TERMINAL REPORT

IND/78/020

CENTRE OF ADVANCED STUDIES
IN
MARICULTURE

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
POST BOX No. 2704, E R G ROAD, COCHIN - 682 031

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Prepared by

Dr. A. Noble,
Scientist Grade S-3

&

Dr. R. Paul Raj,
Scientist Grade S-2

Edited and issued by

Dr. P. S. B. R. James,
Director,
Central Marine Fisheries Research Institute,
Cochin - 682031.

CONTENTS

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FOREWARD

The Centre of Advanced Studies in Mariculture with the objective to promote and catalyse research and post-graduate education in the subject instituted in July, 1979 at the Central Marine Fisheries Research Institute, Cochin with financial assistance of UNDP and ICAR was over by September, 1986. Affiliated to the Cochin University of Science and Technology, this centre offered 2-year M.Sc. and 3-year Ph.D. Degree courses in mariculture since 1980. At an intake capacity of 10 fellows a year each in each course, 5 M.Sc. and 3 Ph.D. batches were completed before its culmination. A good number of candidates trained at the centre are presently engaged in research and a few teach at University level. Some serve as experts in mariculture farms belonging to governmental and non-governmental organisations. Considering the need for more expertise in the country in the discipline, ICAR accorded sanction to continue these degree courses further during the VII Five Year Plan period as the Post-graduate Education and Research Programme in Mariculture of CMFRI. Two more M.Sc. and 3 Ph.D. batches are, therefore presently proceeding with their studies at the Institute. The report presented here deals comprehensively with the activities that took place at the centre during its tenure under UNDP/ICAR aid towards manpower development through teaching, research, expert consultancy, faculty improvement programme, conduct of seminars and workshops, and arrangement of special lectures. Highlights of research carried out on the variety of subject matter areas such as ecology of different culture systems and the biology, physiology, nutrition, pathology and genetics of innumerable cultivable organisms given in the body of the report form useful information towards development of mariculture and augmentation of production.

CMFRI,
Cochin-682 031,
July 21, 1987

P.S.B.R. JAMES
Director of the Institute
and
Sub-project Coordinator of the Centre

1. INTRODUCTION

1.1. Project Background

India has a coastline of 6100 km providing deck for marine capture fisheries. An estimated 2.6 million ha. of contiguous estuarine and brackish water areas suitable for culture are additionally available. Fish culture, however, is practised in only about 25,000 ha.

Demand for fish as a source of protein is ever increasing. The annual marine fish production from capture fisheries, nevertheless, has more or less stabilized at 1.4 million tonnes in the recent past. Development of mariculture/coastal aquaculture to augment fish production, therefore, assumed importance in the national programme for fisheries development. What little culture already practised was by some traditional methods only. Scientific culture, therefore became imperative. Technical competence in this, in the country was but inadequate. This lacuna, it was felt, could be overcome by strengthening post-graduate teaching and research facilities in specific fields. Government of India in 1966 requested UNDP to provide assistance, and as a result, the Centre of Advanced Studies in Mariculture came into being.

1.2. Outline of official arrangements

In response to specific needs of India's fast developing agriculture and the demands for its modernisation; under an agreement already signed on 25th of October, 1959, between Government of India and UNDP concerning assistance from the latter's "special fund" sector and after taking into account the observations of UNDP/UNESCO/FAO Advisory Mission of October, 1975 reviewing certain development

programmes in the line already started, the Project Committee Meeting held on 21st of January, 1978, decided to establish in its Phase III the above Centre.

The Central Marine Fisheries Research Institute (CMFRI), Cochin under Indian Council of Agricultural Research (ICAR) was already handling important research projects in Mariculture and had developed some expertise. The Institute was recognised by the Inter-University Board of India as a Centre to carry out research leading to Post-graduate and Doctoral Degrees. Besides undertaking research, the Institute was conducting training programmes on various subjects of marine fisheries including Mariculture. Having a number of Research Centres and Field Centres, distributed all along the coasts of India, and being equipped with good laboratory and library facilities and manned by qualified scientists of high calibre, CMFRI was the only agency in the country suitable to house this Centre of excellence in teaching and research in Mariculture. The Centre of Advanced Studies in Mariculture was thus established at CMFRI, Cochin in July, 1979.

1.3. Objectives

The main objective of the project was to provide highly specialised and competent professionals required to plan, execute and co-ordinate mission-oriented research and improve production potentials of fish in the country. Plans to achieve this objective were as under:

(a) Improve the quality of post-graduate education and research. Under this, the plan was to offer M.Sc. and Ph.D. courses in Mariculture to educate and train 50 Ph.D. and 80 M.Sc. students during the project period.

(b) Offer advanced training to staff members under faculty

improvement programmes so as to increase their professional competency.

Overseas fellowship training of Indian Scientists to the tune of 150 man-months in 23 subject matter areas were proposed for the project.

(c) Draw consultancy service of subject matter experts. Expert consultants to a total of 45 man-months in 7 subject matter areas were proposed during the tenure of the project.

(d) Provide adequate facilities to carry out research of excellence. Twenty-eight equipments to build up infrastructure facilities were sanctioned.

(e) Develop and execute mission-oriented research programmes of strategic importance to solve constraints on realising production potentials.

(f) Organise seminars and workshops.

(g) Develop linkages between the Centre and other Institutions in the country.

2. INSTITUTION OF THE CENTRE

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Dr. E. G. Silas, Director of CMFRI was designated as the Sub-Project Co-ordinator from its inception to August, 1985. Subsequently, in September, 1985; Dr. P.S.B.R. James took over as the Director of the Institute and the Sub-Project Co-ordinator of the Centre. Post for Professors and Associate Professors in Physiology, Nutrition and Fish Farm Engineering were specially sanctioned as they were not available in the staff of CMFRI. Of these, only Associate Professors in Physiology and Nutrition were appointed (Appendix 6.1). No suitable candidates could be selected to the other posts despite repeated advertisements and interviews. However, the project was implemented by deploying other Scientists of CMFRI as Associate Faculty Members and also arranging guest lectures (Appendix 6.2) through eminent staff of other organisations. The posts of 2 Technical Officers in Farm Engineering and Farm Management, 3 Office Assistants and 2 Junior Stenographers were filled up in time (Appendix 6.1) against sanctinoed strength.

2.2. Teaching programme

Class rooms, laboratories and other teaching facilities were developed and the University of Cochin (now known as the Cochin University of Science and Technology) was approached in connection with starting of M.Sc. and Ph. D. Degree programmes. The University soon constituted a Commission to examine the facilities available in CMFRI for offering the Post-graduate Education and Research Programmes. This Commission visited the Institute on 3.10.1979 and made recommendations. A Board of Studies was accordingly constituted by the University to recommend the course programmes and schemes of examnination for the M.Sc. Degree. The draft syllabus for the M.Sc. programme was discussed and approved by the Board of Studies and submitted to the Faculty and Academic Council. Similarly a draft syllabus for the Ph.D. course work in Mariculture, during the 1st semester was also prepared and presented for approval.

2.2.1. Master's Degree Programme

The syllabus drawn and approved by the University is given at the end as Appendix 6.3.

The course programme for M.Sc. in Mariculture is of 2 years duration comprising of 4 semesters with subjects like Basic Sciences, Marine Biology, Coastal Hydrography, Physiology, Endocrinology and Cytogenetics of Marine Animals in the 1st semester; Fisheries, Fish and Fishery Biology, Finfish Culture, and Fish Farm Engineering Technology in the 2nd semester; Culture of Crustacea, Culture of Mollusca, Culture of Seaweeds, and Research Methodology in the 3rd semester; and Management of Mariculture Farms and Extension and Dissertation in the 4th semester.

The course programme in structure comprises of regular lecture classes, practicals in the laboratory as well as in field, study tours to important mariculture and aquaculture facilities in different parts of the country, seminars, workshops and preparation of dissertation based on a short-term research problem related to mariculture.

At the end of each semester the University conducts theory and practical examinations in the subjects listed. A viva-voce is also conducted by the University at the end of each semester after the practical examination. Besides these, the day to day progress of the students are monitored through internal evaluation procedure involving, class tests, assignments, quiz programme and seminars; and the performance communicated to the University at the end of each semester for them to consolidate the results. The dissertations done under the guidance of supervising teachers, are submitted to the University for evaluation.

The candidates for the M.Sc. programme are selected based on their performance in an entrance examination conducted, the marks obtained in the qualifying examination at Degree level and interview. Usually 10 students in the order of merit are admitted giving due reservations for Scheduled Caste, Scheduled Tribe and Backward Communities as per University/ICAR regulations.

Names of candidates admitted in different batches of M.Sc. programme along with some other particulars are given in Appendix 6.4. The following Table shows the number of candidates admitted in each batch, the number completed, discontinued, and continuing:

Batch No.	Academic Year	No. of Candidates			
		Admitted	Completed	Discontinued	Continuing
1	1980-82	10	9	1	-
2	1981-83	15	12	3	-
3	1982-84	10	10	-	-
4	1983-85	10	10	-	-
5	1984-86	9	8	1	-
6	1985-87	9	-	-	9
7	1986-88	9	-	-	9
	Total	72	49	5	18

Of the 72 candidates admitted 5 discontinued. Among the successful candidates of 1st to 5th batches, 4 passed out in First Class with Distinction and 43 with First Class. One candidate, however, could secure only a Second Class. All the M.Sc. students were awarded Junior Research Fellowships (Rs.400/- per month for students up to 3rd batch

and Rs.800/- from 4th batch onwards) by the Indian Council of Agricultural Research. Each fellowship carries a contingent grant of Rs.2000/- also per annum.

The topics of dissertation in the M.Sc. programme by each fellow are given in Appendix 6.5, and the highlights of these short-term research projects are given in section dealing with it later (Appendix 6.16).

2.2.2. Ph.D. Degree Programme

The Ph.D. Degree programme is of 3 years duration with a possible extension of 6 months (12 months for Scheduled Caste and Scheduled Tribe). It consists of 2 semesters of course work in the beginning. The course work in the 1st semester is on mariculture, and it is common for all the Ph.D. candidates. The syllabus followed in this course work is given in Appendix 6.6. The 2nd semester, however, deals with course work on specialised area of their research projects, and each Supervising Teacher prepares its syllabus and submits to the University.

The areas identified as priorities for Ph.D. specialised programmes are (1) Ecology, (2) Physiology, (3) Nutrition, (4) Endocrinology, (5) Pathology, and (6) Culture system of cultivable organisms.

The candidates are selected based on their performance in the qualifying examination (Master's Degree) and interview. Usually 10 candidates are selected from the merit list prepared and are awarded a Senior Research Fellowship of the ICAR. Batch-wise names of candidates selected for the Ph.D. programmes along with some other particulars are given in Appendix 6.7. The Senior Fellowship was a sum of Rs.600/- per month per person in first 2 years and Rs.700/- in third year for the batches up to the 3rd. From 4th batch onwards it was raised to Rs.1000/- per month in the 1st two years and Rs.1200/- in the 3rd

year and after. The fellowship also carries a contingent grant of Rs.5000/- per annum per scholar.

At the end of course work, the Research Fellows have to appear for a qualifying examination conducted by the Cochin University of Science and Technology.

A Doctoral Committee is constituted for each Fellow and each Fellow works under the guidance of a Supervising Teacher. Periodic review on the performance and progress of research by the Fellow is done by the Doctoral Committee. The Fellow has to submit quarterly, half yearly and annual reports for reviewing the progress achieved by them. After completion of the research programme, the Fellow submits the thesis to the University for valuation and award of Ph.D. Degree. A viva-voce is conducted before the award.

The following table gives the position of Senior Research Fellowships awarded to the Ph.D. Scholars during the period up to December, 1986.

Batch No.	Year	Admi-tted	Comple-ted	Discon-tinued	Conti-nuing	Thesis Submi-tted	Degree awarded
1	1980-83	4	4	-	-	3	3
2	1981-84	9	9	-	-	6	2
3	1982-85	10	8	2	-	1	-
4	1983-86	11	-	4	7	-	-
5	1984-87	10	-	5	5	-	-
6	1985-88	10	-	1	9	-	-
	Total	54	21	12	21	10	5

Topic of research allotted to the Senior Research Fellows are given in Appendix 6.8.

2.3. Employment of Fellows after completion of M.Sc./Ph.D. Degree courses (Please see Appendix 6.5 and 6.6 respectively)

Out of the 70 Junior/Senior Fellows who have completed their programmes, 12 candidates are employed as Scientists, 4 as University Teachers, 2 in Fisheries Administration and Extension, 15 as Technical Experts in Aquaculture with organisations like MPEDA, TATA, Vorion Chemicals and Hindustan Lever and Commercial Banks. Five others are engaged in other jobs like computer programming, business, and general administration. Eighteen of our candidates with M.Sc. Degree are at present undergoing higher studies leading to Ph.D. (mostly) and M.B.A. Out of the remaining 6 of those in the batches upto the 5th, 3 are not very keen on getting employed as they are settled down as house wives. Thus only 3 remain unemployed just because they are critical in their career selection. Out of the 8 candidates of 5th batch of M.Sc. programme 2 are already selected for jobs (one in culture and other in teaching). Others in this batch prefer to improve their qualification through higher studies, if possible. Similarly 2 Fellows in the 4th batch of Ph.D., though selected as aquaculture experts are continuing the course.

2.4. Faculty improvement programme

Faculty improvement consisted of Consultancy Service by Foreign Experts in specialized subject matter areas and Fellowship Training of the Institute's Scientists. Soon after the commencement of the Centre, Dr. E.G. Silas, the then Sub-Project Co-ordinator of the Project and Director of the Institute undertook a study tour to Japan, USA, UK and Italy to identify foreign collaborating Institutes for assigning consultants to India and training of our faculty members abroad.

Subsequently 2 Senior Scientists also visited the Research and Development Institutes, dealing with fisheries and aquaculture in Italy, France, Spain and U.K. with the objective to observe the aquaculture practices as also to identify consultants and Institutes for collaboration.

