

such as sewage, industrial waste streams, or contaminated groundwater. The microbial communities can be used to produce a wide variety of biochemicals that are then purified and utilized for public good, including medicines, food additives, or chemical additives for cleaning products. The microbes attached to particles of contaminated soils and aquatic sediments help degrade soil-bound contaminants occurring from chemical releases into the environment. Biofilms attached to the plant roots of some crops help cycle nutrients as well as biocontrol of pests and diseases, resulting in increased agricultural productivity. As such, the microbial communities exert either beneficial or harmful effects to the total environment. Therefore, there is a great scope for developing a biofilm technology of producing eco-friendly, beneficial microbial (EBM) biofilms for numerous applications.

In the past and the present to a great extent, microbes have been used in various biotransformation processes, of which single (pure) strains in their biofilm mode are employed. Biologists have observed naturally-occurring biofilms in various environments, and their biological activities have been examined. However, complex interactions of their resident microbes have not been studied adequately. Knowledge on those is very important in any attempt of designing effective EBM biofilms. Co-inoculation⁷ and co-culture⁸ of microbes have been observed

to perform the tasks better than their individual microbes. An interesting example of co-culturing microbes is the development of effective microorganism (EM) technology in Japan⁹. This consists of lactic acid bacteria (LAB), phototrophic bacteria (PB) and yeasts in an anaerobic microenvironment. LAB produce lactic acid through carbohydrate fermentation, and keep the medium acidic, which excludes many pathogenic microbes. They also produce antifungal compounds to inhibit undesirable fungal growth. PB produce carbohydrates required for LAB and yeasts, without generating O₂, which helps to keep the medium anaerobic. In addition, PB break down toxins in the medium. Yeasts produce ethanol and CO₂ by glucose fermentation. Ethanol and CO₂ are important for maintaining antifungal activity of LAB, and for photosynthesis of PB, respectively. In this manner, this microbial community maintains an excellent metabolic cooperation leading to self-sufficiency, which helps its stability and a wide range of activities in the environment. This community has specific mechanisms to survive even in the dark, and even under aerobic conditions.

My project recently developed and observed *in vitro* a rhizobial-fungal biofilm using common soil fungi¹⁰. This has important implications in rhizobial survival and soil N economy under conditions devoid of vegetation. It also has applications in producing improved biofertilizers that

supply most of the nutrients required for plant growth. As such, we can manipulate the development of EBM for optimized effectiveness.

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MEETING REPORTS

Freshwater prawns*

Freshwater prawn farming the world over has registered increase in the past decade. In India, a spurt in freshwater prawn farming activities can be seen in the recent years. The objective of the symposium was to evaluate globally the progress made and to critically analyse the constraints and shortcoming in fresh-

water prawn farming and research. K. V. Thomas, Minister for Fisheries and Tourism, Government of Kerala while inaugurating the symposium, stressed on the importance of freshwater prawn farming in India, especially in Kerala. He expressed concern over the pollution of the freshwater bodies in the country and suggested a scheme for cleaning Vembanad Lake, one of the largest lakes in the country.

The business session of the symposium started with a keynote address by

Michael New (European Aquaculture Society, UK). In the address, New reviewed the current global status of freshwater prawn farming with comments on the statistical information available. Going by statistical information of FAO for 2001, India produced 24,230 mt of the popular freshwater prawn variety *Macrobrachium rosenbergii*, standing at the 3rd position after China and Vietnam, which produced 128,338 and 28,000 mt respectively. He predicted that national production of scampi in India will be

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well above 50,000 mt/year by 2010. After the keynote address, status papers of different countries were presented. Melkar N. Tayamen (National Freshwater Fisheries Technology Centre, Philippines) presented the status paper of giant freshwater prawn *M. rosenbergii* programmes in the Philippines. He gave a brief update of the technology development of freshwater prawn with emphasis on the Bureau of Fisheries and Aquatic Resources, national programmes and strategies commercialization. Nguyen Thanh Phuong (College of Aquaculture and Fisheries, Cantho University, Vietnam) pointed out that Vietnam had 90 prawn hatcheries by the end of 2002 and produced over 115 million post larvae. The Vietnam model was notable due to its simplicity, limited use of water and artemia, high productivity up to 50 to 75%, survival rate and high profit. A. M. Jayasekara (FAO expert) mentioned that the Government of Sri Lanka had envisaged bringing 300 ha of area for freshwater prawn farming in the country. It is planned to construct a new hatchery with a capacity of 4 million post larvae annually under the ADB-funded Aquatic Resources Development and Quality Improvement Project. Rahima Nazar stated that Bangladesh had about 40,000 cold water shrimp farms covering 1,70,000 ha and 1,05,000 Golda farms covering 30,000 ha. The Department of Fisheries of Bangladesh Government has established the Fish Inspection and Aquaculture Control Act. The status paper of freshwater prawn culture in Brazil prepared by Wagner C. Valenti (Savo Polo State University, Aquaculture Centre, Brazil) was presented by M. N. Kuttu. *M. rosenbergii* is the only species in the small farms concentrated in the south-east region of Brazil. However research projects are being carried out with developed technology to produce the native species *M. amazonicum*. Monoculture and polyculture with Tilapia were performed. Productivity varied from 1000 to 4500 kg/ha/year. Status of freshwater prawns culture in China with special reference to the high density culture of *M. nipponensis* prepared by Miao Weimin (Freshwater Fisheries Research Centre, China) was presented by Michael New. David Yasharian (Aquaculture Research Centre, Kentucky State University, USA) reported that the culture of *Macrobrachium* in temperate zones offered positive opportunities despite the inability to culture year round. Farming with the best

