adyar creek and estuary, Tamil Nadu

- Navsari Gujarat Research Centre of ICAR-CIBA, Navsari, Gujarat organized open speech competition among students on “Importance of Clean India” at Aadarsh Buniyadi Prathamik Shala, Matwad village, Matwad, Navsari, on 24th December 2018.



School competition, Aadarsh Buniyadi Prathamik Shala, Matwad, Navsari, Gujarat



Prize distribution - School competition at Navsari

- Awareness programme on water harvesting through excavation of pond and utilization of the harvested rain water for round the year horticultural crop and fish cultivation at Mundapara- Manmathapur, South 24 Parganas, West Bengal on 27th December 2018.



Demonstration of water harvesting through excavation of pond, South 24 Parganas, West Bengal

Distinguished Visitors

Headquarters, CIBA, Chennai

Sl. No	Details of visitors	Date of visit
1.	Dr. K.K. Ramachandran, Scientist and Head, Central Geomatics Lab, Group Head atmospheric process group, Ministry of Earth Science, Government of India	20.04.2018
2.	Dr. George Chamberlain Managing Director, Kona Bay & President - Global Aquaculture Alliance	01.05.2018
3.	Dr. M.R.Ramesh Kumar, Chief Scientist, Physical Oceanography Division, CSIR –National Institute of Oceanography- Goa	15.05.2018
4.	Dr.E.Vivekanandan, National Consultant, Bay of Bengal Programme	05.06.2018
5.	Dr. R. Venkatesan, Scientist G & Head and Ocean Observation systems, National Institute of Ocean Technology, Pallikaranai, Chennai	08.06.2018
6.	Mr Rabindra Jena, Hon'ble Member of Parliament	10.07.2018
7.	Dr.G.S.Sameeran, IAS, Director of Fisheries, Government of Tamil Nadu	30.07.2018
8.	Dr.K.Narayana Gowda, Former Vice-Chancellor, UAS, Bangalore & Chairman, ARYA Programme of ICAR	29.8.2017
9.	Dr.Vipin Chandra, Joint Secretary, MoES, at NIOT campus, Chennai.	25.09.2018
10.	Dr. Madhavan Rajeevan, Secretary, Ministry of Earth Sciences(MoES)	25.09.2018
11.	Dr. M.A. Atmanand, the Director of NIOT, Chennai	25.09.2018
12.	Mr. Harnath Singh Yadav, Member of Parliament (Rajya Sabha)	04.10.2018
13.	Shri Pradeep Tamta, Member of Parliament (Rajya Sabha)	04.10.2018
14.	Shri Prataprao Ganpatrao Jadhav, Member of Parliament (Lok Sabha)	04.10.2018
15.	Dr. Sunil Baliram Gaikwad, Member of Parliament (Lok Sabha)	04.10.2018
16.	Dr. Prasanna Kumar Patasani, Member of Parliament (Lok Sabha) and Convenor of the second sub-committee of Parliament on Official Language	04.10.2018
17.	Dr. Malathi, Adjunct Professor, Department of Plant Pathology, TNAU, Coimbatore	30.10.2018
18.	Dr. K.S. Palaniswami, Former Director (Research), TANUVAS	30.10.2018
19.	Dr. Aniket Sanyal, Co-ordinator, CRP on Vaccines & Diagnostics	30.10.2018
20.	Dr. Ashok Kumar, ADG (AH), ICAR	30.10.2018

21.	Dr. J K Jena, DDG (Fy. Science), ICAR, New Delhi	30.10.2018
22.	Mr. Nishanth Reddy, Nellore, Andhra Pradesh	30.10.2018
23.	Prof. (Dr) Mohan Joseph Modayil, Former ASRB Chairman, Ex-Director CMFRI	15.11.2018
24.	Joint Secretary, Department of Animal Husbandry, Dairying & Fisheries, New Delhi	10.12.2018
25.	Dr. M. A. Atmanand, Director, National Institute of Ocean Technology (NIOT), Chennai	29.12.2018
26.	Shri.N.Vasudevan, Additional Principal Conservator of Forest, Mangrove Foundation, Govt. of Maharashtra	22.01.2019
27.	Dr.M.S. Swaminathan, The doyen of Indian Agricultural Research and Education	22.01.2019
28.	Thiru.D.Jayakumar, Hon'ble Minister for Fisheries, Personnel and Administrative Reforms, Govt. of Tamil Nadu	22.01.2019
29.	Dr.K.Gopal, IAS, Principal Secretary, Animal Husbandry, Dairying & Fisheries, Govt. of Tamil Nadu,	22.01.2019
30.	Dr.B.Meenakumari, Chairperson, National Biodiversity Authority (NBA), Chennai	22.01.2019
31.	Dr.J.K.Jena, Deputy Director General (Fisheries) and Animal Sciences, ICAR, New Delhi	23.01.2019
32.	Dr.S.K.Saxena, Director, Export Inspection Council, GOI	23.01.2019
33.	Dr.Trilochan Mohapatra, Secretary, DARE & DG, ICAR, New Delhi	23.01.2019
34.	Dr. S.D.Tripathi, Former Director Central Institute of Freshwater Aquaculture and Central Institute of Fisheries Education	25.01.2019
35.	Dr.Modadugu Vijay Gupta, World Food Prize Laurate	25.01.2019
36.	Prof. Chris Hauton, University of South Hampton, UK	25.01.2019
37.	Mr. Mathew Jose, CEO, Paperman Foundation, Chennai	13.02.2019
38.	Shri.N K Uppal, Vice President (Corporate Growth Projects), Rallis India limited	15.02.2019
39.	Mr. Atul Barman, Director, Aker Bio marine India Private Limited, Mumbai	28.03.2019
40.	Dr. A. K. Munirajan, Professor & Head, Department of Genetics, University of Madras, Chennai	12.03.2019
41.	Shri. T. Purushothaman, President, Aquaculture Development Cooperative Society (ADCOS), Payyanur, Kerala	25.03.2019

Kakdwip Research Centre, Kakdwip

Sl. No	Details of visitors	Date of visit
1	Dr. J.K. Jena, DDG (Fisheries & Animal Science), ICAR	10.05.2018
2	Dr. S.S. Mishra, Director, ICAR-CIFA	12.06.2018