Besides these 28 other Scientists of the Institute were deputed for specialized training with UNDP/FAO Fellowship Programme in the following areas:

1.	Physiology and Endocrinology	-	6
2.	Nutrition and Bioenergetics	-	2
3.	Biochemistry	-	1
4.	Fish and shellfish diseases	-	2
5.	Finfish and shellfish culture	-	7
6.	Live feed culture	-	1
7.	Seaweed culture	-	1
8.	Genetics of cultivable organisms	-	4
9.	Tissue culture	-	1
10.	Aquaculture economics	-	1
11.	Water quality management	-	1
12.	Ecology of mangroves	-	1

The above Scientists went to various Research Institutes in countries such as U.S.A., France, U.K., Japan, Philippines, Belgium, Malaysia, China, Australia, Spain, Netherlands and Canada for training; the period of which ranging between 2 to 6 months. Further details are available in Appendix 6.9.

The experience gained and knowledge acquired are being used in the improvement of education and research programmes of the Institute.

2.5. Consultancies

Under this programme a total of 15 Foreign Experts from countries like U.S.A., U.K., Japan, Philippines, Belgium, France, Canada and Australia visited the Centre and offered consultancies. Subjects, period and names of consultants are given in Appendix 6.10 attached separately.

They held discussions, conducted seminars and arranged workshops during the period of consultancies and suggested improvements in the syllabii for Master's Degree and Doctoral course and research programmes. Besides, they also suggested improvement in developing better infrastructural and laboratory facilities in the specialised areas of their consultancies. These consultancies also provided opportunity for our scientists and students to get exposed to advanced methodologies in research. Most of the consultants took pain to put these methodologies in print as manuals in research methodologies for future use. A list of such manuals is also appended.

2.6. Seminars/Workshops/Group Discussions/Special Lectures

A total of 69 seminars (Appendix 6.11), 158 Group Discussions (Appendix 6.12) and 12 Workshops (Appendix 6.13) were organised during the visit of expert consultans in their specialised areas.

Besides these, the Institute organised 5 National Workshops (Appendix 6.13) of which 3 were in collaboration with the University of Madras (2 numbers) and Marathwada University (1 number). While the Workshops conducted by the consultants were exclusively for the scientists and studentws of the Institute, the National Workshops were attended by Faculty Members from many Agricultural Universities also.

The Centre also organised 45 Special Lectures/Talks on a variety of subjects (Appendix 6.14) through National and International Scientists/Professors who visited the Centre.

During the course of the programme, the Institute under UNDP aid imported a number of useful, costly and sophisticated necessary equipments which are listed in Appendix 6.15.

3. HIGHLIGHTS OF RESEARCH

During the period under report 49 short-term and 42 long-term research projects were undertaken by Junior Research Fellows (M.Sc.) and Senior Research Fellows (Ph.D.) respectively. Topic of researh, name of Research Fellow (JRF & SRF), the name of Supervising Teacher (ST) and the present status of each of the project are given in the Appendix 6.16 (1 to 91).

The findings in each of the projects are also included in this Appendix.

The following are some of the salient observations on these projects and conclusions drawn under various disciplines.

3.1. Ecological studies on culture systems

Ecology of coastal waters, lagoons and backwater culture systems were studied at various localities.

3.1.1. Soil and water

The suitability of a derilict saline lagoon at Mandapam on the

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3.1.1. Soil and water

The suitability of a derilict saline lagoon at Mandapam on the

south-east coast of India for the culture of finfish and prawns was studied (Appendix 6.16.53) and indicated it to fall under the category of ultra oligotrophic type. When the fresh water and sea water inflow ceases it becomes more anoxic, but the concentration of hydrogen sulphide in the water was not found detrimental to the inhabiting organisms. The investigation reveals that the major deterents for mariculture operation here are the frequent occurrence of low water level, low rate of primary and secondary production, and vulnerability of culture organisms to predators. However, the study shows that the production in the lagoon may be increased by application of NPK fertilizers. Further, the culture of fish in areas where depth of water is more than 30 cm is recommended for better production.

In a study on the soils of prawn culture fields of south-west coast (Appendix 6.16.5), it was observed that in the seasonal field where paddy-cum-prawn culture was practised, the fertility was the highest. Fertility was also the highest in soils predominated with clay and silt.

Further, the carbondioxide equilibria and nutrients in the seasonal and perennial prawn culture systems, and nutrients' availability (Appendix 6.16.22) showed the occurrence of high 0_2 and low CO_2 values during peak monsoon and early postmonsoon months. The bicarbonate alkalinity was also high but the total alkalinity was relatively low during the peak monsoon season. The CO_2 equilibrium was mostly dependent on water temperature, and pH. It had very little correlation with the biological cycle of nutrients.

The exchangeable cat-ions (sodium, potassium and calcium) (Appendix 6.16.40) also registered low values here during the monsoon period. Significant correlations were obtained between the grain size and the concentration of exchangeable cat-ions as well as total phosphorus.

The calcium exchange (Appendix 6.16.34) between the soil and overlying water was relatively high during monsoon in the ponds subjected to tidal influence. An inverse relationship between carbonate and bicarbonate alkalinities was observed. The release of phosphorus from sediments to overlying water was observed under low-oxygenated state.

The reactive phosphorus (Appendix 6.15.44) was at its peak in the seasonal ponds when oxygen was low. But there was no correlation between total phosphorus and hydrophysical conditions of overlying water. Relatively high concentrations of organic carbon and carbohydrate were observed due to decaying of organic manure and paddy stumps.

The available forms of nitrogen in the sediments (Appendix 6.16.48) showed higher values than in the overlying water, whereas the available phosphorus was more in the overlying water than in the sediment. The high concentration of nitrogen in monsoon months was accompanied by an increase in the plankton biomass.

Diurnal variations in temperature, oxygen, pH, Eh, salinity, nitrite, nitrate, phosphate and ammonia in the brackishwater culture systems near Cochin were studied (Appendix 6.16.10). Diurnal variations of temperature, pH, Eh and dissolved oxygen of water during pre-monsoon and monsoon periods were regular. The values of these between the surface and bottom waters did also not vary significantly. The temperature was maximum at 16.00 hrs and minimum at 04.00 hrs; pH and Eh were maximum at 16.00 hrs and 18.00 hrs and minimum at 06.00 and 08.00 hrs. Concentrations of nutrients including ammonia did not show any definite pattern with time of the day.

3.1.2. Microbiological investigations

With a view to elucidating the turnover of nitrogen in perennial and seasonal prawn culture fields of Kerala, studies were conducted

(Appendix 6.16.60) on the various bacterial groups associated with nitrogen cycle with special emphasis on environmental factors which influence the distribution of total heterotrophic, proteolytic, ammonifying, nitrifying, denitrifying and nitrogen fixing bacteria in both sediments and water. The bacterial population was found to be maximum during the pre-monsoon and minimum during the monsoon seasons in both the ecosystems. The pH of the water and sediment, and the water temperature were observed to be the most important among the factors influencing the distribution and abundance of most of the bacterial groups.

The rate of bacterial nitrogen fixation was more in seasonal than in perennial ponds. It was more in sediments than in water in all the ponds, and found to vary during the different seasons. It was significantly affected by water temperature, water and sediment pH, dissolved oxygen content, salinity, nitrite, nitrate, ammonia and total phosphorus contents in almost all the ponds. In the case of seasonal ponds the sediment Eh also significantly influenced the bacterial nitrogen fixation rate. A direct relationship was noticed between the viable number of nitrogen fixing bacteria and the rate of nitrogen fixation.

Characterisation of 30 different aerobic nitrogen fixing Azotobacter strains were carried out after their isolation and purification to the species level, of which 13 strains belong to A. chroococcum, 9 strains to A. vinelandii and 8 strains to A. beijerinckia. Experimental studies on the nitrogen fixing ability of these 30 strains, show that in 2 strains of A. chroococcum and one of A. beijerinckia, rate of nitrogen fixation was the highest. The effect of 4 vitamins namely cyanocobalamine (B 12), biotin, thiamine and ascorbic acid on 9 strains comprising of 3 each in each species were studied. The strains belonging to A. chroococcum showed maximum growth at 4/ug/l of cyanocobalamine, 60/ug/l biotin, 80/ug/l thiamine and 130 /ug/l ascorbic acid. The A. beijerinckia strains, however, showed maximum growth at 6/ug/l

cyanocobalamine, 60 µg/l biotin, 40 µg/l thiamine and 100 µg/l ascorbic acid. All the 3 strains of A. vinelandii showed maximum growth at 5 µg/l cyanocobalamine, and 50 µg/l biotin. In the case of thiamine one strain showed maximum growth at 50 µg/l and the remaining 2 at 40 µg/l. In the case of ascorbic acid, 2 strains showed maximum growth at 120 µg/l and one strain at 140 µg/l.

Significant differences in the optimum requirement of trace elements (cobalt, zinc, copper and iron) for maximum growth was observed among the 9 strains.

Salinity and pH of the medium were observed to have significant influence on the growth and nitrogen fixation of the different Azotobacter strains. The optimum salinity for maximum growth ranged from 25 to 35 ppt in various strains, whereas the optimum pH varied from 6.5 to 8.0.

Studies on short-term variations in sulphate reducers (Appendix 6.16.24) with respect to heterotrophic populations and physico-chemical parameters were carried out in a perennial and a seasonal field to find out the factors responsible for quantitative variations in hydrogen sulphide production. Salinity, sediment, Eh and total heterotrophs had significant correlation with sulphate reducers. Biochemical tests reveal that the species involved in the process of sulphate reduction in both perennial and seasonal fields are Desulphovibrio desulphuricans and D. aestuarii.

Seasonal variations in heterotrophic bacterial populations (Appendix 6.16.36) in relation to rainfall, physico-chemical characteristics like temperature, pH, Eh, electrical conductivity of the soil, and organic carbon, available phosphorus and nitrate were investigated in a mangrove ecosystem. Available phosphorus alone showed significant relationship with total heterotrophs. Alcaligenes dominated the generic

composition of bacteria followed by Pseudomonas, Flavobacterium and Micrococcus.

Distribution of microflora in the rhizosphere and non - rhizosphere mangrove environment was studied (Appendix 6.16.43) with reference to certain physicochemical parameters and found a significant relation between the microflora and chemical factors such as pH, Eh, organic carbon content, available nitrate and phosphate. A significant negative correlation was observed between the bacteria and actinomycetes populations. The rhizosphere microflora of Acanthus ilicifolius have greater ability than the non-rhizosphere soil populations to effect greater mineralization of organic matter.

3.1.3. Mangroves

Studies on colonization of mangroves (Appendix 6.16.29) show that Acanthus ilicifolius has a varied distribution pattern in the sea accreted regions of Cochin with large colonies occurring in association with Avicennia. The standing crop and shore density were observed to be controlled by environmental parameters. A moderate soil salinity, tidal enundation, lower redox potential and fine grain soil with silt and clay were found to be favourable to the colonization of the species. A lowering of soil salinity was found to trigger the vegetative propagation and sexual reproduction in the species.

Experiments on the germination of Avicennia officianalis (Appendix 6.16.39) show that salinities less than 15 ppt are essential for maximum sprouting of the seeds, and the seeds fail to sprout when kept immersed in water throughout the day. The percentage of germination of seeds in low and high tide levels in nature was found to be 45 and 60, respectively. In darkness in an inert medium, the seeds sprouted and grew to 2-leaf stage indicating that the food reserve in the seed is sufficient to support growth upto this stage. The germination rates of seeds were augmented by mineral enriched beach sand.

3.1.4. Primary production

The effect of environmental parameters on photosynthesis and productivity in prawn culture ponds was studied (Appendix 6.16.45) to assess the biogenic capacity of the pond water. The nutrient concentration in the pond was higher than that of natural brackishwater environment due to leaching from fertilized agriculture fields. The relation between primary production and chlorophyll was found to be negative. The areas studied were highly productive (7.5 gc/m^3/day).

3.1.5. Benthos

The benthic macrofauna of perennial and seasonal prawn culture fields and canals in coconut groves was studied (Appendix 6.16.2). Polychaetes, nematodes, tanaidaecides, amphipods and bivalves in all the 3 systems showed seasonal variations. Benthic biomass was significantly influenced by salinity and organic carbon with a positive correlation at 1% level. But the redox potential and nitrate had a negative correlation with the benthic biomass. The temperature, pH of mud and water, and nitrate had no significant influence on benthic biomass.

The distribution and abundance of meiobenthic fauna in the canals of coconut groves (Appendix 6.16.17) were significantly influenced by the salinity and dissolved oxygen. In perennial and seasonal fields, the available phosphorus and temperature acted as major controlling factors in the distribution of benthic meiofauna.

3.1.6. Pollution

Toxicity of hydrogen sulphide to juveniles of the prawn Penaeus indicus was studied (Appendix 6.16.23) in a flow-through apparatus in 24 hour LC 50 experiments and found its lethal concentration to be 7.2 ppm for 20 to 25 mm size juveniles; 6.4 ppm for 40 to 45 mm sizes and 3.35 ppm for 80 to 85 mm sizes. The lethal

concentration for 40 to 45 mm juveniles, however, declined with decreasing pH. It was 6.8 ppm at pH 8.9 to 9.3, 6.4 ppm at pH 8.1 to 8.3, 3.1 ppm at pH 6.9 to 7.3 and 0.47 ppm at pH 5.9 to 6.3. The experimental animals lost 7.3% of their weight at 30.0 ppt salinity in 24 hour exposure to H_2S. In aquarium experiments, the juveniles avoided resting and burying in soil rich in total sulphides. A filamentous sulphur bacterium was found to grow on the gills and pleopod setae of the prawns exposed to H_2S.

Effects of lethal and sublethal concentrations of selected pesticides such as malathion and 'Ekalux' on the larvae, post-larvae and juveniles of P. indicus were investigated (Appendix 6.16.42). The median lethal concentration of malathion on mysis stage was 2.97 ppt at 36 hrs., while that of 'Ekalux' was 2.62 ppt at 24 hrs. The median lethal concentrations of malathion and 'Ekalux' on post-larvae were at 2.55 ppt at 48 hrs. and 2.70 ppt at 24 hrs. respectively. The oxygen consumption and ammonia excretion of juveniles reduced on exposure to sub-lethal concentrations of malathion.

3.2. Sea-weeds and sea-grass

Studies on sporulation and propagation of 4 commercially important red algae (Agarophytes) namely Gelidiella acerosa, Gracilaria corticata, G. edulis and Hypnea musciformis, off Mandapam Coast were carried out (Appendix 6.16.51). The population of all the above species and their tetrasporophytes were found to occur throughout the year. The carposporophytes of G. corticata and G. edulis were also seen throughout the year. But the occurrence of carposporophytes of H. musciformis was seasonal. Cystocarpic plants were not found in the case of G. acerosa.