management practices was by compiling factors such as evaluating and maximizing the relative contributions of natural feeds, facts of artificial substrates on growth and prawn population structure and grading of animals prior to pond stocking to reduce heterogeneous individual growth. Using best management practices, production of 1500–1800 kg/ha has been achieved in commercial ponds on 110 days. J. Bojan Marine Products Export Development Authority (MPEDA) presented the status paper on scampi farming in India. Scampi is cultured in 34,630 ha area in the country. The average production per hectare ranges from 880 to 1250 kg. He has noted that 62% of the scampi culture operation is in Andhra Pradesh. Presently 71 hatcheries are operating in various states supplying 183 billion scampi seeds to the farmers in India. The high cost of seed and feed is a problem facing scampi farming in India.

In the biology and capture fisheries session, Jain M. Wagner (Griffith University, Queensland, Australia) presented a paper on the implication of translocation and interbasin water transfers of the *Paratya australiensis* species in Western Australia. E. B. Agasen (Philippines) presented a paper on the commercially important species of freshwater prawns in Luzon and Pena Island of Philippines. Twelve species of freshwater prawns were identified, the largest among these was giant freshwater prawn *M. rosenbergii*. P. Das (CIBA, Bhubaneswar) described the genetic characteristics of the species of *Macrobrachium* using RARD PCR profiling. The lead paper in the Disease and Health Management session was by C. V. Mohan (NACA, Bangkok). He gave an overview of the issues and responsibilities involved in health management in aquaculture. Jean Robert Bonami, a world authority on fish diseases from France, presented a characterization of two virus (*MrNV* and *DSV*), pathogenic agents of the White Tail Disease (WTD) of the giant freshwater prawn *M. rosenbergii*. Joannes Sri Widada (University Montpellier II France) presented a paper entitled 'Genome-based detection methods of *MrNV* and *DSV*, the pathogenic agents of White Tail Disease (WTD) in *M. rosenbergii*, possible use in the study of viral association and the evaluation of disease severity'. He suggested that due to its sensitivity and ease, the use of RT-PCR appeared to be a

versatile method for early diagnosis of white tail disease which causes a high mortality of *M. rosenbergii*. Sahul Hameed (Abdul Hakeem College, Vellore) discussed the clinical and histopathological signs of white tail disease of *M. rosenbergii*.

In the session on hatchery technology, David Yesharian and James Tidwell (Kentucky State University) discussed the effect of tank colouration on the larval development of freshwater prawns. Nani Gopaldas (University of Chitagong, Bangladesh) reported on the rematuration of hatchery used wild spawners of *M. rosenbergii* in captivity. C. Vasudevappa (University of Agricultural Sciences, Bangalore) reported that freshwater cladocerm (Hoinasp.) can be substituted for larval rearing in freshwater prawn *M. rosenbergii*.

In the session on farming technology, Illan Karplus of Israel presented a paper touching areas of crucial research to gain better understanding of the growth-regulating mechanism of *M. rosenbergii*. A paper on prawn fish culture in backyard water berths in Bangladesh was presented by Kan Mohammed Nurul Islam (Caritas Fisheries Project, Bangladesh). Vu N. M. Son (Asian Institute of Technology, Thailand) presented a paper on the river culture of giant freshwater prawns of *M. rosenbergii* in South Vietnam. David Yesharian reported the effects of stocking different grades of prawn juveniles on production. Effects of different fertilizers on the production of integrated rice prawn culture was dealt with by Davohuygiap (Asian Institute of Technology, Thailand). Hardayal Singh (Ludhiana Centre of CIFA) reported record growth of production of giant freshwater prawns *M. rosenbergii* in Haryana. Debbie Williams (DANIDA project, Bangladesh) presented the prospects of giant freshwater prawn farming in Bangladesh.

A farmers–scientists–officials–industrialists interaction session was held. More than 100 farmers from different states of India participated in the interaction session. Haribabu (College of Fisheries, Nellore) translated the gist of presentations in Telugu.