Navsari Gujarat Research Centre, Gujarat

1.	Dr. J.K. Jena, Deputy Director General (Fisheries), ICAR	07.06.2018
2.	Shri. R.C. Patel, Member of Legislative Assembly, Navsari	07.06.2018
3.	Dr. C.J. Dangaria, Vice Chancellor, NAU	07.06.2018
4.	Dr.C.Gopal, Member Secretary, Coastal Aquaculture Authority, Govt. of India, Chennai	07.06.2018
5.	Dr. Pravin Puthra, Assistant Director General (Fisheries), ICAR	07.06.2018
6.	Dr. N.H. Kelawala, Dean, Veterinary College	07.06.2018
7.	Shri. Mohammed Shahid (IAS), Commissioner of Fisheries, Department of Fisheries, Gujarat	05.09.2018
8.	Shri. R. C. Faldu, Hon'ble Cabinet Minister for Agriculture, Rural Development, Fisheries, Animal Husbandry and Transport, Government of Gujarat.	05.09.2018

Personnel

Personnel as on 31.03.2019			
Sl.No.	**NAME**	**DESIGNATION**	
1.	Dr.K.K.Vijayan	Director	
2.	Dr.G.Gopikrishna	Principal Scientist, HOD , NGBD	Retired on 30.11.2018
3.	Dr. S.V.Alavandi	Principal Scientist, HOD , AAHED	
4.	Dr. K. P. Jithendran	Principal Scientist	
5.	Dr.C.V.Sairam	Principal Scientist	
6.	Dr.T. Ravisankar	Principal Scientist	
7.	Dr. M. Muralidhar	Principal Scientist	
8.	Dr. (Smt) M. Jayanthi	Principal Scientist	
9.	Dr. (Smt) B. Shanthi	Principal Scientist	
10.	Dr. C. P. Balasubramanian	Principal Scientist	
11.	Dr. M. Kailasam	Principal Scientist	
12.	Dr. (Smt) D. Deboral Vimala	Principal Scientist	
13.	Dr. M. Shashi Shekhar	Principal Scientist	
14.	Dr. (Smt) P. Nila Rekha	Principal Scientist	
15.	Dr. K. Ambasankar	Principal Scientist	
16.	Dr. J. Syama Dayal	Principal Scientist	
17.	Dr. Akshya Panigrahi	Principal Scientist	
18.	Dr. M. Kumaran	Principal Scientist	
19.	Dr. S. Kannappan	Principal Scientist	
20.	Dr. (Smt) M.Poornima	Principal Scientist	
21.	Dr. (Smt) R. Saraswathy	Principal Scientist	

22.	Dr. M.Makesh	Principal Scientist	
23.	Dr. (Smt) Sherly Tomy	Principal Scientist	
24.	Dr.Debasis De	Principal Scientist	
25.	Dr. Prasanna Kumar Patil	Principal Scientist	
26.	Dr. Subhendu Kumar Otta	Principal Scientist	
27.	Dr. (Smt) P. Mahalakshmi	Principal scientist	
28.	Dr. Satyanarayan Sethi	Principal Scientist	Promoted on 15.05.2017
29.	Dr.K.P.Kumaraguru vasagam	Principal Scientist	Promoted on 26.03.2018
30.	Shri. Ashok Kumar Jangam	Scientist	
31.	Dr. Vinaya Kumar Katneni	Scientist	Promoted On 12.06.2016
32.	Dr. R. Ananda Raja	Scientist	Promoted on 08.01.2017
33.	Dr.(Smt) Krishna Sukumaran	Scientist	Promoted on 07.01.2017
34.	Dr.(Smt)P. Ezhil Praveena	Scientist	Promoted on 07.01.2017
35.	Dr. Sujeet Kumar	Scientist	
36.	Dr. (Smt).Shyne Anand	Scientist	
37.	Dr. (Smt) N. Lalitha	Scientist	
38.	Dr. (Smt) T. Bhuvaneswari	Scientist	
39.	Dr. P. Kumararaja	Scientist	
40.	Dr.B.Sivamani	Scientist	
41.	Dr. (Smt) Vidya Rajendran	Scientist	
42.	Dr. Satheesha Avunje	Scientist	
43.	Shri. K.P.Sandeep	Scientist	
44.	Ms. Babita	Scientist	
45.	Dr. Aritra Bera	Scientist	

46.	Shri. T.Sathish Kumar	Scientist	
47.	Smt.M.U.Rekha	Scientist	
48.	Dr.N.S.Sudheer	Scientist	
49.	Dr. Suvana Sukumaran	Scientist	
50.	Dr.(Smt)Neethu.K.C.	Scientist	
51.	Shri.R. Aravind	Scientist	
52.	Shri.Dani Thomas	Scientist	
53.	Shri.Biju.I.F.	Scientist	
54.	Ms. Misha Soman	Scientist	
55.	Smt.Mary Lini	Scientist	
56.	Dr.J.Raymond Jani Angel	Scientist	
57.	Shri.T.Sivaramakrishnan	Scientist	
58.	Dr.Vinay Tharabenahalli Nagaraju	Scientist	
59.	Dr.(Smt)R.Geetha	Scientist	

TECHNICAL			
1.	Shri R. Elankovan	Chief Tech. Officer	
2.	Dr. S. Sivagnanam	**Chief Tech. Officer**	Promoted on 14.02.2017
3.	Shri D. Raja Babu	Chief Tech. Officer	Promoted on 13.03.2017
4.	Shri M. Shenbagakumar	Chief Tech. Officer	Promoted on 07.07.2018