In laboratory conditions, the tetraspore output was for a period of 6 to 14 days in G. acerosa, 6 to 27 days in G. corticata, 3 to 30 days in G. edulis and 3 to 23 days in H. musciformis. The

carpospore liberation was 6 to 30 days in G. corticata, 10 to 30 days in G. edulis and 2 to 24 days in H. musciformis.

Diurnal periodicity in the liberation of tetraspores with a prominent peak between 2.00 and 6.00 p.m. was observed in G. acerosa, whereas the maximum liberation of spores in G. corticata, G. edulis and H. musciformis occurred between 10.00 a.m. and 2.00 p.m.

Salinity has been found to influence shedding of spores with peaks at 30 ppt in G. edulis and H. musciformis and 40 ppt in G. acerosa and between 30 and 40 ppt in G. corticata.

Peak sporulation was observed at low light intensity of 500 lux in G. acerosa, G. corticata and G. edulis and 1000 lux in H. musiformis. The maximum spore output was at 25°C in G. acerosa and 30°C in H. musciformis and between 25 and 30°C in G. corticata and G. edulis.

Studies on the edible economically important marine algae in the intertidal and subtidal regions occurring around Mandapam in the south east coast of India were made (Appendix 6.16.75) with reference to their frequency, coverage, frequency-cover-ratio and biomass of dominant and sub-dominant species. In the study at intertidal zone, 13 species were recorded from Gulf of Mannar and 10 species from Palk Bay. The total standing crop of each of these species was estimated by random sampling in 6 quartets each of 0.25 m^2.

Biomass estimates of the algal population at sub-tidal zones were carried out by sampling from 12 quartets of 0.5 m^2 from depths 0.5, 1.0, 1.5, 2.0 and 4.0 m. Biochemical composition of 5 species of algae were determined.

Studies on the sea-grass ecosystem around Mandapam in the south east coast of India (Appendix 6.16.70) revealed the presence of

8 species belonging to 6 genera, under 2 families namely Potamogetonaceae and Hydrocharitaceae. The species present were Cymodocea serrulata, C. protendata, Syringodium isoetifolium, Halodule uninervis, Halophila ovalis, H. stipulacea, Enhalus acoroides and Thalassia hemprichii. Of these C. serrulata is the most abundant sea-grass and it grows luxuriently in between 0.25 and 4.00 m deep waters.

Analysis of sea-grass beds' fauna indicated that these beds host commercially important finfish like mullets and Gerres and the prawn P. semisulcatus. Productivity of sea-grass as estimated in C. serrulata, S. isoetifolium, H. uninervis and H. ovalis varied from 0.941 to 6.989, 0.419 to 3.429, 1.485 to 7.452 and 0.777 to 1.928 mg C/g dry wt/hr respectively.

3.3. Seed resources, transportation and hatchery production

Studies on prawn seed transportation (Appendix 6.16.1) show that about 250 seeds of 14 to 18 mm size per litre could be transported for 24 hrs. with 70% survival. For 48 hrs. transportation the density/ltr. should be 100. For larvae of 8 to 12 mm size, 70% survival could be obtained during 24 and 36 hrs. at a density of 300 and 150 numbers per litre respectively. At a density of 150 seeds/ltr., 70% survival was obtained with 13 to 15 mm size for 48 hrs. Survival rate of small sized seeds was relatively low for longer periods of transportation mainly due to cannibalism. When pH of the medium fell below 6.6 and ammonia level exceeded 70 to 80 ppm, mortality was high. With 1:1 ratio of oxygen to water, depletion of oxygen was not found to be the main cause of mortality.

Laboratory experiments conducted to study the chronic and acute toxicity (Appendix 6.16.6), showed that nitrate is toxic to the prawn larvae only in very high concentrations which are not ecologically significant. The tolerance to ammonia and nitrite was the best in

nauplius stage and the former was nearly 3 times more toxic than the latter. Tolerance to ammonia and nitrite increased progressively as the larvae metamorphosed into protozoea and mysis stages. Nitrite turned to be more toxic than ammonia in late protozoea and mysis stages. Larvae from the wild spawners were more sensitive to nitrite and ammonia than the larvae from eye stalk ablated spawners. The incipient LC 50 values were 11.99 ppm of ammonia-nitrogen and 3.29 ppm of nitrite-nitrogen. EC 50 values were 3.23 ppm of ammonia-nitrogen and 1.90 ppm of nitrite-nitrogen. The safe levels of ammonia and nitrite for P. indicus larvae were estimated as 0.32 ppm ammonia-nitrogen and 0.18 ppm nitrite-nitrogen.

Studies on the quality of freshly collected sea water containing more dissolved and particulate organic matter and stored sea water (Appendix 6.16.47) revealed that the former was more suitable for the normal survival and growth of newly hatched prawn larvae. Neverthless, for post-larvae and subsequent stages, stored sea water also proved to be a good medium for rearing. The POM values were generally higher in fresh sea water during the monsoon period.

3.4. General biology

Studies were carried out on the systematics and phenotypic and genotypic character variation in different populations of Etroplus suratensis and E. maculatus (Appendix 6.16.59) from 8 estuarine systems and a landlocked fresh water habitat. Electrophoretic studies show that the protein patterns of blood serum, blood haemoglobin, gonad and liver varied with size, sex and maturity. But the protein pattern of muscle and eye lens remained the same. Six iso-enzymes namely lactate dehydrogenase, malate dehydrogenase, alcohol dehydrogenase, acid phosphatase, esterase and catalase were separated on poly-acrylamide and starch gel electrophoresis. The chromosome numbers were 48 in

E. suratensis and 46 in E. maculatus. The biochemical studies showed that the protein, lipid and moisture contents decrease in the muscle and increase in the liver with the advancement of gonadal maturity. E. suratensis was found to spawn in Cochin backwater throughout the year with peaks in November - January and March - April periods.

The larval history of spiny lobster, Panulirus homarus was studied (Appendix 6.16.62) by collecting berried animals and rearing the hatched larvae in sea water of different salinities, pH, temperature and dissolved oxygen. The phyllosoma larvae were reared from the 1st stage to the 4th stage on Artemia nauplii and jelly fishes as feed. The optimum level of salinity was found to be between 28 and 32 ppt. The pH suitable for larval survival and moulting was 8.0 to 8.6. The optimum temperature for better growth was 31.0^{o}C with 4.0 ml/l of oxygen. The phyllosoma larvae obtained from plankton collections of FORV SAGAR SAMPADA were examined and found to include different stages of P. homarus, P. versicolor, P. ornatus, P. longipes, P. penicillatus and P. polyphagus.

Relative abundance, distribution, size, age composition and reproductive biology of Artemia population were studied (Appendix 6.16 78) from the high saline habitat (salt pans) at Tuticorin. The development of Artemia population depends mainly on environmental parameters. Low salinity favours hatching of cysts. In very high salinity production of nauplii stops and instead cyst production takes over. The propagation of Artemia population in this region, therefore is only through parthenogenesis.

3.5. Physiology

Under this there are 2 sub-disciplines namely ecophysiology and reproductive physiology.

3.5.1. Ecophysiology

Comparative evaluation of polyethylene and perspex aquaria as rearing tanks for juveniles of P. indicus revealed (Appendix 6.16.52) that the polyethylene tanks are superior to perspex tanks in promoting survival and growth. Prawns reared in perspex tanks showed higher rates of ammonia excretion. In darkness, growth was significantly superior with lower excretion rates than those reared under light. Diurnally the rate of ammonia excretion had 2 peaks regardless of the size of prawns. In juveniles there was an uptake of ammonia from the ambient waters and it was subsequently confirmed.

The juvenile prawns in experiments required optimum salinities of 20-35 ppt range for best growth and survival. The optimum pH for maximum growth was observed to be 7.0 and extremes of it (5.0 and 9.0) caused poor growth and survival, and enhanced the respiratory and excretory rates considerably. Growth, survival and percentage dry weight in juveniles were inversely related to stocking density, whereas rate of excretion and final biomass were directly related. Excretion of ammonia and build up of nitrogenous waste increased with less frequent water change.

The stress caused by changes in salinity, mechanical chasing and transportation in high densities in P. indicus was studied (Appendix 6.16.46) by determining changes in the protein, magnesium and calcium. In lower salinities, the protein and magnesium in the haemolymph show high values, and low values in high salinities. Mechanical chasing in the ponds increase the calcium and magnesium concentrations in the haemolymph. In transportation, the calcium and magnesium levels rise up initially. But after 43 hours of transportation the values become normal and drop to subnormal levels.

Optimum salinity ranges, lethal salinity level and effect of salinity acclimation on different size groups of post larvae of P. indicus

were worked out (Appendix 6.16.7). On sudden exposure from a pre-acclimation salinity of 20 ppt the range of tolerance observed was 4 to 40 ppt for 8 to 9 mm size, 3 to 49 ppt for 13 to 15 mm size and 2 to 50 ppt for 18 to 19 mm size group with optimum at 10 to 25 ppt, 5 to 35 ppt and 5 to 40 ppt respectively. Lower lethal level of salinity was 3 ppt for 8 to 9 mm size, 2 ppt for 13 to 15 mm size and 1 ppt for 18 to 19 mm size. At the upper level 50 ppt was lethal to 13 to 15 mm size.

Seasonal variations in calcium, magnesium, phosphorus, copper and zinc in water and sediment of marine and estuarine areas were studied (Appendix 6.16.56) in relation to their occurrence and concentrations in different tissues of P. indicus. The salinity, calcium and magnesium contents of the water and sediment showed considerable decrease during monsoon and postmonsoon seasons in estuarine system in contrast to the stable values in the marine ecosystem. The total phosphorus, copper and zinc contents in water and sediments were, however, similar in both the ecosystems.

Variations in concentration of bioelements in the tissues of male and female P. indicus were insignificant during the non-monsoon period and significant at other times. The calcium content in exoskeleton decreased during monsoon and post-monsoon period, but was always higher in haemolymph than in the ambient medium. The magnesium contents in various tissues were relatively stable in prawns from marine ecosystem. The haemolymph phosphorus showed erratic seasonal variations. But the exoskeletal phosphorus remained low in both ecosystems. Phosphorus values of hepatopancreas and gonads were low during monsoon and post-monsoon periods in the estuarine ecosystem.

Contents of copper and zinc with various tissues were similar in both the sexes and ecosystems. However, they increased in haemolymph and muscle during monsoon and post-monsoon seasons. There was no variation between the exoskeletal copper and zinc levels between

seasons or between ecosystems. The seasonal variation of copper and zinc in haemolymph and muscle are significantly correlated to that in the water and sediment in both the ecosystems.

The LC 50 and LD 50 values of pH and temperature for the post-larvae of P. indicus were determined (Appendix 6.16.28). The pH between 6.0 and 9.0 were not lethal. Between 6.0 and 7.0; sub-lethal effects on growth, metabolic rate and swimming activities were; however, observed. pH values above 9.0 and below 6.0 rapidly increased mortality rate. In pH 3.0 and pH 10.0 mortality was total within 45 minutes.

Chromatophores on the cuticle were concentrated in acidic waters and expanded in alkaline waters. The optimum temperature for post-larvae was between $30^{o}C$ to $32^{o}C$. The LD 50 values of post-larvae 1 to 25 were $32.27^{o}C$ to $38.51^{o}C$.

In a study on the influence of salinity, pH and light on developing embryos and early larvae of Liza parsia spawned in the laboratory (Appendix 6.16.27), when eggs from normal sea water were transferred to test salinity ranges of 0 to 51 ppt, hatching rates increased with increasing salinity up to an optimum of 26.63 ppt and decreased with further increase. Extremes of salinity caused mortality of developing eggs if not abnormalities in embryos. When eggs from sea water of 8.15 pH were transferred to test conditions of pH 5.0 to 10.0 hatching occurred in pH upto 9.0. But extreme values in this range caused maximum mortality. Optimum pH for hatching was 7.5 and for survival of larvae it was between 7.3 to 7.8. When viable eggs were exposed to light intensities ranging from 0 to 1700 lux and normal day light, optimum hatching occurred in 109 lux. Direct sunlight was, however, lethal.

Studies on the metabolic, excretory and behavioural response of adult P. indicus (Appendix 6.16.12) exposed to different salinities

indicated the rates of oxygen consumption and ammonia excretion, and the ammonia quotient to increase with decrease in salinity. The random activity and the maximum energy expenditure was higest in the lowest salinity level of 2.10 ppt, and lowest in 34.0 ppt. The P. indicus spends least energy in an optimum salinity of 25.5 ppt, but spends more energy for activity in lower salinities.

The oxygen consumption and random activity of P. indicus (Appendix 6.16.25) decreased with increase in body size; whereas rate of ammonia excretion and rate of ammonia quotient values increased with increasing body weight. The rate of oxygen consumption, ammonia excretion and random activity increased with increase in temperature, while the ammonia quotient values showed a reverse trend. The asphyxial level of the prawns was influenced by body size and temperature. The level was lower in smaller prawns.

The oxygen consumption and respiratory rate in nauplius, protozoea and mysis stages of P. indicus were determined (6.16.9). The O_2 consumption increased with increase in size and progress in developmental stage. The respiratory rate declined with increase in body weight of the individual. There was significant difference in the rate of O_2 uptake between stages. In hatchery system high concentration of phytoplankton caused mass mortality of larvae due to O_2 depletion at night on account of cessation of photosynthesis.

Removal of eyestalk in P. indicus (Appendix 6.16.38) resulted in increased oxygen consumption. The rate of oxygen consumption in eyestalk ablated prawns increased with increase in temperature but decreased with increase in salinity. The ablated females showed higher rates of O_2 than males. The rate of ammonia excretion increased after the eyestalk ablation and increase in temperature but decreased with increasing salinity. The ammonia quotients decreased after eyestalk ablation irrespective of changes in salinities and temperature.

In order to understand the role of endocrine factors on osmoregulation, the effects of eyestalk ablation on sodium, potassium and chloride levels in the haemolymph and on ammonia excretion were studied in P. indicus (Appendix 6.16.16). The sodium, chloride and potassium ions in the haemolymph and the ammonia excretion rate increased with unilateral eyestalk ablation and further enhanced by bilateral ablation. In destalked animals injected with eyestalk extract, the levels decreased and approached normal values. These results thus indicate that the eyestalk contains factors for regulating ionic balance.