In the award distribution ceremony, U. K. Viswanatha Raju (Ananda Group of Companies, Bhimavaram) won the Pioneer Award for setting up the first commercial hatchery in the country. His hatchery was based on the technology

developed by the Fisheries College, Panangad. K. Gopala Reddy of Nellore won the Best Freshwater Prawn Farmer Award, while ch. Srikanth, Nellore won the Propagation Award for Scampi. The Best Young Scientist Award was won by K. R. Salin for his paper 'Live transportation of scampi without water'. The Best Scampi Exporter Award went to K. Eravikumar (Five Star Marine Exports (P) Ltd, Chennai) and the Second-Best Scampi Exporter Award to M/s Victoria Marine and Agro Exports Ltd, Chennai. Outstanding Aquaculture Scientist Award instituted by Aquaculture Foundation of India was given to C. Mohanakumaran Nair (College of Fisheries, Panangad). Best State Award for Scampi Culture Propagation was given to the state of Andhra Pradesh which now has about one lakh acres under freshwater prawn farming.

Four scientific sessions were held on the final day of the symposium. In the session on nutrition and feeds, the lead paper on *Macrobrachium* nutrition, feed and feeding was presented by Mali Boonyartpalin, Thailand. She suggested that a level of 30 to 35% of protein in diet of freshwater prawns *M. rosenbergii* is ideal. Brood stock feed of high level of 18: 2n - 6 and n - 3 HUFA (13 and 15 mg/g DW) has been found to improve fecundity, egg hatchability and overall quality of the larvae. Madhumita Mukherjee, West Bengal reported that feeding with natural food alone up to 9th day and artificial food thereafter resulted in successful production of post larvae of *M. rosenbergii*.

In the session on post-harvest technology, K. A. Devadasan, Central Institute of Fisheries Technology (CIFT), Kochi

highlighted the salient features of the post-harvest technology in giant freshwater prawn. M. K. Mukundan (CIFT, Kochi) said that chemical contaminants and antibiotic residues were threats for scampi raised by aquaculture. However, he mentioned that microbial quality of farmed giant freshwater prawns in India did not exceed tolerance limit. Cadmium, lead, mercury in ppm were within limits. It was mentioned that to reduce TPC, antibiotics were being used, which was causing problems. Mukundan said that a farming package based on sanitation and hygienic safety had to be developed for ensuring production of good quality giant freshwater prawns. In the session on economics and marketing, J. Bojan (MPEDA) reported that in India there was a spurt in the freshwater prawn farming activity in recent years resulting in production of 30,450 mt from 34,630 ha in 2002-03. He attributed this mainly to the availability of water bodies, establishment of hatcheries, production of low cost prawn feed and enthusiasm of entrepreneurs. J. V. H. Dixtulu (Fishing Chimes, Visakhapatnam) stressed the need for nation-wide promotion of giant freshwater prawn farming through survey of sites, assured aquaculture inputs and technical support for farming, processing and marketing. In the session on sustainability and environment, M. N. Kutty, who presented the lead paper, said that the annual expansion rate of freshwater prawn farming in the world during the decade ending 2001 was estimated as 29% and that between 1999 and 2001 as high as 48%. He emphasized the requirement of establishing sustainable freshwater prawn farming systems as per the guidelines formulated by FAO and other agencies in

order to prevent an unexpected collapse as in the case of shrimp farming.

Michael New, UK made remarks consolidating the points raised in the symposium in the plenary session. He was impressed with the enthusiasm shown for scampi production in India and its rapidly expanding output. Regarding hatchery technology, he suggested the need for having small seasonal hatcheries on all farms or for co-operative seasonal hatcheries that serve a number of small local farms. Breeding programmes to improve performance, and possibly the production of hybrids that exhibit the favourable characteristics of more than one species, are desirable. There is also a need to protect the natural resources in a country like India where the major cultured species are indigenous. Conservation of genetic diversity is critically important. Everybody agrees that all-male culture of *Macrobrachium* is beneficial. This can be achieved by the administration of substances derived from the androgenic gland to induce all-males. The second possibility would be the production of all-male progeny through the development of functional neo-females to be mated with normal males. Michael New said that the latter solution could lead to global dominance by a few major hatcheries that would control the supplies of superior stock, an analogous situation to that prevailing in the poultry industry globally. The former solution would better protect the small operators around the globe.

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Animal communication*

Studies on bio-acoustics started about 50 years ago, when Peter Marler published a research paper entitled, 'Characteristics of some animal calls' in *Nature*¹. After

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this, many ethologists, ecologists and behavioural biologists have been working in this field throughout the world. In India however, studies are scanty and most of them are in collaboration with foreign laboratories. Acoustical Society of America (ASA)² and International Bio-acoustics Council (IBAC)³ are the two major organizations, which provide international platforms for the development of bio-acoustic studies through in-

ternational conferences and publications. The present report highlights latest developments in the field of bio-acoustics, presented in two international conferences on acoustic communication in animals, held during 2003, in North and South America, respectively.

The first International Conference on Acoustic Communication by Animals⁴ was sponsored by ASA and the Center for Comparative and Evolutionary Biol-