5.	Shri R. Puthiavan	Assistant Chief Tech. Officer	
6.	Smt. K. Jacquline	Assistant Chief Tech. Officer	
7.	Shri Joseph Sahayarajan	Assistant Chief Tech. Officer	Promoted on 08.12.2015
8.	Shri S. Rajamanickam	Assistant Chief Tech. Officer	Promoted on 28.10.2015
9.	Shri S. Nagarajan	Assistant Chief Tech. Officer	Promoted on 03.01.2017
10.	Dr. A. Nagavel	Assistant Chief Tech. Officer	Promoted on 02.08.2017
11.	Shri R. Subburaj	Assistant Chief Tech. Officer	Promoted on 27.08.2017
12.	Shri N. Ramesh	Tech. Officer	
13.	Shri S. Saminathan	Tech. Officer	
14.	Shri N. Jagan Mohan Raj	Tech. Officer	
15.	Shri D. M. Ramesh Babu	Tech. Officer	Promoted on 24.07.2017
16.	Shri G. Thiagarajan	Tech. Officer	Promoted on 04.08.2017
17.	Shri K. Paranthaman	Senior Tech. Asst.	
18.	Shri K. Karaian	Senior Tech. Asst.	Promoted on 10.09.2017
19.	Shri. S.Prabhu	Technical Asst.	Joined on 14.09.2018
20.	Shri. K.V. Delli Rao	Senior Technician	

ADMINISTRATION			
1.	Shri.K.V.S.Satyanarayana	Administrative Officer	Retired on 31.10.2018
2.	Shri.Babu.R.K.	Finance & Accounts Officer	Joined on 23.05.2018
3.	Shri R. Kandamani	Asst. Admn. Officer	
4.	Smt. V. Usharani	Asst. Admn. Officer	
5.	Shri S. Pari	Asst. Admn. Officer	
6.	Shri P. Srikanth	Junior Accounts Officer	
7.	Smt. S. Nalini	Private Secretary	Promoted on 08.05.2018
8.	Shri. K.G. Gopala Krishna Murthy	Personal Assistant	
9.	Smt. K. Subhashini	Personal Assistant	Promoted on 06.12.2018
10.	Shri A. Manoharan	Assistant	
11.	Smt. E. Amudhavalli	Assistant	
12.	Shri A. Sekar	Assistant	
13.	Smt. E. Mary Desouza	Assistant	
14.	Shri. Raghavendra.K	Assistant	
15.	Smt. K. Hemalatha	Stenographer, Grade – III	
16.	Smt. R. Vetrichelvi	UDC	
17.	Smt. M. Mathuramuthu Bala	UDC	

18.	Smt. B. Prasanna Devi	UDC	Promoted on 27.10.2018
19.	Shri.B.Palanivelmurugan	UDC	Transfer to CMFRI, Mandapam on 31.10.2018
20.	Shri. R. Kumerasen	LDC	
21.	Shri A. Paul peter	LDC	
SKILLED SUPPORT STAFF			
1.	Shri V. Jeevanantham	Skilled Support Staff	
2.	Shri K. Nithyanandam	Skilled Support Staff	
3.	Shri V. M. Dhanapal	Skilled Support Staff	
4.	Shri V. Kumar	Skilled Support Staff	
5.	Shri E. Manoharan	Skilled Support Staff	
6.	Shri C. Saravanan	Skilled Support Staff	
7.	Shri.S.Kuppan	Skilled Support Staff	VRS on 03.04.2018
8.	Shri M. Pichandi	Skilled Support Staff	
9.	Shri S. Selvababu	Skilled Support Staff	
10.	Shri D. Senthil Kumaran	Skilled Support Staff	
11.	Shri C. Ragu	Skilled Support Staff	
12.	Shri P.G. Samuvel	Skilled Support Staff	

13.	Shri M. Sakthivel	Skilled Support Staff	
14.	Shri R. Mathivanan	Skilled Support Staff	
15.	Shri R. Indra Kumar	Skilled Support Staff	
16.	Shri G. Dayalan	Skilled Support Staff	
17.	Shri Kanaka Prasad	Skilled Support Staff	
18.	Smt. S. Premavathy	Skilled Support Staff	
19.	Shri. J. Murugan	Skilled Support Staff	
20.	Shri.V.Kishorkumar	Skilled Support Staff	

NAVSARI RESEARCH CENTRE OF CIBA, GUJARAT

NGRC SCIENTISTS

1.	Shri.Pankaj Amrut Patil	Scientist	Transferred on 24.07.2018
2.	Shri.Tanveer Hussain	Scientist	Transferred on 20.09.2018
3.	Shri.Jose Antony	Scientist	Transferred on 17.09.2018

KRC Staff

SCIENTISTS

1.	Dr.T.K.Ghosal	Principal Scientist	
2.	Dr.Sanjoy Das	Principal Scientist	

3.	Dr.Gouranga.Biswas	Scientist	Promotedo **on 08.01.2017**
4.	Dr. Prem Kumar	Scientist	
5.	Ms.Christina Lalramchhani	Scientist	
6.	Ms. Leesa Priyadarsani	Scientist	

TECHNICAL

1.	Shri.P.S.Samanta	Tech. Officer	Retired on 30.09.2018
2.	Smt. Chhanda Mazumder	Senior Tech. Asst.	

ADMINISTRATION

2.	Shri. S.K Bindu	Assistant	

1.	Shri.N.N.Jana	Skilled Support Staff	Retired on 28.02.2019
2.	Shri K.P.Naskar	Skilled Support Staff	
3.	Smt L.R. Bhuiya	Skilled Support Staff	
4.	Shri U.K. Santra	Skilled Support Staff	
5.	Shri P.C. Das	Skilled Support Staff	
6.	Shri.Sanjoy Some	Skilled Support Staff	