3.5.2. Reproductive Physiology/Endocrinology

The reproductive physiology of 2 species of mussels namely the brown mussel, Perna indica and the green mussel P. viridis occurring along the south west coast of India was studied (Appendix 6.16.50). Sexual maturity in the species coincides with peak in phytoplankton production and P. indica spawns during July - September and P. viridis during September - October. The morphology and physiology of the gametes of 2 species are more or less similar. In both, the sperms are viable for about 4 hrs. and the eggs upto 7 hrs. in salinities 32.0 to 35.0 ppt. Salinities below 20.5 ppt and above 43.8 ppt are lethal to the gametes. Biochemical studies revealed that the composition of tissues vary with the stages in maturity and seasons. Protein is selectively stored in the adductor muscle, carbohydrates in mantle and lipids in digestive gland. Ovary had relatively higher lipid than the testis. The lipid stored in digestive gland was mobilized during active vitellogenesis.

Scanning electron microscopic studies showed the sperms of P. indica to have 4 distinct parts; namely acrosome, nucleus, middle piece and a tail. Neurosecretory cells of pyriform type were observed in central and visceral ganglia of both species. Cytochemical studies showed the neurosecretory material to be acidic and glycolipoprotein

in nature. Experimental bilateral cerebralectomy elicited greater spawning response than unilateral extirpation. The process of gametogenesis, maturation and spawning appears to be triggered by decrease in salinities.

In another study (Appendix 6.16.61), the neurosecretory system and neurosecretory cells in P. monodon were traced and identified. Five types of neurosecretory cells were observed in the species. Based on their tinctorial properties 5 types of neurosecretory cells were observed in the species. Activity of neurosecretory cells in brain and thoracic ganglion was observed to be high during the active phase of maturation and moulting. The process of oogenesis was studied in detail and 5 stages were identified. Eyestalk ablation (both uni and bilateral) shortened the moulting period. Frequency of moulting was significantly affected by photo-period, pH, and changes in salinity. Biochemical constituents such as protein, lipids, carbohydrates, cholesterol and moisture were found to vary markedly during maturation process.

In a study on the spermatogenesis in Mugil cephalus and Liza parsia (Appendix 6.16.57) higher salinity induced maturation. Temperature, however, had no significant effect. Morphologically, the testes in both the species exhibit cyclic volumetric changes and 6 distinct maturity stages. Histologically they are of the unrestricted spermatogonial type. The sperms in both species, through electron microscopy are found to lack acrosome while the ultra structure of spermatozoa in both was similar. The size of cell types and the sperm of M. cephalus is smaller than that in L. parsia. Biochemically, the protein and lipid levels increase in the gonad from stage I to IV, while that of carbohydrates decrease.

Based on histological details of the cuticle and morphological characters of setae (Appendix 6.16.66), the moult cycle of P. indicus is classified into 8 well defined stages. The distribution pattern of nucleic acids in hepatopancreas and muscles show maximum RNA content in

stage D and minimum in stages A and B of the moult cycle. However, no significant changes in the DNA content of the hepatopancreas was noticed. In the muscle, DNA showed relatively higher values in the later premoult and early postmoult stages. Higher values of glucosamine were recorded in the haemolymph in the late premoult stages.

Investigations on the process of oogenesis (Appendix 6.16.69) showed 2 distinct proliferative and differentiative phases in P. indicus. In proliferative process, primary oocytes form from the primary oogonial cells. In the differentiative process, the primary oocytes are transformed into fully mature ova. Detailed studies on spermatogenesis showed that the spermatozoa are packed in spermatophores within vas deferentia and stored in terminal ampoules. In ultra structure the sperms are highly polarized unistellate type. The neuroendocrine cells were classified into 5 different types based on their size, stage and tinctorial properties.

The mechanism of neuroendocrine control of reproduction was studied in the females and found that during immature stage, neuro-secretory cells of the eyestalk were in active phase. But in the mature females very few NSC were active. In experiments, unilateral eyestalk ablation enhanced maturation. Bilateral ablation did not induce full maturity. Administration of vertebrate gonadotropin resulted in partial development of the ovary. In the gonads, biochemical constituents such as protein, lipid, carbohydrates, cholesterol, DNA, RNA, carotenoids and moisture showed an increase with progression of maturity.

Bilateral andrectomy was carried out successfully in 17 males. Histological examination of the testes of these individuals revealed that unlike the normal testes, due to the decrease in activity of the periferal germinal epithelium the lobes were empty with few spermatocytes and spermatid cells. These experiments thus suggest that androgenic glands are responsible for the regulation and maintenance of secondary sexual characters in P. indicus. Furthermore the testicular activity, it is clear, is under the control of the hormone produced by the androgenic gland.

Investigations on the ultra structure of the neurosecretory system of pearl oyster Pinctada fucata showed (Appendix 6.16.68) the visceral ganglion to contain 58 neurosecretory granules of sizes varying between 1000 A^{O} and 1250 A^{O}. The total length of the sperm was about 37 μ; with the head 2.0 μ and tail 35.0 μ. The acrosome in head measured 0.3 μ.

Gel electrophoresis of immature male gonads, adductor muscles and hepatopancreas showed 14, 13 and 15 protein fractions respectively. The 14th and 8th fractions in fully mature specimens in all the 3 tissues, showed thick bands compared to those in immature ones.

In a work on the reproductive biology of the Indian whiting Sillago sihama (Appendix 6.16.67), the fish is observed to have a prolonged breeding period in the south east coast of India. The size at 1st maturity is 186 mm for females and 158 mm for males. The maximum fecundity was estimated as 34,500. Histologically the ova have chromatin nucleus stage; perinuclear stage; early and late yolk-vesicle; primary, secondary and tertiary yolk globule stage; migrating nuclear stage and hyaline stage. The oocytes are basophylic and the sperms acidophylic. Biochemically the muscle protein and lipids decline markedly as the female matures. Salinity manipulation experiment to induce spawning resulted in positive response when the fish was gradually acclimated from 15.0 ppt to 23.0 ppt. Pituitary hormones of carp, human chorionic gonadotropin and chorionic gonadotropin were administered separately as well as in combination in induced breeding experiments. The carp pituitary hormones as prime dose and human chorionic gonadotropin as spawning dose were effective.

Studies on pearl sac formation in the Indian pearl oyster (Appendix 6.16.76), showed that under normal conditions using ventral marginal mantle tissue, pearl sac is formed within 2 weeks. When

posterior and anterior mantle tissues are used the sac formation took 19 to 21 days. Also the secretion of conchiolin was relatively less when compared to the ventral margin. Sac formation was not found when central mantle tissue was used. Pearl sac formation in experiments using sterilized and filtered sea water was similar to that of eosin treated mantle. Experiments conducted with a Japanese dye in place of eosin advanced the sac formation to be within one week, and the secretion of the organic matrix was richer in this case. Graft mantle tissue kept at room temperature for one hour before implantation delayed the sac formation to 20-22 days. In tissues kept for 2 hours 75% failed to form pearl sacs, and the secretion of conchiolin was thin if not nil.

Biochemical changes taking place during reproductive cycle in the ovary of P. indicus showed (Appendix 6.16.4) that the organic reserves are built up during the process of vitellogenesis. As protein and lipids are the major energy rich components of yolk, large quantities are accumulated in the ovary. Organic reserves in the hepatopancreas declined with progression in gonadal maturity due to the mobilization of lipids to the gonads. The protein and lipid contents in the muscle were relatively stable.

Biochemical parameters like cholesterol, glucose, free amino acids and lipids in the serum, muscle and liver of adult Etroplus suratensis were studied (Appendix 6.16.18) and found all of them to show statistically significant decrease with increasing periods of starvation.

Biochemical changes in muscle, hepatopancreas and haemolymph associated with the moult cycle in P. indicus reveal (Appendix 6.16.19) that the maximum amount of organic reserves (lipid, cholesterol, protein and glycogen) are kept during the early premoult stage and utilized during moulting, thereby resulting in depletion during postmoult stage.

The relationship between growth rate, protein and nucleic acids concentration was studied in P. indicus (Appendix 6.16.33). The RNA concentration declined with increase in the size of the prawn, whereas the protein values increased as the size of the animals increased. Starvation resulted in significant decrease in RNA and protein contents, but the DNA content remained unchanged.

The morphology, histology, and histochemistry of the spermatophore and thelycum of P. indicus were studied (Appendix 6.16.35) to understand the structure and role of these organs in reproduction. The spermatophore of P. indicus consists of a chitinous sperm bag and wings with a sticky mass of granules rich in sulphated AMP. The sticky substance helps to cement the 2 spermatophores as one unit. Inside the sperm bag the sperm mass is embedded in a spongy matrix rich in carboxylated AMP. The thelycum of P. indicus consists of lateral plates which form a trident with a conical median process with minute setae on the ventral lips. On the ventral margin of the lip numerous minute cuticular pores are seen. The epithelial secretion of the thelycum is rich in carboxylated AMP.

The morphology and histology of 3 species of mullets viz. Valamugil cunnaesius, Liza parsia and Mugil cephalus, and the catfish Trachysurus maculatus were studied (Appendix 6.16.21). Morphologically in all the 4 fishes, the pituitary was of leptobasic type in position, and dorsobasic with regard to the point of entry of pituitary stalk into the brain. Histologically the pattern in all the 4 species was similar. The prolactin and TSH cells were observed in the rostral pars distalis and the ACTH cells in the interphase between the neurohypophysic and the rostral pars distalis.

3.6. Nutrition

3.6.1. Nutritional requirements and feed development

Nutritional studies in juvenile P. indicus indicated (Appendix 6.16.55) that the prawns prefer semi-moist diet compared to dry or moist ones. The survival, growth, food intake, food conversion and biochemical composition of prawns, varied depending upon the concentration of the tested dietary nutrients, viz. proteins and vitamins. The protein and vitamin deficient diets severely affected the survival rates. Sub-optimal and supra-optimal concentrations of the tested nutrients in the diets resulted in lower survival, growth, and poor food conversion. A greater percentage of mortalities, encountered in prawns fed on protein and vitamin deficient diets, were post-moult deaths. Experiments with isocaloric diets containing graded levels of protein showed that the juveniles have a dietary protein requirement of 35 to 40% for maximum growth. The supra-optimal protein level in diets induced catabolism of protein resulting in increased ammonia excretion rate.

Studies on the nutritive value of protein rich ingredients showed that the animal protein sources have superior biological values when compared to plant protein sources. Among the plant protein sources soyabean meal promoted best growth and feed efficiency, indicating that amino-acids profile of soyabean meal may satisfy the needs of the juvenile prawns. Supplementation of purified diet containing casein as a protein source with a mixture of amino-acids-phenylalanine, lysine, cysteine, tryptophan, taurine, glycine, proline and glutathione enhanced the nutritive value of casein for the prawn.

The water soluble vitamins like choline, ascorbic acid, mesoinositol, thiamine, riboflavin, phyridoxine, pantothenic acid and nicotinic acid were found to be indispensable in the diet of P. indicus

However, choline can be dispensed with if Lecithin (phosphotidyl choline) is included in the diet in adequate levels. Exclusion of ascorbic and pantothenic acids from the diet affect the survival and growth and cause severe deficiency symptoms in the form of black lesions and partial moulting. The dietary requirement for optimum responses ranged from 0.4 to 0.8 g ascorbic acid, 0.5 g choline chloride, 0.01 to 0.02 g thiamine hydrochloride, 0.075 to 0.1 g calcium pantothenate, 0.02 to 0.03 g pyridoxine hydrchloride and 0.025 to 0.05 g nicotinic acid.

The dietary protein requirement of post-larvae of P. indicus (Appendix 6.16.8) decreased with increase in their size. The post-larval stage from 1 to 10 were found to require 40% protein in the diet in combination with 35 to 40% carbohydrate and 12% lipid. Post-larval stages from 11 to 42 required about 30% protein in the diet in combination with 35 - 40% carbohydrate and 10% lipid.

The metabolic, excretory and growth rates in juvenile P. indicus were studied (Appendix 6.16.3) in relation to a natural diet and 3 pelleted foods of varying protein contents. The differnces between starved and fed animals were also recorded. The metabolic rate in starved prawns was logarithmically linear to body weight. The fed rates were invariably higher than starved rates. The fed excretion rate was influenced by the protein consumed. The study revealed that the growth rate is negatively incluenced by routine metabolism and SDA and positively by protein content in the diet.

Testosterone, glucosamine, chitin and alfa-alfa extract when supplemented at 5 mg, 0.98 g, 1.5 g and 1.5 ml per 100 g of diet respectively (Appendix 6.16.14) have been found to promote growth significantly in juveniles of P. indicus. The antibiotic tetracycline and thyroid hormone did not have any growth promoting effect.

Salinity has been found (Appendix 6.16.15) to significantly influence food consumption, growth, conversion efficiency and proximate

composition of juvenile P. indicus. The food intake was found to be independent of the quality of food supplied, but was dependent on the salinity of the medium. Juveniles of size 13 - 14 mm required an optimum salinity of 25 ppt for maximum utilisation of the food and protein. Juveniles of 26 - 32 mm sizes, requred 20 ppt salinity as optimum for maximum growth, food and protein utilisation, and greater deposition of protein in the tissue. At the lowest level of 5.0 ppt salinity, in both the above size groups, least food intake was observed due to lower metabolic rate. At a salinity of 35 ppt, ammonia excretion was significantly higher than in lower salinity treatments due to the increased catabolism of amino acids.

The stability of nutrients in pelleted diets of particle sizes 50 - 500 μ was studied (Appendix 6.16.26). The optimum water stability of the feed pellets and the minimum loss of nutrients could be obtained when the ingredients were ground to a particle size of 212 μ. The digestibility, growth, and feed conversion rates were also the best at 212 μ size. The nutrient leaching was enhanced by aeration upto 20% over that of control.

Studies on the protein budget of juvenile P. indicus (Appendix 6.16.32) showed that the efficiency of protein assimilation improves with increase in size of juveniles. It was also found that most part of the assimilated protein was utilized for routine metabolism rather than for tissue building.