REDEPLOYED STAFF FROM PURI RESEARCH CENTER of CIBA TO CIFA, BHUBANESHWAR

1.	Shri.P.C.Mohanty	Technical Assistant	
2.	Shri.Premanadha Bisoi	Skilled Support Staff	

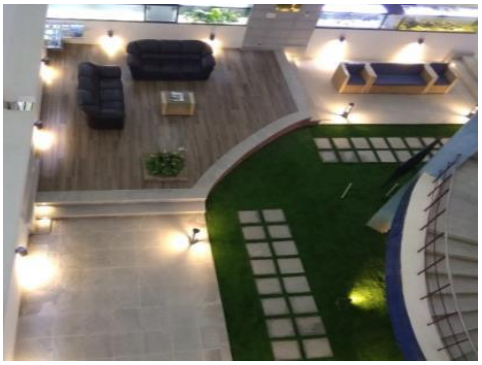
Infrastructure Development

1. Construction of laboratory building at CIBA Head Quarters, Chennai
2. Replacement of floor tiles in 1st & 2nd floor corridor at Main Lab cum Admin building of CIBA Head Quarters, Chennai
3. Pavement blocks for car parking in back side of the main building at CIBA Head Quarters, Chennai
4. Renovation of storm water trench including earth filling at CIBA Head Quarters, Chennai
5. Construction of sewage collecting tank at CIBA Head Quarters, Chennai
6. Construction of atrium space at CIBA Head Quarters, Chennai
7. Providing gate in southern side of the compound wall at CIBA Head Quarters, Chennai
8. Providing Non- Essential panel including cabling for connecting the existing two generators and two transformers at CIBA Head Quarters, Chennai
9. Re-routing the existing wet raiser system at CIBA Head Quarters, Chennai
10. Supply & installation of Electrical Distribution panel board near Trainees hostel at CIBA Head Quarters, Chennai
11. Supply and fixing of exterior aluminium composite panel in the sit out area in the first floor at CIBA Head Quarters, Chennai
12. Fabrication and supply of glass water fountain at CIBA Head Quarters, Chennai
13. Renovation of internal road in CIBA Head Quarters, Chennai
14. Supplying and fixing LED light in the roof of court yard at CIBA Head Quarters, Chennai
15. Construction of Central drainage pond at Muttukadu Experimental Station, Muttukadu
16. Construction of 5000 litres RCC tanks in place of FRP tanks with pipe line for water and aerator at Muttukadu Experimental Station, Muttukadu
17. Construction of first floor over the existing wet laboratory building at KRC of CIBA, Kakdwip
18. Construction of Trainees Hostel under Tribal Sub-plan completed at KRC of CIBA, Kakdwip



















19. Construction of Electrical Sub-station building completed and new transformer with enhanced load (200 KVA) installed at KRC of CIBA, Kakdwip
20. Barbed wire fencing at C-sector farm completed at KRC of CIBA, Kakdwip
21. Executed the work Re-excavation of inlet canal at Sector-B at KRC of CIBA, Kakdwip

Library and Documentation

a. Library holdings

CIBA Library procured 45 new books including official language books during the period 2018-19 and currently holds 2,776 books, subscriptions for four international and national journals at the headquarters, Chennai and Kakdwip Research Centre in West Bengal. The details of Library holdings as on March 31, 2019 are provided in the diagram below.

b. *Library and e-Resource Centre*

The CIBA library has been upgraded as Library and e-Resource Centre with six workstations having the facility to access e-books, online journals, Institute publications and scientists publications for ease of use by scientists and scholars. This facility is now open to students, scholars and other researchers from Universities, Colleges and other academic Institutes. The timing of the facility also has been extended till 6 p.m. to enable students to use it effectively.

c. Digital Repository

Under the digitalization initiative, all institute publications and individual scientist's publications have been digitized and uploaded in the KRISHI Portal. It will be further uploaded in the E-prints open sources software) and linked to the international databases to enhance visibility of CIBA research achievements across the globe.

d. Online access to the CIBA Subscribed & CeRA journals and Document delivery services:

CIBA has access to e-books and journals published by Springer, John Wiley and Elsevier through ICAR- CeRA resource sharing platform. For the ease of use, the library has listed all the full content accessible online journals along with their access links in CIBA web portal. The library section supplied photocopies of journal articles requested from various ICAR institutes, scientists and research scholars under CeRA-Document Delivery Request (DDR).

e. Exchange services

CIBA library maintained exchange relationship with various national and international organizations working on fisheries and aquaculture on mutual interest. The

library maintained free mailing of institute's annual report and other Institute publications to various research organizations, universities and other agencies to provide updates on the institute research and development programmes.

f. Information services to the stakeholders

CIBA library acted as a reference library by providing access to the reference books & journals available in the library to the scientific personnel of other research organizations, academia, university/ college students, research scholars, stakeholders and other related visitors. The library provided photocopying service to users on nominal payment basis.

g. Utilization of funds

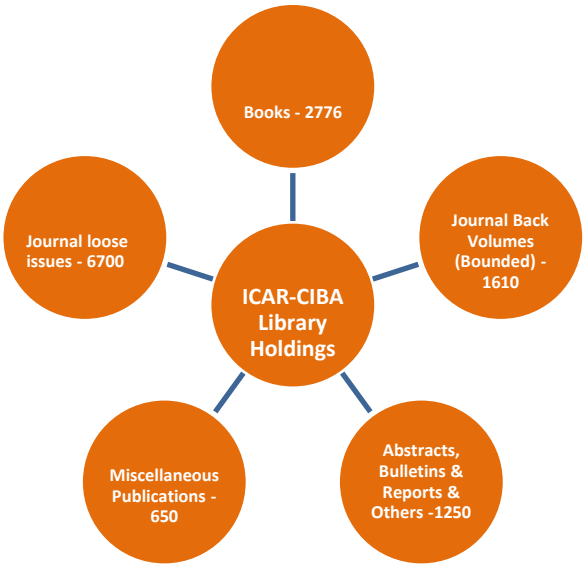
The funds available to the tune of Rs. 10.00 lakhs were effectively utilized towards the procurement of new books. Journals, Anti-plagiarism and Grammarly software for the library users, Scientists & Staff of Headquarters and KRC library of CIBA.

h. ISBN Numbers

CIBA has obtained 50 ISBNs for five years from the Ministry of Human Resources Development for its publications. Fifteen books have been allotted ISBN numbers as of March 2019.

i. KRISHI Portal

ICAR-CIBA has uploaded more than 700 of its publications consisting of research papers and Institute publications in the ICAR-KRISHI Portal. The Institute was felicitated with a Certificate of Appreciation for proactively implementing ICAR-Research Data Management Guidelines and uploading the publications.



CIBA – Overview of Library Holdings



Publication, Participation in Conferences, Meetings, Workshops, Symposia

Institute Publication List

Annual Report 2017-18
Training Calendar 2018-19 (http://krishi.icar.gov.in/jspui/handle/123456789/20307)
Jal Tarang Vol. 4 (Hindi magazine)
(http://krishi.icar.gov.in/jspui/handle/123456789/20311)

CIBA Extension Series

- Information and communication technology for brackishwater aquaculture technology. ICAR-CIBA Extension Series No. 61. (http://krishi.icar.gov.in/jspui/handle/123456789/20216)
- Demonstration of brackishwater finfish farming in Gujarat - CIBA initiatives. ICAR-CIBA Extension Series No. 62. (http://krishi.icar.gov.in/jspui/handle/123456789/20215)
- Application of minerals in shrimp culture systems. ICAR-CIBA Extension Series No. 63. (http://krishi.icar.gov.in/jspui/handle/123456789/20217)
- Community and family farming initiatives for tribal and aqua farmers of Gujarat. ICAR-CIBA Extension Series No. 64. (http://krishi.icar.gov.in/jspui/handle/123456789/20218)
- Advisories on Infectious myonecrosis (IMN) (http://krishi.icar.gov.in/jspui/handle/123456789/20316)
- Hepatopancreatic microsporidiosis (HPM) (http://krishi.icar.gov.in/jspui/handle/123456789/20314)
- White spot disease (WSD) (http://krishi.icar.gov.in/jspui/handle/123456789/20317)
- Acute hepatopancreatic necrosis disease (AHPND) (http://krishi.icar.gov.in/jspui/handle/123456789/20315)
- Aquastat India 2018. ICAR-CIBA. Extension Series No.66. (http://krishi.icar.gov.in/jspui/handle/123456789/20293)

CIBA Technology Series

- Poly ^{plus} – a cost effective feed for brackishwater polyculture. CIBA Technology Series, 15. (KRISHI: Technology Repository)
- Metagenomics studies: an aquaculture perspective. CIBA e-publication series 2019 – No. 30. (http://krishi.icar.gov.in/jspui/handle/123456789/20252)

CIBA Training Manuals

- Recent advances in soil and water management in brackishwater aquaculture – a training manual. CIBA-TM Series-2018, No. 8. (http://krishi.icar.gov.in/jspui/handle/123456789/20211)
- Training manual on seed production and farming technology of brackishwater catfish, *Mystus gulio*. CIBA- TM Series 2018 No. 11. (http://krishi.icar.gov.in/jspui/handle/123456789/20308)
- Hands on training on aquaculture genomics and bioinformatics. CIBA-TM Series-2018- No. 12. (http://krishi.icar.gov.in/jspui/handle/123456789/20256)
- Training manual on seed production and farming of brackishwater finfishes (http://krishi.icar.gov.in/jspui/handle/123456789/20299)

- Water and soil treatment application in aquaculture - a training manual. CIBA- TM Series 2018, No. 13. (http://krishi.icar.gov.in/jspui/handle/123456789/20212)
- Training manual on recent advances in farming of Pacific white shrimp, *Penaeus vannamei*. CIBA- TM Series, 2018, No. 14.
- Training manual on hatchery production and farming of milkfish and mullets. (http://krishi.icar.gov.in/jspui/handle/123456789/20306)

Books by CIBA

- Fostering aquaculture Start-Ups: 2019 (http://krishi.icar.gov.in/jspui/handle/123456789/20290)
- A Guide to milkfish (*Chanos chanos*) aquaculture. ISBN: 978-81-932937-5-1 (http://krishi.icar.gov.in/jspui/handle/123456789/20213)
- Family farming model in brackishwater aquaculture for livelihood support of communities living around Adyar Creek and Estuary. ISBN 978 - 81 - 932937 -9- 9. (http://krishi.icar.gov.in/jspui/handle/123456789/20214)
- Innovative approaches and success stories of brackishwater aquaculture farmers, *Farmers Conclave.* BRAQCON World Brackishwater Aquaculture Conference 22-25, January, 2019 (http://krishi.icar.gov.in/jspui/handle/123456789/20197)
- Souvenir book, BRAQCON World Brackishwater Aquaculture Conference 22-25, January, 2019. (http://krishi.icar.gov.in/jspui/handle/123456789/20289)
- Book of abstracts Braqcon 2019, BRAQCON World Brackishwater Aquaculture Conference 22-25, January, 2019 (http://krishi.icar.gov.in/jspui/handle/123456789/20295)

Peer Reviewed Journals

1. Alavandi, S.V., Muralidhar, M, Dayal, J.S., Rajan, J.S., Praveena, P.E., Bhuvaneswari, T, Saraswathy, R., Chitra, V., Vijayan, K.K., Otta, S.K., 2019. Investigation on the infectious nature of running mortality syndrome (RMS) of farmed Pacific white leg shrimp, *Penaeus vannamei* in shrimp farms of India. Aquaculture, 500, 278-289. (https://krishi.icar.gov.in/jspui/handle/123456789/11324)
2. Ali, S.S.R., Ambasankar, K., Praveena, P.E., Nandakumar, S., Musthafa, M.S., 2018. Effect of dietary prebiotic inulin on histology, immuno-hematological and biochemical parameters of Asian seabass (*Lates calcarifer*). Aquac. Res., 49, 2732–2740. (http://krishi.icar.gov.in/jspui/handle/123456789/10632)
3. Anand, P.S. S., Balasubramanian, C. P., Lalramchhani, C., Kumar, S., Biswas, G., De, D., Ghohsal, T. K., Vijayan, K. K., 2019. Substrate based black tiger shrimp, *Penaeus monodon* culture: Stocking density, aeration and their effect on growth performance, water quality and periphyton development. Aquaculture, 507, 411-418. (http://krishi.icar.gov.in/jspui/handle/123456789/20205)
4. Anand, P.S. S., Balasubramanian, C.P., Lalramchhani, C., Panigrahi, A., Gopal, C., Ghoshal, T.K., Vijayan, K.K., 2018. Comparison of mudcrab-based brackishwater polyculture systems with different finfish species combinations in Sundarban, India. Aquac. Res., 49(9), 2965-2976. (http://krishi.icar.gov.in/jspui/handle/123456789/20204)
5. Antony, J., Balasubramanian, C. P., Balamurugan, J., Sandeep, K. P., Biju, I. F., Vijayan, K. K., 2019. Optimization of nursery rearing for megalopa of giant tiger crab *Scylla serrata* (Forskaal, 1775). Indian J. Fish., 66(1), 43-50. (*http://krishi.icar.gov.in/jspui/handle/123456789/20202*)
6. Bedekar, M. K., Soman, P., Kole, S., Anand, D., Tripathi, G., Makesh, M., Rajendran, K.V., 2018. Evaluation of interferon gamma (IFN-γ) of *Labeo rohita* as an immunomodulator: in vitro expression model. Aquacult. Int.,