The possibility of utilizing mangrove foliage in fresh and decomposed form as a feed component for juvenile P. indicus was studied (Appendix 6.16.41). Among the 4 species Rhizophora mucronata, Avicennia officianalis, Acanthus ilicifolius and Broguriera gymnorhiza studied, the green leaves of the first had the highest, while the last the lowest protein content. A. officianalis had the highest non-protein nitrogen content. The crude fibre was the highest in A. ilicifolius. The total

nitrogen, non-total nitrogen and crude protein contents showed significant increase after 30 days of decomposition of fresh green leaves. The overall increase in the crude protein content was the highest in B. gymnorhiza and R. mucronata. The total lipid, crude fibre and nitrogen free extract significantly decreased after decomposition. Feeding experiments conducted with juveniles of P. indicus showed that fresh and decomposed green mangrove leaves can be incorporated in the diets without any significant alterations in normal growth at levels of up to 25% when compared to controlled diet without mangrove leaves.

Among finfish, nutritional studies were carried out in the mullet Liza parsia (Appendix 6.16.72). The optimum dietary protein and lipid requirements for maximum growth and best food conversion rate for the fry of the species was about 40% and 6% respectively. Lipid levels above 6% resulted in retardation of growth. With a view to identifying natural protein rich ingredient for practical feed formulations a number of plant and animal protein sources were tested for their suitability. A mixture of plant and animal protein sources provided the best response in the fish. Among the plant protein sources, the alga Spirulina provided the best response. Similarly a number of plant and animal lipid sources were also tested for their suitability, and the mixture of both plant and animal lipids gave the best growth and food conversion rates. The essentiality of various water soluble vitamins in the diet of the species was established using vitamin free purified diets in a 21 week experiment and the deficiency symptoms recorded. Based on these findings a few feeds were compounded and their efficacy are being tested in field trials.

The anabolic effect of a few steroid hormones was studied (Appendix 6.16.71) in the fry of L. parsia. The androgen, 17 alfa-methyl testosterone was found to have maximum anabolic efficiency and the best response was obtained at an optimum level of 2 mg/kg weight of body. Incorporation of hormone at higher levels resulted in retardation of growth. A dose of 40 mg/kg of body weight induced high mortality

rates. The steroid diethylstilbesterol at a dosage of 0.3 mg/kg of body weight gave maximum growth, but further increase depressed the growth. A third steroid known as estrone up to a dose of 2 mg/kg body weight augmented growth.

3.6.2. Digestion and metabolism

Studies were carried out on the morphology, histology, histochemistry and ultrastructure of the hepatopancreas of P. indicus (Appendix 6.16.63). The most salient finding is the identification of 5 different types of cells through electron microscopy. Detailed studies on these types of cells were further made.

A survey of the digestive enzymes showed the hepatopancreas to be the main organ producing most of the enzymes. The important carbohydrates identified in the hepatopancreas are alphaamylase, maltase, lactase, and sucrase. Detailed studies carried out on the alphaamylase revealed that this enzyme has a maximum activity at pH ranging between 5.5 and 6.5 at constant temperature; and the maximum hydrolysis of starch occurs within 15 to 20 minutes of incubation. The rate of hydrolysis increased with time reaching the maximum between 50 and 60 minutes followed by an abrupt decline after 60 minutes. Hydrolysis of starch increased with increased substrate concentration up to 1%. The optimum temperature for maximum activity was between 40 and 50^{o}C. Chlorides of copper, mercury, aluminium and antimony inhibited the activity of enzyme. Nickel and cobalt chlorides at lower concentrations were highly effective in activating the enzyme. Chlorides of manganese, calcium, strontium, barium, potassium, sodium, magnesium and ammonia activated the amylase. Eyestalk extirpation studies revealed that the hormones of eyestalk controlled the activity of alphaamylase. Bilateral ablation induced higher amylase activity than unilateral ablation. Studies on the influence of diet showed the enzyme activity to increase with the starch content in the diet with maximum activity between 5 and 20% level. Twentytwo different aminoacids were tested for their effect on

amylase activity. Aminoacids like glutamic acid, alanine, dopa, phenyl alanine, L-ornithine and L-cysteine activated the enzyme. Proline and methionine inhibited the enzyme. Among vitamins, ascorbic acid, ß carotene, folic acid, choline and riboflavin activated the enzyme while nictonitic acid, inositol and menadione inhibited the enzyme. The enzyme has been purified through molecular exclusion chromatography and gel electrophoresis and 2 isozymes have been identified. The study also includes relative activity of proteolytic and lypolytic activity in the hepatopancreas.

Studies on L. parsia showed (Appendix 6.16.77) that alpha amylase is distributed throughout the alimentary canal. Maximum activity of carbohydrate hydrogenase enzymes was found in pyloric caeca and anterior intestine. Cellulase activity could not be detected in any region of the digestive track. Protease activity was observed mainly in the pyloric caeca and anterior and posterior intestines. The activity of lipase and esterase were highest in the pyloric caeca followed by the intestine. Alkaline phosphatase activity was found all through the intestine. Pepsin activity was observed in the stomach in pH ranging from 2.0 to 4.0.

Studies on protein metabolism in the lobster Panulirus homarus showed (Appendix 6.16.64) that in its haemolymph the level of protein goes up before moulting, followed by a sudden drop in the early premoult stage. Eyestalk ablation in the lobster resulted in precocious ovarian development leading to the production of abnormal eggs. Bilateral eyestalk ablated lobsters were highly sensitive to oxygen depletion.

Analysis of blood calcium showed (Appendix 6.16.65) that it increased during premoult stage and about 20 to 80% of the calcium was in the bonded state. Fully ripe lobsters had higher calcium levels in the haemolymph than the spent lobsters. The haemolymph calcium level was maintained above that of the environmental calcium content even in

dilute medium. Exposure to low pH (6.0-6.5) increased the haemolymph calcium content in the 1st few hours but returned to normalcy after 12 to 24 hours. The haemolymph calcium showed diurnal variation with the highest content during the night.

3.6.3. Live food culture and their nutritive values

The culture and growth kinetics of 4 species of nannoplankters namely Chromulina freiburgensis, Isochrysis galbana formanova, Synechocystis salina and Tetraselmis gracilis were studied (Appendix 6.16.49a). The cultures of these species raised in the laboratory grew asymptotically completing the exponential phase within 4 to 6 days of innoculation with a mean doubling time of 9 hours. The pigment content and physiological activity were found to be high in the exponential phase of growth. Studies on the biochemical composition of the species revealed that they synthesise about 45 to 58% protein during the exponential period but the rate of excretion of organic metabolites was observed to be minimum during the exponential period.

Salinity and pH tolerance studies indicated that S. salina requires an optimum of 34 ppt salinity and pH 8.0 for maximum growth.

Mass culture of 2 species viz. C. freiburgensis and I. galbana was carried out and fed to the larvae of the edible oyster Crassostrea madrasensis to evaluate their food value. The larvae accepted both these species and settled the spat within 17 to 19 days. C. freiburgensis seems to be the most potent species for development as live food in oyster hatcheries.

The effect of trace elements (copper, manganese and zinc) on the growth of 2 species of microalgae viz. I. galbana and S. salina were studied (Appendix 6.16.24) and it was observed that the growth as well as the contents of chlorophyll a and c, carotenoids and the rate of

carbon fixation were accelerated by the inclusion of trace elements in the medium. The biochemical composition of the 2 species showed considerable variations during different phases of the life cycle.

The nutritive value of several species of microalgae for the larvae of pearl oyster Pinctada fucata was studied (Appendix 6.16.58) and it was found that 3 species namely I. galbana, Pavlova lutheri and C. freiburgensis were identified to be good for the growth and larval settlement. Compared to pure cultures, mixed cultures gave better results. The optimum feeding concentration of Isochrysis for the larvae was worked out. Freeze dried algal cells were also found to have some nutritional potential for the larvae.

Biochemical changes occurring in the larvae during metamorphosis was studied and it was found that lipid play an important role in the larval development.

Moina, rotifer and Artemia nauplii and decapsulated cyst of brine shrimp were tested (Appendix 6.16.13) to determine their suitability as live feed for postlarval stages of Penaeus indicus. Although the postlarvae fed with these live feed gave comparable results in terms of survival, none showed better growth than those fed with decapsulated Artemia cyst.

The survey of seagrass of the south east coast of India reveals (Appendix 6.16.70) that these beds support many commercially important species of fishes and fingerlings like mullets, Gerres and the prawn Penaeus indicus. Among the 8 species of seagrasses found there Cymodocea serrulata is most abundant.

3.7. Pathology

Six diseases namely microsporidiosis, ciliate infestation of gills, soft prawn disease, helminth parasitisation, isopod parasitisation and

and red rostrum disease were found to occur in penaeid prawns at Cochin, Tuticorin and Mandapam (Appendix 6.16.54). Detailed studies were carried out on microsporidiosis and 3 new species of microsporidian parasites were identified from Penaeus semisulcatus and Metapenaeus affinis, and their characteristics and mode of propagation studied. One of the microsporidians belonged to the genus Thelohania and it occurred throughout the year in prawns above 60 mm length. It infected mainly the muscle, gonad and hepatopancreas and midgut wall where the host cells are eventually replaced by masses of spores. The disease has experimentally been transmitted to healthy prawns by direct ingestion through food. Another microsporidian has been identified to belong to a new genus under the family Thelohanidae based on its ultrastructure. It specifically infects the ovary and blood vessels. The ova are either greatly reduced in number or completely destroyed in the heavily infested individuals. The third microsporidian is a new species of Nosema, infecting muscle, ovary and digestive tract. The spores of this lie singly or in masses among the muscle fibres and cause lysis when infection is heavy.

In another study (Appendix 6.16.81), abnormality in the eyes of post larvae, infestation of mysis stage by vorticella, infestation by amoeboflagellate in nauplii, protozoea and mysis stage, infestation of mysis stage by Nitzschia closterium, whirling disease of postlarvae, appendage rot in mysis are identified as causes of mortality in the larval stages.

3.8. Genetics

Intra species variations among spawning stocks of Penaeus indicus and Parapenaeopsis stylifera are studied (Appendix 6.16.73) from different parts of the Indian coasts. The general protein patterns of a number of closely related species also are being studied.

Karyological investigation (Appendix 6.16.20) on juveniles of P. indicus, P. monodon and M. monoceros showed that during the metaphase diploid number of chromozomes were 66, 84 and 92 respectively. In M. dobsoni the diploid number was found to be between 80 and 86.

Studies with Liza parsia occurring in Cochin backwaters showed (Appendix 6.16.30) that there is no difference in the muscle protein patterns between juveniles and adults. Three groups of esterase enzyme system with a total of 6 bands were identified in liver, kidney, heart, eye, muscle and brain. Lactate dehydrogenase isoenzyme showed two loci, Ldh-1 and Ldh-2 with 5 bands in the eye; while in heart, muscle, liver and brain tissue, the Ldh-1 was expressed in equal intensities, and a faint expression of the Ldh-2 along with one or two interlocus hybrids were present. The ontological development of the Ldh--isoenzyme system showed that it develops in the stage between 1.4 mm larvae and 24 mm juveniles. At the initial stage of post-hatching (2.4 mm) only the Ldh-1 locus was expressed. The faster locus Ldh-2 was found polymorphic with 2 alleles, Ldh-2 (100) and Ldh-2 (125). These allelic frequencies were 0.649 and 0.341 which were not significantly different from the expected values. Average heterozygosity ($\bar{H}$) obtained from the analysis of polymorphic loci Ldh-2 was 0.452.

Electrophoretic studies (Appendix 6.16.31) on the proteins of P. monodon indicated tissue to tissue variation with the muscle, eye, hepatopancreas and the serum, producing 16, 15, 23 and 27 bands respectively. Besides, the electrophoretic mobilities of different bands varied from tissue to tissue and these differences reveal tissue specific nature of muscle protein. The muscle myogen electrophoretic pattern of both male and female were identical. In females of 170 to 190 mm size, the serum proteins produced 17 bands while that of smaller females had only 15 bands. The muscle protein pattern in postlarvae, juvenile and adults collected from Cochin and Madras showed identical electrophoretic pattern.

Electrophoretic studies were carried out (Appendix 6.16.37) in M. cephalus and L. parsia to determine the tissue specific expression of acid phosphatase, tetrasodium oxidase, esterase, alcohol dehydrogenase, malate dehydrogenase and maleic enzyme. Also the presence of genetic polymorphism at lactate dehydrogenase loci was determined in fingerlings of M. cephalus. In M. cephalus there were indications of ontological development of acid phosphatase and presence of 8 co-dominant alleles of lactic dehydrogenase.

For biochemical characterisation of lactate dehydrogenase iozymes (LDH), their activity and the genetic variation of LDH loci were examined in M. cephalus and L. parsia (Appendix 6.16.49). It was observed that there is no significant genetic variation in the adult specimen of L. parsia. The enzyme activity measurements indicated tissue specific and species specific differences.

4. PUBLICATIONS BY THE CENTRE

Thirteen manuals (Appendix 6.17) were published and four more are also accepted for publication. Another thirtytwo papers (Appendix 6.18) were also published from the results of the work carried out at the centre.