https://doi.org/10.1007/s10499-018-0292-9
(http://krishi.icar.gov.in/jspui/handle/123456789/20286)
7. De, D., Ghoshal, T.K., Biswas, G., Mukherjee, S., Kumar, S., Anand, P.S.S., Raja, R.A., Vijayan, K.K., 2018. Evaluation of growth performance in *Mugil cephalus* L. juveniles fed diets incorporated with fermented plant feedstuffs replacing fishmeal or diets supplemented with fish gut bacteria. J. Food. Process. Technol., 9(4), 728. (http://krishi.icar.gov.in/jspui/handle/123456789/20193)
8. De, D., Raja, R.A., Ghoshal, T.K., Mukherjee, S., Vijayan, K.K., 2018. Evaluation of growth, feed utilization efficiency and immune parameters in tiger shrimp (*Penaeus monodon*) fed diets supplemented with or diet fermented with gut bacterium *Bacillus* sp. DDKRC1. isolated from gut of Asian seabass (*Lates calcarifer*). Aquac. Res., 49, 2147-2155. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/9660)
9. Duvvuru, J.A., Arjun, R., Sethi, S.N., Kasthuri, R., 2018. Inhibition and recovery of aquatic macrophyte *Lemna gibba* exposed to a combination pesticide. Indian J. Natur. Sci., Vol.8 (46), Feb. 2018. (http://krishi.icar.gov.in/jspui/handle/123456789/20291)
10. Gora, A.H., Ambasankar, K., Sandeep, K. P., Rehman, S., Agarwal, D., Ahmad, I., Ramachandran, K., 2019. Effect of dietary supplementation of crude microalgal extracts on growth performance, survival and disease resistance of *Lates calcarifer* (Bloch, 1790) larvae. Indian J. Fish., 66(1), 64-72. (http://krishi.icar.gov.in/jspui/handle/123456789/20194)
11. Jannathulla, R., Ambasankar, K., Dayal, J.S., Rajamohmed, M.K., Sravanthi, O., Rajesh, B., 2019. Studies on functional properties and chemical composition of commercial shrimp feeds used in Andhra Pradesh, India. Int. J. Fish. Aquat. Stud., 7(2), 84-89. (http://krishi.icar.gov.in/jspui/handle/123456789/20195)
12. Jannathulla, R., Dayal, J.S., Ambasankar, K., Claret, E.A., Muralidhar, M., 2018. Fungus, *Aspergillus niger* fermented groundnut oil cake as a fishmeal alternative in the diet of *Penaeus vannamei.* Aquac. Res., 49:2891-2902. doi.org/10.1111/are.13756. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/14492)
13. Jannathulla, R., Dayal, J.S., Ambasankar, K., D. Thulasi, D. Vasanthakumar, and Muralidhar, M. 2018. Carcass amino acid, fatty acid and mineral composition of *Penaeus vannamei* Boone, 1931 fed diets with fermented oilseed meals/cakes. Int. J. Fish. Aquat. Stud., 6(6), 233-240. (http://krishi.icar.gov.in:8080/jspui/handle/123456789/14492)
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Participation in Conferences, Meetings, Workshops and Symposia

Director

1. Workshop on 'Brackishwater Fish Farming', an initiative for the development of brackishwater aquaculture, organized by Anthoor Municipality at Kannur on 5 April 2018
2. Review Meeting of ICAR Regional Committee No.VIII at Sugarcane Breeding Institute, Coimbatore on 17th April 2018
3. 61st Foundation Day of Central Institute of Fisheries Technology, Kochi on 28th April 2018
4. Review Meeting of the Directors of Fisheries Institutes of ICAR and DADF Institutes to discuss regarding Skill Development Programmes, organized by National Fisheries Development Board (NFDB) at Hyderabad on 2 May 2018.
5. Inauguration of the first customized shrimp feed mill at Bhiwani, Haryana and Farmers Meet-cum-MOU signing ceremony with Dr.Attar Aqua Feed at Bhiwani, Harayana, under the ARYA initiative in connection with Vanamiplus feed technology transfer on 15 May 2018.
6. Inauguration of the Navsari-Gujarat Research Centre of CIBA at Navsari Agricultural University Campus, Navsari on 7 June 2018.
7. Inter-session Meeting of the Consultative Committee of the Ministry of Agriculture and Farmers Welfare, held on 2 July 2018 at Hotel Hyatt Rameshwaram
8. 90th Foundation Day of Indian Council of Agricultural Research (ICAR) at A.P.Shinde Hall, NASC Complex, Pusa , New Delhi held on 16 July 2018
9. National conference "PONSHRIMP 2018" Organized by Tamil Nadu Dr. MGR Fisheries College and Research Institute, Ponneri , TNFU on 25 July 2018 - Dr. K. Ambasankar
10. Brainstorming Workshop on "Fisheries and aquaculture development in Malabar Region", organized by Kerala University of Fisheries and Ocean Studies (KUFOS) at KUFOS, Payyanur, Kerala on 3 August 2018.

11. Consultancy Evaluation Committee of National Biodiversity Authority (NBA) at NBA, Chennai on 14 August 2018.
12. Assessment Committee Meeting for the promotion from Senior Scientist to Principal Scientist, under the Revised Career Advancement Scheme at ASRB, New Delhi on 30 August 2018
13. Inauguration of the Community Development Centre for Learning, Livelihood and Research under the CSR initiative, by KCT Group, at Bhimavaram on 12 September 2018
14. 58th Executive Committee Meeting and 24th Annual General Body Meetings of RGCA, 12th Annual General Body Meeting of NaCSA and 32nd AGM of OSSPARC organized by MPEDA at Kochi on 5 October 2018
15. Inauguration of the Aquaculture Development Cooperative Society (ADCOS) at Payyanur on 11 October 2018
16. Curtain Raiser Programme of the 80th Anniversary Celebrations, School of Marine Sciences, Cochin University of Science and Technology (CUSAT), Kochi on 2 November 2018.
17. Meeting of the Fisheries Minister of South India, at Central Marine Fisheries Research Institute, Kochi on 10-11 November 2018.
18. Fourteenth Meeting of the Project Screening Committee constituted under the Guidelines for establishment of operation of SPF Shrimp Broodstock Multiplication Centre (BMC), at Krishi Bhavan, New Delhi held on 16 November 2018.
19. 61st Meeting of the Coastal Aquaculture Authority organized by CAA at Chennai on 10 December 2018
20. Fifteenth Meeting of the Project Screening Committee constituted under the Guidelines for establishment and operation of SPF Shrimp Broodstock Multiplication Centre (BMC), at Krishi Bhavan, New Delhi held on 17 December 2018
21. Selection Committee Meeting for appointment of Dean (Fisheries) and Associate Professor (Aquaculture) for Kerala University of Fisheries and Ocean Studies, at KUFOS, Kochi held on 22 December 2018

22. DST-INSPIRE Internship Science Programme, hosted by Central University of Kerala, Periye, Kasargod on 26 December 2018
23. Director's Conference of ICAR Institutes held at A.P.Shinde Symposium Hall, NASC Complex, New Delhi during 31 January – 1 February 2019
24. Meeting of the Directors of Fisheries Institutes at SMD (Fisheries), ICAR, New Delhi on 2 February 2019
25. Selection Committee Meeting for the Selection of "Senior Administrative Officer" and Sixty Second meeting of the Coastal Aquaculture Authority at CAA, Chennai on 14 February 2019
26. Stakeholders Meeting to discuss various issues of shrimp aquaculture sector held at GRT Radison Blue Hotel, Chennai on 14 February 2019
27. Expert Consultation on biosecurity measures in shrimp aquaculture organized by Kerala University of Fisheries and Ocean Studies (KUFOS) in association with ReAct Asia Pacific, at Kochi on 8 March 2019

Scientists

1. Brainstorming session on Fish reproduction Biotechnology: current and Future prospects during 6-7 April 2018 at Visva-Bharati, Santiniketan, West Bengal- Dr. Premkumar
2. International Congress on Engineering and Life Science (ICELIS 2018) during 26-29 April 2018 at Kastamonu, Turkey - Dr. Gouranga Biswas
3. Syllabus Review Meet for updating postgraduate and doctoral syllabi of disciplines offered by the University, ICAR-CIFE, Mumbai on May 19-20, 2018 – Dr. M. S. Shekhar
4. Interface Meeting with developmental Departments in Tamil Nadu organized by ICAR-CRIDA, Hyderabad along with Department of Agriculture, Govt. of Tamil Nadu on 25 May 2018 at Chennai – Dr. M. Muralidhar, Dr. R. Saraswathy

5. National dialogue on Application of Artificial intelligence and Internet of Things (IoTs) in Agriculture organized by NAARM during 1-2, June 2018 at Hyderabad - Dr. M. Muralidhar
6. 16th Aquaculture Expo organized by Aqua Tech at Bhimavaram during 16-17 June, 2019 - Dr. M. Muralidhar
7. Seminar on Climate Change and Sustainable Development Jointly organized by MSSRF and Center for Environment Education on 26 June, 2018 at Chennai - Dr. M. Muralidhar
8. National Symposium on the Application of Genomics and Proteomics in Aquaculture, Fisheries and Marine Biology (omicsAFM 2018) at Centre for Ocean Research, Sathyabama Institute of Science and Technology, organized by Centre for Ocean Research Col. Dr. Jeppiaar Research Park, Sathyabama Institute of Science and Technology, June 20-21, 2018, Chennai - Dr. M. S. Shekhar, Dr. K. Vinaya Kumar
9. Regional Committee meeting for Zone-II during June 21-14 2018 at ICAR-CIFA, Bhubaneswar - Dr. T.K. Ghoshal
10. Brainstorming Workshop on Start-up India Programme for Aquaculture Sector on the occasion of ICAR Industry Day Celebration organized by CIBA on 16 July 2018 at Chennai - Dr. M. Muralidhar, Dr. B. Sivamani
11. One day workshop on ranking of ICAR institutes at NAARM, Hyderabad, 20 July 2018 – Dr. S. K. Otta
12. Meeting with delegation of Minister of State for Universities, Science, Research and Innovation UK on Poverty alleviation through prevention and future control of the two major socio-economically important pathogens in Asian aquaculture IIT, Chennai on 27 July 2018 - Dr. M. S. Shekhar
13. Launching programme of Network Project on "Ornamental fish breeding and Culture"(NPOFBC) held at CMFRI, Kochi on 28 July 2018 - Dr. Krishna Sukumaran
14. 6th Annual NICRA Workshop organized by CRIDA, Hyderabad during 7-8, August 2018 at New Delhi- Dr. M. Muralidhar
15. International consultation on water: Augmentation of supply and

management of demand during 7-9 August 2018 at MSSRF, Chennai in partnership with various national and international agencies. – Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. S. Suvana