5. CONCLUSION

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The chart showing the organisational function of the centre is as follows:

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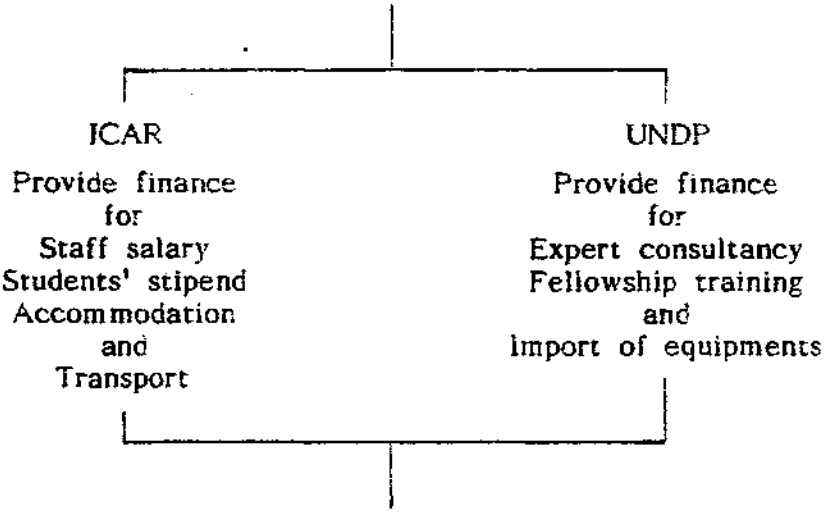
PROJECT COORDINATOR

(D.D.G., Education ICAR)

CENTRE OF ADVANCED STUDIES
in
POST-GRADUATE EDUCATION AND RESEARCH

IND/78/020



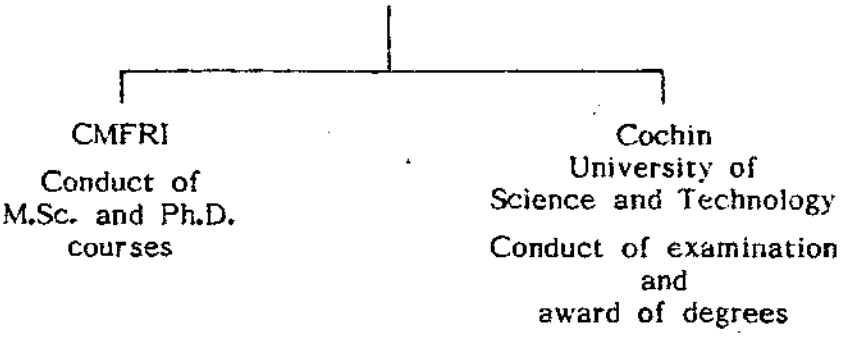
SUB-PROJECT COORDINATOR

(DIRECTOR, CMFRI)

CAS
in
MARICULTURE

at

CMFRI



The project which scheduled to commence on April, 1979 actually started only in July, 1979. As per the original plan, the Centre of Advanced Studies in Mariculture was to conclude by March, 1986. However, it had another 6 months of phasing out period extending upto September, 1986; after which the Centre under ICAR/FAO/UNDP collaboration was over. As per the agreement already taken before the conclusion of the Centre, one of our Scientists could proceed overseas on Fellowship Training for 6 months under Faculty Improvement Programme only by the end of December, 1986. The Centre had a budget provision of Rs. 3,533,213/- under Government of India expenditure and U.S. $ 669,500 under UNDP a

According to the Project Document, the country in ten years' time of nineteen eighties was estimated to require 250 experts to undertake research and teaching in Mariculture. Approximately, 50 Ph.D. and 80 Master's Degree holders were to be brought out by the Centre during its 7 year tenure. This requirement, however, was not fully met when the project ended in September, 1986. The Indian Council of Agricultural Research therefore has given permission to CMFRI to continue the Centre during the 7th five-year plan period as the "Post-graduate Education and Research Programme in Mariculture of the Institute with finances met from its already sanctioned budget.

The country is said also to require about another 2,000 expert manpower in the ten year period as Technical Personnel, Farm Managers, Mariculture Specialists & Development Officers, Fish Farm Engineers, Extension Workers and Farm Economists & Statisticians. The degree holders from the Centre would utilise their specialised training in improvement of teaching and research standards of other sister institutions in the country and create a multiplier effect. The cadre of highly competent professional scientists created through advanced level training in India through Expert Consultancy and Overseas Fellowship Training would in turn train graduates posted in the field to man the various production programmes.

5.2. RECOMMENDATIONS

To fill the void of much needed professionally competent personnel of high managerial and technical calibre who can shoulder the responsibility of developing and augmenting production and supply of fish through farming in the country, the Centre of Advanced Studies in Mariculture was started in 1979 at the Central Marine Fisheries Research Institute, Cochin. According to the project document IND/78/020 - Annexure IV dealing with the CAS in Mariculture, the country in about 10 years time is said to require 2,000 Mariculture Specialists, Researchers, Technical Hands and Fish Farm Engineers, Managers, Economists and Statisticians. During the 7 years of the project period when the Centre functioned under FAO/UNDP aid, 67 Junior and 42 Senior Research Fellows were undergoing studies and undertaking researches leading to M.Sc. and Ph.D. Degrees respectively. But the development in coastal aquaculture in the recent past was so fast that the demand from various research. educational, developmental and industrial institutions for professional hands remained high and the supply short. In this context, the Indian Council of Agricultural Research decided to continue the Centre during the VIIth Five Year Plan period extending upto 1990/91 under its new name "The Post-Graduate Education and Research Programme in Mariculture" at the Central Marine Fisheries Research Institute.

1. Development of open sea farming

In the hatchery production, nursery management, and field culture systems of crustaceans and certain molluscs like the pearl oyster and mussels, technologies are developed to pilot project level and transferred to commercial status. But in finfish culture, the advancement is limited. Other than the culture of pearl oyster, mussel and seaweeds

which are tried out in the sea, the technologies developed are mostly confined to estuarine ecosystems only. Sea ranching and open sea culture are yet to start. The Centre, therefore plans to give attention to the culture of marine species suitable for open sea farming in the future. Tuna live-bait, marine ornamental fishes, holothurians, squids, cuttle fishes, oysters, octopus, corals, marine prawns, lobsters, crabs, flat fishes, catfishes, seaweeds, etc., are some of our resources where scope for development exists.

2. Continued assistance in import of instruments and spares

The CAS in Mariculture under FAO/UNDP aid has set up laboratory facilities in CMFRI for education and research. Some sophisticated equipments were imported and installed at the Centre. But spares for them pose serious problems unless some assistances is continued. Moreover, updating of technological developments in instrumentation and electronics on laboratory and field facilities on par with advancements elsewhere is necessary to maintain high standards of teaching, research and development in Mariculture. Financial assistance of UNDP for additions and replacements of instruments and sophisticated laboratory facilities will be of immense value in future programmes.

3. Development of mariculture engineering

Expansion of culture practices into the open sea demands development of connected mariculture engineering technology. Aquaculture Engineering is relatively poorly developed in India, and expertise in Mariculture Engineering is totally lacking. Site selection for sea ranching; design, construction, maintenance and management of hatcheries, nurseries and grow-out systems in mariculture; and fabrication of infrastructures such as cages, rafts, pens, mats, ropes, lines, etc., suitable for different culture practices in open sea have not yet been developed

for want of research and technical know-how. In the culture programme, development of Mariculture Engineering Technology is therefore imperative warranting top priority, special and immediate attention at national level. Areas requiring actions on these lines are:

1. Recruitment of Engineering Graduates and their deputation for long-term training abroad where Mariculture Engineering is well developed.

2. Get long-term consultancy service of experts from developed countries on erection, maintenance and management of hatcheries, nurseries and open sea farming systems and development of related infrastructure facilities.

3. Put qualified Indian counterparts under such Expert Consultants for practical field training.

4. Give more stress on the teaching and research of Mariculture Engineering in the curricula of the Centre's programmes.

4. Strengthening of research

Research on nutrition, physiology, pathology and genetics has to be continued on the species presently cultured and also being taken afresh for ranching and open sea farming.

1. A major aspect of investigation needed in any culture programme is that of nutrition and development of feed technology. Based on our studies of the past 7 years, considerable amount of information on nutritional requirements and feed formulations for the larval and juvenile stages of some finfishes and prawns have accumulated.

Similarly, some information on the nutritional needs of molluscan larvae and the nutritional value of some phytoplankters and micro-algae were also worked out. But low-cost, non-leaching, dietary formulations with long shelf-life, and high conversion ratio for exclusive use in the culture of specific marine species have to be developed especially from novel feed ingredients. Competition for food ingredients between aquaculture and animal husbandry is ever increasing. Studies should be intensified to identify non-conventional ingredients such as salt marsh plants, mangrove foliage, aquatic weeds and their silage preparations, waste from agriculture, animal husbandry, sericulture, and fish and shellfish processing plants for development of low-cost practical feed formulations.

Research on digestibility of the new feed ingredients, toxic principles or factors present in them if any, the conversion ratios of the ingredients, protein efficiency ratio, net protein retention and deficiency and hyper dosage syndromes of nutrients have to be carried out. Intensification of research on brood stock management through dietary manipulations has to be made. Technologies developed are to be tested in the grow out/pilot systems and transferred to fields.

2. Research on physiology, genetics and pathology has to be continued to evolve sturdy, disease resistant, fast growing, high yielding, prolific breeding strains suitable for economic ranching in the open sea.

3. A healthy environment maintains a healthy race. Investigations in ecology, therefore, is in no way less important in a culture system. Therefore, research on this subject has to be strengthened and expanded to the open sea farm sites and their surroundings.

A multifaceted approach of long duration is recommended as feasible in the research and development of mariculture programmes especially in the open sea ranching and farming.

5. Extension

Organise short-term refresher courses/summer institutes in specific areas like nutrition, physiology, ecology, hatchery production, nursery management and culture techniques.

6. Expert consultancy/training of scientists

1. Continue liaison with overseas institutions on exchange programmes such as expert consultancy and training in areas like maintenance and management of open sea farming, culture of marine ornamental fishes, bait fishes, food fishes, prawns, crabs, lobsters, mussels, oysters, cephalopods, sea cucumbers, etc.

2. Offer advanced training in nutrition especially in the field of feed technology, studies on nutrient metabolism using radio-isotope tracer techniques, brood stock nutrition, fish and shellfish feed toxicology.

7. Elevate CMFRI to the level of a Centre of Excellence/Deemed University of International stuatus

The Institute has a number of points in favour of it.

1. Recognition: The Central Marine Fisheries Research Institute from its inception in 1947, was recognised by a number of Universities for offering research degree

programmes. A large number of Ph.D. Degrees and a few M.Sc. Degrees by research and D.Sc. Degrees were awarded on investigations carried out at this Institute in the past. Coverage of subject matter areas taken up for investigations at the Institute was diverse and many falling in the fields of physical, chemical and biological oceanography viz., studies on hydrology, phytoplankton, zooplankton, euphasids, prawns, crabs, lobsters, molluscs, corals, sponges, sea cucumbers, seaweeds, a variety of fishes, fisheries and population dynamics. With the commencement of Centre of Advanced Studies in Mari-culture, regular courses of M.Sc. and Ph.D. were started, and the fields of studies got expanded to cover basic subjects such as ecology, physiology, nutrition, pathology and genetics of cultivable finfishes and shellfishes and their live food organisms.

2. Equipments and experience: The CMFRI is unique among the research and teaching agencies of developing countries in the world where both Post-graduate and Doctoral Degree courses are simultaneously offered and is having a highly qualified and experienced faculty to handle several special subjects.

The Institute is accommodated in a multi-storeyed building with well equipped laboratories including a Transmission-cum-Scanning Electron Microscope and a Micro 32 Computor System of ECL 512 KB (being installed) and has a good library of its own with reprographic facilities. The Institute has a fleet of Research Vessels, which includes the 107' R.V. SKIPJACK and a series of Cadalmin boats. Besides these the FORV SAGAR SAMPADA owned by Department of Ocean Development is at the disposal of the Institute for fishery oceanographic investigations of the

EEZ. Also the Institute owns a Mobile Laboratory and an array of vehicles for field work. The Institute has its own hatchery and farms and also a number of Regional/Research Centres and Field Centres.

The Institute offers also regular training course in fishery statistics and population dynamics to sponsored candidates from within and outside the country. A number of candidates from many neighbouring African, Arab and South-east Asian countries were already trained here. The multistage, random sampling system developed by the Institute in the collection and compilation of statistics on marine fish landings in the country is accepted by FAO and followed in many other countries in the world. Taking into consideration the facilities and manpower available in the Institute, FAO justifiably had its training course on "Stock Assessment" at the Institute in 1982. Also the FAO/UNDP identified the Institute as the venue for Expert Consultation Meet in 1980 to prepare field identification sheets on commercially important species of fishes of the Western Indian Ocean.

The Institute has conducted a number of Summer Institutes and Training Courses in subjects like Aquaculture, Prawn culture, Pearl culture, Mussel culture, Oyster culture, Seaweed culture and Hatchery Technologies.

Research, teaching and training by CMFRI do not stay at the post-graduate and higher levels alone. Results of research developed in the laboratories are brought down to the hands of farmers in the field for benefit of application. The Krishi Vigyan Kendra (KVK) of CMFRI takes care of this transfer of technology, through lab-to-land

programmes and farmer's training. It also runs periodic refresher programme through Trainers' Training Centre (TTC) for Field, Extension and Development Officers of State Departments dealing with fish and fisheries problems.

3. Location of the Institute: The Institute is ideally placed in Cochin surrounded by the age old paddy-cum-prawn culture fields and Cochin has a big and well maintained Fisheries Harbour. A large number of fish processing units are situated in and around Cochin. Export of marine products through Cochin is the highest. The Marine Products Export Development Authority concerned with the promotion of export of marine products through identification of market avenues, diversification of products and provision of aids to the development of export oriented infrastructure such as freezing and processing plants justifiably has its headquarters at Cochin. Similarly Cochin is the headquarters of many other fisheries organisations like the Central Institute of Fisheries Technology doing research on craft and gear and processing technology; Export Inspection Agency taking care of the quality control of export items, the Central Institute of Fisheries Nautical and Engineering Training to train necessary manpower required by fishing industry for operational needs in different areas such as navigation, nautical engineering, craft and gear, and fishing; the Integrated Fisheries Project dealing with demonstration of infrastructure for fishing (craft and gear), processing and marketing; and Cochin Base of Fishery Survey of India charting the fishing grounds of south-west coast through exploratory surveys. Kerala Agricultural University has its Fisheries College offering Bachelor's and also Master's Degrees in Fisheries Science. The Cochin University of Science and Technology has its

Department of Marine Science and Department of Industrial Fisheries offering M.Sc. course in the disciplines concerned. The National Institute of Oceanography has its Regional Centre at Cochin. The Naval Physical and Oceanographic Laboratory of Defence Department is also based in the city.

Besides these, Cochin accommodates a number of State Government offices of the Fisheries Department.

Situated in such a surrounding, the Central Marine Fisheries Research Institute with large number of Scientists, technical know-how, modern laboratories and equipments and vast experience of running the M.Sc. and Ph.D. regular courses since 1979, is now fit to be raised to the level of a Centre of Excellence with the status of a Deemed University offering courses in M.Sc. and Ph.D. Degrees in marine capture and culture fisheries.