16. Workshop on Carrying capacity assessment of water bodies organized by Fisheries Department on 11 Sept, 2018 at Bhimavaram, Andhra Pradesh - Dr. M. Muralidhar
17. Meeting of Inauguration of state-of-the-art Community Development Centre for Learning, Livelihood & Research (CDC-LLR) Laboratory in Bhimavaram by KCT on 12 Sept, 2018. - Dr. M. Muralidhar
18. Aquaculture Seminar for "RAS and Krill as a feed ingredient" organized by Innovation Norway at Trident hotel, Chennai on 19 September 2018 – Dr. Krishna Sukumaran
19. Workshop "Norwegian Technology for land based RAS and Krill; an important ingredient for fish & shrimp feed" organized by Norwegian Embassy at Hotel Trident, Chennai on 19 September, 2018 - Dr. K. Ambasankar
20. Parliamentary Committee on Official language, October 3-5, 2018, Chennai - Dr. M. S. Shekhar
21. 4th India International Science Festival (IISF-2018) during 5-8 October, 2018 at Lucknow" – Shri T. Sathish Kumar
22. First Steering committee meeting of Tamil Nadu Irrigated Agriculture Modernization Project at Directorate of Fisheries, Chennai on 10 October, 2018 - Dr. K. Ambasankar
23. 13th Annual convention of Central Information Commission, New Delhi, held on 12 October 2018 – Dr.S.K.Otta
24. Workshop on knowledge management in Marine Fisheries conducted by BOBP, Chennai on 12 October 2018 – Dr. C. P. Balasubramanian
25. Workshop on "Knowledge Management in Marine Fisheries Sector" Organized by BOBP-IGO at Hotel Raintree, Chennai on 12 October, 2018 - Dr. Debasis De

26. Annual Review meeting 2017-2018 of Consortium Research Platform on Vaccines and Diagnostics held at ICAR-CIBA, Chennai during 30-31 October, 2018 – Dr. K.P.Jithendran, Dr. R. Ananda Raja
27. Workshop on "Framing guidelines for culture of *P.vannamei* outside the jurisdiction of CAA " on 8 Nov, 2018 at DOF, Chennai – Dr. R. Saraswathy
28. "Fourth National Agricultural Science Tamil Research Conference" organized by Agricultural Scientific Tamil Society, New Delhi at the Directorate of Research, TNFU Campus, OMR, Vaniyanchavadi, Chennai during 10-20 November 2018 – Dr.R.Ananda Raja
29. Meeting with Hon'ble Union Minister of Agriculture on 16 November 2018 in Kolkata - Dr. T.K. Ghoshal
30. Seminar on "Ion Chromatography Uses" during 16 November 2018 at Chennai organized by Metrohm India Ltd, Chennai - Dr. S. Suvana
31. Fourth National Agricultural Science Tamil Research conference during 19-20th November 2018 at TNJFU, Chennai – Shri T. Sathish Kumar
32. Eighth Conference of Indian Meat Science Association and International Symposium on Technological Innovation in Muscle Food Processing for Nutritional Security, Quality and Safety during 22-24 November 2018 at West Bengal University of Animal and Fishery Sciences, Kolkata - Dr. Sanjoy Das
33. Conference on Revisiting Agricultural Research and Monitoring system for developing innovations during 24-25 November 2018 at ICAR-CIWA, Bhubaneswar – Dr.Premkumar
34. Workshop of nodal officers of ICAR Research Data Repository for Knowledge Management during 4-5, December, 2018 at ICAR, New Delhi – Dr. R. Saraswathy
35. Dissemination workshop by National Biodiversity Authority at India Habitat Centre, New Delhi held on 5 December 2018 – Dr. S.K.Otta
36. Scientist's interaction meet of ICAR-CIBA, Chennai and IISER, Thiruvananthapuram conducted by ICAR-CIBA, 13 December 2019, Chennai - Dr. M. S. Shekhar, Dr. Sherly Tomy, Dr. B. Sivamani, Ms. Misha Somen
37. Town Official Language Implementation Committee (TOLIC) meeting during

18 December, 2018 at NIOT, Chennai - Dr. S. Suvana

38. World Disaster Management Congress organized by IIT, Mumbai during 29 January – 1 February – Dr. R. Saraswathy
39. Meeting with the Secretary and Director of Department of Industrial Policy and Promotion (DIPP) for transfer of surplus salt pan land ICAR-CIBA on 4 January 2019 - Dr. S. Kannappan
40. Golden Jubilee International Salinity Conference on "Resilient Agriculture in Saline Environments under Changing Climate: Challenges and Opportunities" during 7-9 February 2019 at ICAR-CSSRI, Karnal - Dr. P. Kumararaja
41. National Workshop - Aquaculture as a Livelihood Option for Tribal Farmers of India during 18-19 February 2019 at ICAR-CIFA, Bhubaneswar - Dr. T.K. Ghoshal
42. Expert Committee Meeting of Hilsa Project Phase-II at NASC complex, New Delhi on 14 February, 2019 - Dr. Debasis De
43. Fourth HLMC meeting on Aquazonation organized by Fisheries Departmrnt at Secretariat, Velagapudi, Amaravati, Andhra Pradesh on 21 February, 2019 - Dr. M. Muralidhar
44. "Interactive meeting-cum-workshop of Scientists in IT/Computer Application" with Secretary DARE & DG ICAR scheduled for 6 March 2019 at NASC Complex, New Delhi – Dr. P. Mahalakshmi
45. Brain storming session on Metagenomics applications in brackishwater aquaculture under the Network Project for Agricultural Bioinformatics and Computational Biology (CABin) during 8 March, 2019 at ICAR-CIBA, Chennai - Dr. M. Muralidhar, - Dr. M.S.Shekhar, Dr. N. Lalitha, Dr.R.Ananda Raja
46. Technical and Inspection Committee on Establishment of Shrimp Broodstock Multiplication Centres for *Penaeus monodon* and *P. vannamei* by Government of Andhra Pradesh Submitted to the Ministry of Agriculture and Farmers' Welfare on 12 March, 2019 – Dr. C. P. Balasubramanian
47. National Workshop on Brackishwater Aquaculture Resource Mapping for

Sustainable Development during 14-15, March 2019 at ICAR-CIBA, Chennai – Dr. M. Muralidhar, Dr. R. Saraswathy, Dr. P. Kumararaja, Dr. Gouranga Biswas, Dr. Prem Kumar, Dr.R.Ananda Raja

48. Seminar on Climate Change, Demographic Pressures and Global Sustainability organized by MSSRF on 19 March 2019 at Chennai - Dr. M. Muralidhar
49. Meeting on Revival of domestication of tiger shrimp Penaeus monodon project (DTSP) in Andaman and Nicobar islands organized by Department of Commerce through joint venture with AQUALIMA-UNIMA, Madagascar on 28 March, 2019 – Dr. C. P. Balasubramanian



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