The Centre now selects candidates on an All-India basis. On account of the international reputation of CMFRI, the Centre of Excellence should draw Fellows from other developing countries also, every year through a quota system with UNDP assistance.

6. APPENDICES

There are eighteen sub-headings under this and a large number of items included in these sub-headings.

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6.1. LIST OF NATIONAL STAFF OF THE PROJECT

Sl. No.	Name and Address	Function	From	To
1.	Dr. E.G. Silas, Director, CMFRI, Cochin-31.	1. Sub-Project Coordinator 2. Faculty Member - Teaching World Fisheries.	Jul. 1979	Aug. 1985
2.	Dr. P.S.B.R. James, Director, CMFRI, Cochin-31.	1. Sub-Project Coordinator 2. Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Fisheries Management.	Sep. 1985	Dec. 1986
3.	Dr. A.D. Diwan, Associate Professor in Physiology, CMFRI, Cochin-31.	1. Faculty Member - (a) Guiding at M.Sc. & Ph.D. level. (b) Teaching Physiology, Endocrinology, Microtomy and craft and gear. (c) Semester-in-Charge, M.Sc. Degree Programme.	Dec. 1980	Dec. 1986

4.	Dr. R. Paul Raj, Associate Professor in Nutrition, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. and Ph.D. level. (b) Teaching Fish Nutrition, Crustacean Nutrition, Freshwater Fishes of India and Chromatographic techniques. (c) Semester-in-Charge, M.Sc. Degree Programme.	Sep. 1981	Dec. 1986
5.	Mr. K.V. George, Farm Manager, CMFRI, Cochin-31.	Faculty Member - Teaching Farm Management.	Jul. 1981	Dec. 1986
6.	Mr. B.S. Ramachandrudu, Farm Engineer, CMFRI, Cochin-31.	Faculty Member - Teaching Fish Farm Engineering.	Aug. 1981	Dec. 1986
7.	Mr. K.G. Nair, Assistant, CMFRI, Cochin-31.	Adminisrative Support.	Sep. 1979	Dec. 1986
8.	Mr. M.J. John, Assistant, CMFRI, Cochin-31.	Administrative Support.	Oct. 1979	Dec. 1986

9.	Mr. M. Ramakrishnan, Assistant, CMFRI, Cochin-31.	Administrative Support.	Nov. 1979	Dec. 1986
10.	Mr. C.G. Thomas, Jr. Stenographer, CMFRI, Cochin-31.	Administrative Support.	Nov. 1979	Dec. 1986
11.	Mr. C.N. Chandrasekharan, Jr. Stenographer, CMFRI, Cochin-31.	Administrative Support.	Sep. 1979	Dec. 1986

6.2. LIST OF ASSOCIATE FACULTY MEMBERS

Sl.No.	Name and Address	Function	From	To
1.	Dr. P. Vedavyasa Rao, Scientist S-3, CMFRI, Cochin-31.	1. Assist the Sub-Project Coordinator in the Administration of the Project. 2. Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Crustacean Culture and Integrated Farming.	1979	1985
2.	Dr. A. Noble, Scientist S-3, CMFRI, Cochin-31.	1. Assist the Sub-Project Coordinator in the Administration of the Project.	1986	-
		2. Faculty Member - Teaching Fishery Biology and World Fisheries.	1980 1985	1981 1986

3.	Mr. K. Nagappan Nayar, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Oyster Biology & Culture.	1980	1986
4.	Mr. K.H. Mohamed, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding M.Sc. level. (b) Teaching Crustacean culture.	1980	1983
5.	Dr. P.V. Ramachandran Nair, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. level. (b) Teaching Primary production and marine pollution.	1980	1986
6.	Dr. K. Alagarswami, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. level. (b) Teaching Pearl Oyster Culture.	1980	1986
7.	Mr. T. Jacob, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Biostatistics and production economics.	1980	1986

8.	Mr. C.P. Ramamirtham, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Oceanography.	1980	1986
9.	Dr. V.S.K. Chennubhotla, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Seaweed Culture.	1980	1986
10.	Dr. K. Alagaraja, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Biostatistics and production economics.	1980	1986
11.	Dr. S.V. Bapat, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Fisheries Administration and Management.	1980	1984
12.	Dr. A.V.S. Murthy, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Physics and Meteorology.	1980	1986
13.	Dr. M.J. George, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Crustacean biology and culture.	1980	1985

14.	Mr. M.S. Muthu, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Crustacean culture.	1980	1986
15.	Dr. G. Luther, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Fishery Biology.	1980	1986
16.	Dr. M.V. Pai, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Fishery Biology.	1982	1984
17.	Mr. S. Mahadevan, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Fish and Shellfish pathology.	1980	1985
18.	Mr. M.S. Rajagopalan, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Marine Fisheries.	1984	1986
19.	Dr. K.A. Narasimham, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Clam and cockles biology and culture.	1980	1986

20.	Dr. P. Parameswaran Pillai, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Ecology and Culture systems.	1980	1986
21.	Dr. K.C. George, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Fishery Biology.	1980	1986
22.	Mr. K.V. Narayana Rao, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Fishery Biology.	1980	1984
23.	Mr. G. Venkataraman, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Marine Fisheries.	1980	1984
24.	Dr. C. Suseelan, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Zoology, Crustacean Fisheries and Biology.	1980	1986
25.	Dr. C.P. Gopinathan, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Teaching Botany.	1980	1986

26.	Mr. D. Sadananda Rao, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Biochemistry.	1980	1981
27.	Mr. Syed Ahamed Ali, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Biochemistry.	1982	1986
28.	Mr. D. Kandasamy, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Biochemistry.	1985	1986
29.	Mr. D.C.V. Easterson, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Molluscan nutrition and Microscopy. (c) Semester-in-Charge M.Sc. Degree Programme.	1981	1986
30.	Dr. K.J. Mathew, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. level. (b) Teaching Plankton, Nekton and Benthos.	1980	1986
31.	Mr. V. Kunjukrishna Pillai, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Marine Pollution and Estuarine Fisheries.	1980	1986

32.	Dr.(Mrs.) V. Chandrika, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Microbiology.	1982	1986
33.	Dr. A. Geethanand Ponniah, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Physiology and Electrophoresis techniques.	1981	1986
34.	Dr. V.S. Kakati, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Physiology.	1984	1985
35.	Dr. M.K. George, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. level. (b) Teaching Genetics.	1983	1986
36.	Dr. L. Krishnan, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. and M.Sc. level. (b) Teaching Finfish Breeding and Seed Production.	1980	1986
37.	Mr. A.R. Thirunavakkarasu, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Finfish and Crustacean Culture.	1980	1986

38.	Mr. N. Neelakanta Pillai, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at M.Sc. level. (b) Teaching Prawn Culture.	1980	1986
39.	Dr. P.S. Kuriakose, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Mussel Biology and Culture.	1980	1986
40.	Dr. N. Kaliaperumal, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Seaweed Culture and Production.	1980	1986
41.	Dr. S. Kulasekhara Pandian, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - (a) Guiding at Ph.D. level. (b) Teaching Culture of Live Food Organisms.	1983	1986
42.	Mr. P. Bensam, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Farm Management.	1980	1986
43.	Dr. S.C. Mukherjee, Scientist S-3, CMFRI, Cochin-31.	Faculty Member - Teaching Fish Pathology.	June 1986	onwards

44.	Dr. N. Gopinatha Menon, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Fishery Biology.	June 1986	onwards
45.	Mr. K.K.P. Panikkar, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Production Economics.	1981	1986
46.	Dr. K.S. Scariah, Scientist S-2, CMFRI, Cochin-31.	Faculty Member - Teaching Fish Statistics.	1986	-
47.	Mrs. Krishna Srinath, Scientist S-1, CMFRI, Cochin-31.	Faculty Member - Teaching Extension.	1980	1986
48.	Mr. S. Natarajan, Technical Officer, CMFRI, Cochin-31.	Faculty Member - Teaching Instrumentation.	1980	1986

GUEST LECTURERS

49.	Mr. Edward Samuel, Integrated Fisheries Project, Cochin-16.	Teaching Fish Processing Technology.	1980	1986

50.	Prof. N. Appukuttan, Sacred Heart's College, Thevara, Cochin-15.	Teaching Genetics.	1980	1985
51.	Dr. K. Devendran, Dept. of Marine Sciences, Cochin University of Science & Technology, Foreshore Road, Cochin-16.	Teaching Microbiology.	1980	1981
52.	Dr. P. Lakshmanaperumal Swamy, Dept. of Marine Sciences, Cochin University of Science & Technology, Foreshore Road, Cochin-16.	Teaching Microbiology.	1980	1981
53.	Dr. K.L. Sehgal, CIFRI, Barackpore, West Bengal.	Teaching Freshwater Fisheries in India.	1980	only
54.	Shri. A.B. Mukherjee, CIFRI, Barackpore, West Bengal.	Teaching Fish Farm Engineering.	1980	only

55.	Dr. Y.L. Dora, Dept. of Marine Sciences, Cochin University of Science and Technology, Forshore Road, Cochin-16.	Teaching Geology.	1980	only
56.	Prof. M. Induchudan, Maharaja's College, Cochin-31.	Teaching Physiology and Endocrinology.	1980	only
57.	Dr. V.R.P. Sinha, CIFRI, Barrackpore, West Bengal.	Teaching Fish Farm Engineering Technology.	1980	only

Technical Assistance

1.	Mr. A. Nandakumar, Technical Assistant, CMFRI., Cochin-31.	Assistance in arranging practical classes and examinations.	1980	1986

6.3. SYLLABUS FOR M.Sc. DEGREE COURSE

SEMESTER I

Subjects taught in this semester are intended to build up a basic background knowledge to learn the major theme of the course, namely Mariculture in the subsequent semesters.

BASIC SCIENCES

BS. 1. GENERAL BIOLOGY 22 + 7

Classification of plants and animals: Principles of taxonomy and classification. Nomenclature and its principles. Concept of species and speciation.

Comparative Zoology: A comparative study of external morphology and internal organisation of the digestive, respiratory, circulatory, excretory, reproductive, nervous, muscular and skeletal systems of an aquatic annelid worm (Annelida) a prawn (Crustacea), a bivalve and a gastropod (mollusca) and a teleost fish (Pisces). General account of reproduction and life cycles of marine animals.

Marine Botany: General classification, distribution, morphology, reproduction and life cycle of economical marine plants. A brief account of important weeds in coastal waters. General account of Thallophyta with special emphasis on algae Chlorophyceae, Bacillariophyceae, Dinophyceae, Phaeophyceae, Rhodophyceae and Cyanophyceae.

Marine and Estuarine Fauna: A general survey of the fauna of economic significance in the Arabian Sea and Bay of Bengal, and of the adjacent estuaries - Their distribution and abundance.

Practicals: Identification of marine plants. Identification of algae, fungi and other Thallophyta. Identification of common marine and brackish water animals.

BS. 2. BIOCHEMISTRY 25 + 18

Solutions - atomic weight, molecular weight, solubility, molar solution, normality and theory of volumetric titrations. Fundamentals of electrochemistry - Faraday's Laws, ionisation, pH, buffer solutions. Fundamental and general chemistry of hydrocarbons, alcohols, aldehydes, ketones, amines, fatty acids and esters. General biochemistry of lipids, carbohydrates, amino acids, proteins and nucleic acids. Natural sources of carbohydrates, fats and proteins.

Practicals: Volumetric analysis, standardisation of sodium carbonate, hydrochloric acid and potassium permanganate using standard oxalic acid. Reactions of common organic acid radicals, formic acid, acetic acid, citric acid and tartaric acid. Characteristic reactions and identification and carbohydrates, fats and proteins. Determination of carbohydrates, lipids and proteins in fish tissues and plankton. Separation of amino acids by paper chromatography.

BS. 3. BIOSTATISTICS 22 + 7

Basic mathematics. Presentation of data, measures of central tendency and dispersion. Fundamentals of probability and standard distributions. Tests of significance (normal, 't' chi--square and F-analysis of variance and covariance). Correlation and regression. Basic concept of sampling. Basic concept of design of experiments.

Practicals: In the above subjects.

BS. 4. PHYSICS 5 + 5

Specific gravity.

Fundamental principles of mechanics: Laws of motion, circular motion, simple harmonic motion.

Hydrostatics: Pressure, Pascal's Law, Archimede's Principle and its application. Surface tension. Viscosity - Newton's Law of Viscosity.

Heat: Conduction, convection and radiation. Laws of radiation, thermometry, specific heats of solids and liquids, heat capacity of a body, Newton's Law of Cooling.

Optics: Reflection, refraction.

Sound: Basic principles, sound propagation.

Electricity: Laws of electricity, concept of static and current electricity and power, Kirchhoff Laws of Electricity, simple electrical instruments.

Practicals: Determination of specific gravity of solids and liquids. Determination of refractive index of water and glass. Determination of relative humidity. Calibration of an ammeter, voltmeter.

MARINE BIOLOGY

MB. 1. MARINE AND ESTUARINE ECOLOGY 15 + 0

Introduction to ecological studies. Classification of marine environments. Ecological parameters in aquatic environments. Biotic and abiotic factors influencing the distribution and abundance of animals in the coastal zone. Adaptation of animals in estuaries, brackish waters and mangroves. Structure and function of ecosystem, theoretical considerations. Population and community ecology. Factors regulating population. Energy flow in ecosystem. Productivity, principle methods of estimation, conversion and food chains. Ecological efficiencies. Animal associations - commensalism, parasitism and symbiosis.

MB. 2. PLANKTON, NEKTON, BENTHOS 10 + 10

Marine phytoplankton: Methodology for collection, preservation and identification of phytoplankton. Estimation of standing crop. Role of phytoplankton in the economy of the sea.

Marine zooplankton: Methods of collection, preservation, analysis and estimation of zooplankton. Organisms in zooplankton, planktonic adaptations and diurnal migrations. Deep scattering layer, plankton and fisheries.

Nekton: Components, adaptations and distribution.

Benthos: Components, adaptations, distribution and importance.

Practicals: Phytoplankton - Methods of collection, identification of common forms, estimation of standing crop. Zooplankton - collection, volume determination, identification of major groups, numerical analysis and quantitative estimation. Benthos - collection, analysis and quantitative estimation of benthic organisms.

MB. 3. MARINE POLLUTION 10 + 6

Various types of pollutants in the marine and estuarine environment. Surveillance and monitoring marine pollution and their significance in mariculture. Environmental parameters with reference to site selection for mariculture. Bacterial pollution and indicator organisms. Environmental stress. Pollution from sewage and other organic wastes, heavy metals, hydrocarbons, pesticides, thermal pollution. Eutrophication. Biossay and its importance in mariculture.

Practicals: Estimation of B.O.D. Estimation of nutrients. Estimation of heavy metals. Toxicity testing - Gas liquid chromatography (pesticides).

MB. 4. MARINE MICROBIOLOGY 25 + 10

Taxonomy - classification of marine and non-marine micro organisms, difference between marine bacteria and non-marine

bacteria. Distribution of bacteria, fungi, actinomycetes, viruses and rickettsiae in the sea, estuarine and brackish water and sediments. Sampling, isolation, purification and identification of marine micro-organisms especially bacteria based on their morphological, physiological and biochemical reactions. Growth and reproduction in bacteria. Role of heterotrophic bacteria in the mineral cycles of the sea. Zymogenous bacteria, chitinoclastic bacteria, and halophilic bacteria. Corrosion by micro-organisms. Autotrophic bacteria in the marine environment. Effects of physical, chemical and biological factors on marine micro-organisms. Bacteriology of fish, spoilage of fish and fishery products. Sanitary significance of bacterial indicators (faecal coliforms) in the mariculture system. Identification of enterobacteriaceae.

Practicals: Sampling, isolation, purification, enumeration, identification and preservation of marine bacteria. Recognition of fungi and actinomycetes. Isolation of indicators of pathogens, faecal index, Imvic test. MPN - methods.

COASTAL HYDROGRAPHY

CH. 1. METEOROLOGY 10 + 2

Introduction - Earth-Sun relationship - seasons. Concept of Coriolis force. Atmosphere - its composition and vertical structure. Weather elements. Solar radiation, temperature, pressure, wind, precipitation, and humidity - their distribution in space and time. Typical instruments for measuring radiation, temperature, pressure, wind, humidity and precipitation.

Clouds - formation and classification. Preliminary ideas about general circulation and monsoons.

Practicals: Handling of common meteorological instruments for measurement of temperature, pressure, wind, humidity, precipitation.

CH. 2. GENERAL HYDROGRAPHY (PHYSICAL) 20 + 5

Introduction - Horizontal and vertical extent of the Oceans. Physical properties of sea and estuarine waters, temperature, salinity, density, specific volume and pressure; optical and sound properties. Distribution pattern of temperature, salinity, density and dissolved oxygen. T-S diagram and its interpretation. Coastal currents. Mixing processes. Fundamental concepts of waves and tides - the causes and their occurrence. General features of sea bottom and bottom sediment.

Practicals: Operation of physical hydrographic instruments - Nansen bottles, Bathythermograph, Seechi disc, and grab. Collection and preliminary analysis of data.

CH. 3. GENERAL HYDROGRAPHY (CHEMICAL) 10 + 5

Composition of sea water. Concept of constant composition. Chlorinity, chlorosity, salinity, specific gravity, dissolved oxygen and carbondioxide systems. Carbonates. Phosphorus and nitrogen cycles.

Practicals: Determination of salinity, dissolved oxygen, dissolved carbondioxide, pH, reactive phosphate, nitrite and nitrate.

CH. 4. FISHERY HYDROGRAPHY 10 + 5

Hydrography of the continental shelf region around India with reference to fisheries.

Practicals: Preparation of vertical and horizontal distribution patterns of temperature, salinity, density and dissolved oxygen and their interpretations.

CH. 5. SEDIMENTS AND SOILS 5 + 10

Fundamental chemistry of sediments and soils. Micro and macro-nutrients. Soil erosion and its control.

Practicals: Analysis of soil for parameters such as sodium, potassium, calcium and carbon.

PHYSIOLOGY, ENDOCRINOLOGY AND CYTOGENETICS OF MARINE ANIMALS

PY. 1. PHYSIOLOGY 30 + 10

Respiration - Respiratory organs, mechanisms of ventilation, respiratory pigments and gasseous exchange mechanism. Digestion, absorption and conversion process. Biological oxidation - metabolism of energy - carbohydrates, protein and fat metabolism. Mechanism of excretion and osmoregulation. Circulatory system and transport mechanisms. Nerve physiology - neural coordination, receptor mechanisms and effector systems. Physiological rhythms - metabolic and behavioural rhythms.

Practicals: Estimation of metabolic rate (oxygen consumption) of fishes and shell fishes. Analysis of blood serum for glucose, proteins, urea and chlorides. Blood cell counts and haemoglobin estimation.

PY. 2. ENDOCRINOLOGY 12 + 4

Neurosecretory system in fishes and shellfishes. Its organisation, general morphology and structure. Neurosecretory substances, their storage and release and functions. Neurohormones and neurohumours. Endocrine control of reproduction, growth and moulting. Environmental factors and reproduction.

Practicals: Dissection of endocrine organs in fishes and shellfishes.

PY. 3. CYTOGENTICS 15 + 3

General cytogenetics: Components of animal cell and their functions. Meiotic and mitotic cycle, chromosomes morphology behaviour and re-arrangements. Chiasma formation and genetic significance. Behaviour of chromosomes in hybrids. Sex determination mechanism and sex chromosomes. Marine genetics, its development, hybridization and hybrids.

Practicals: Preparation of salivary gland chromosomes of Drosophils. Preparation of chromosome mount.

Embryology: Process of oogenesis and spermatogenesis. Embryogenesis - fertilization, cleavage, gastrulation and organogenesis.

SEMESTER II

FISHERIES

MF. 1. WORLD FISHERIES 5 + 0

World fisheries - history and development; major fisheries of fishing nations; production, utilisation and demand.

MF. 2. MARINE FISHERIES OF INDIA 6 + 0

History, development over the years, present status; major pelagic and demersal fishery resources, their exploitation, area, seasons, production, efforts, utilisation, demand, potential resource.

MF. 3. ESTUARINE AND BRACKISHWATER FISHERIES OF INDIA 3 + 0

Major estuarine and brackishwater systems, their characteristics, species of fishes and shellfishes available, their exploitation, area, seasons, production, effort, utilisation, estuarine and marine fisheries inter-relationship.

MF. 4. FRESHWATER FISHERIES OF INDIA 3 + 2

Major river systems, reservoirs, ponds and tanks; freshwater fishes of commercial importance and their fisheries; recent advances in the freshwater capture and culture fisheries, cold water fisheries.

Practicals: Identification of commercially important freshwater fishes.

MF. 5. FISHING CRAFT AND GEAR 8 + 5

Fishing methods, types of craft and gear, their combination; fishing gear and craft material; engines; fishing technology - exploratory, experimental and commercial fisheries.

Practicals: Participation in fishing; visit to boat building yards and net making factories.

MF. 6. FISH PROCESSING AND MARKETING 10 + 5

Chemical composition of important fishes and shellfishes; causes of spoilage; methods of evaluating of freshness of fish; handling of live fish and shellfish; method of preservation and processing of fishes; traditional and modern fishery products and by-products; transportation of fresh fish distribution and marketing - internal and external markets and trade; demand and supply.

Practicals: Visit to processing factories and fish markets.

MF. 7. FISHERY ECONOMICS 12 + 2

Concept, definitions; artisanal and industrial fisheries; investment and financial management; fisheries co-operatives, corporations; socio-economics; demand, supply, consumption and market situations. Production functions; factor-product, factor-factor and product-product relationship; cost-benefit studies.

MF. 8. FISHERIES ADMINISTRATION AND MANAGEMENT 3 + 0

Organisation and administration of fisheries at the Central and State levels, responsibilities, management and conservation of resources. Fisheries legislations and regulations - legal aspects; Exclusive Economic Zone, conception and responsibilities.

FISH AND FISHERY BIOLOGY

FB. 1. TAXONOMY AND DISTRIBUTION

a) Finfishes 4 + 4

Taxonomy and identity of economically important marine and brackishwater fishes of India and their distribution.

b) Crustaceans 4 + 3

Taxonomy and identity of economically important marine and brackishwater prawns, lobsters and crabs of India and their distribution.

c) Molluscs 4 + 3

Taxonomy and identity of economically important marine and brackishwater molluscs of India and their distribution.

Practicals (a, b & c): Identification of important species of the concerned group.

MF. 8. FISHERIES ADMINISTRATION AND MANAGEMENT 3 + 0

Organisation and administration of fisheries at the Central and State levels, responsibilities, management and conservation of resources. Fisheries legislations and regulations - legal aspects; Exclusive Economic Zone, conception and responsibilities.

FISH AND FISHERY BIOLOGY

FB. 1. TAXONOMY AND DISTRIBUTION

a) Finfishes 4 + 4

Taxonomy and identity of economically important marine and brackishwater fishes of India and their distribution.

b) Crustaceans 4 + 3

Taxonomy and identity of economically important marine and brackishwater prawns, lobsters and crabs of India and their distribution.

c) Molluscs 4 + 3

Taxonomy and identity of economically important marine and brackishwater molluscs of India and their distribution.

Practicals (a, b & c): Identification of important species of the concerned group.

FB. 2. BIOLOGY OF IMPORTANT FINFISHES AND SHELLFISHES

(Note: It is envisaged to provide theoretical and practical instructions on methods of investigation in fishery biology and on the general biology of the major commercially important finfishes and shellfishes of India)

a) Finfihses 8 + 3

Life history; reproduction; age and growth; food and feeding; migration and behaviour.

b) Crustaceans 8 + 2

Life history; reproduction, age and growth; food and feeding; migration and behaviour.

c) Molluscs 8 + 2

Life history; reproduction; age and growth; food and feeding; migration and behaviour.

Practicals (a, b & c): Identification of sex, important larval and juvenile stages; classification of maturity stages; estimation of fecundity; growth and age determination; gut content analysis; mark-recovery experiments.

FB. 3. POPULATION DYNAMICS 15 + 5

Principles of population dynamics; unit stock; age and size composition of the population; abundance and density;

recruitment; growth; mortality (fishing and natural); capture and recapture methods; simple models for stock assessment; yield curves; optimum yield; potential resource.

Practicals: Analysis of data pertaining to the above topics.

FINFISH CULTURE

FC. 1. WORLD AQUACULTURE 4 + 1

Role and importance of aquaculture, status of aquaculture in the world, production trends in aquaculture development. Important cultivable species in marine, brackishwater and freshwater regimes. History of freshwater fish culture and mariculture.

FC. 2. SPECIES SELECTION FOR CULTURE 4 + 0

Characteristics and criteria for species selection. Life history; biological features of cultivable salt water fishes of India - reproductive habits, feeding habits, growth, adaptability to environment, disease resistence, seed availability; and genetics. Socio-economical considerations.

FC. 3. SEED PRODUCTION 10 + 5

Natural seed resource, distribution and abundance - methods for resource assessment and collection of seed. Hatchery production of seed; breeding under controlled conditions; techniques of induced breeding; egg incubation and larval

rearing procedures and systems. Mass production of seeds hatchery lay-out; fry transportation.

Practicals: Collection of seed from nature using different gears, seed resource survey, techniques of induced breeding and rearing of eggs and larvae.

FC. 4. NUTRITION 25 + 10

a) General: Introduction, total nutritional requirements of cultivable fishes and shellfishes. Essential nutrients - amino acids (proteins), fats, carbohydrates, vitamins and minerals and their requirement in different life stages. Sources of food - natural food, artificial blooms and artificial feed. Energetics of food conversion and methods of expression and SDA. Nutrition and effects of environmental factors. Growth promotion. Nutritional syndrome. Use of isotopes in nutritional studies. Artificial feed; feed compounding, test diets, optimum protein - caloric diet, feed ingredients, their composition and toxins, binders, antioxidants and use of antibiotics in feed. Feeding schedule, ration size, sanitation. Methods of feed formulation, manufacture, feed dispensers, feed storage, quality control and economics.

b) Finfish nutrition: Discussion on finfish nutrition and recent developments in the field.

Practicals: Proximate composition analysis of feed and feed ingredients. Digestive enzymes. Nitrogenous excretion. Metabolic rate. Feeding - digestibility, feed conversion rates and feed formulation.

FC. 5. FISH DISEASES AND THEIR CONTROL 5 + 2

Identification of important parasites and diseases of fish, life histories of important fish parasites and host specificity; bacterial, fungal and viral diseases; effects of pathogenic organisms on the fish health. Symptoms of diseases and prophylactic measures.

Practicals: Collection and identification of parasites and pathogens from cultivable finfisnes.

FC. 6. FIELD CULTURE 10 + 5

Classification of culture systems; advantages and disadvantages of extensive, semi-intensive and intensive culture system; species involved in India. Culture in ponds, raceways, running waters and recycled waters; cage culture; pen culture. Sea ranching and artificial recruitment. Culture site and its reuirements, preparation and management of nursery and grow-out ponds; eradication of undesirable organisms; nursery techniques; pond fertilization; stocking; feeding, monitoring and management.

Practicals: Operation of nursery and stocking ponds, determination of stocking density, techniques of field culture operation and monitoring; field visits.

FC. 7. POLYCULTURE 5 + 1

Species selection for polyculture, criteria and characteristics of species selected for polyculture; stocking density and ratio, feeding and management.

Practicals: Observation on polyculture operation.

FC. 8. PRODUCTION AND ECONOMICS 3 + 2

Optimal size for harvesting, methods of harvesting, post--harvest technology, preservation, processing, quality, quality control and marketing, production, economics.

Practicals: Observe harvesting operations; data recording, production estimation.

FISH FARM ENGINEERING TECHNOLOGY

FE. 1. CULTURE ECOSYSTEM 5 + 0

Ponds, tanks, estuaries and brackishwaters, shore, intertidal, sublitoral, surface floating, midwater and sea bed - their characteristics, topographical features. Ecosystems suitable for different systems of coastal aquaculture.

FE. 2. SURVEY AND SITE SELECTION 10 + 8

Technical considerations - topography, soil structure, water supply, quality, dynamics; seed availability, productivity. Non-technical considerations - socio-economics, political and legal aspects. General principles and procedures of elementary engineering survey, planning of survey in coastal region; computation of area, volume and cost estimates. Fundamental aspects of tides, waves and non-tidal currents;

tidal gradients. Principles of waves and wind energies. Calculation of water requirements; filling and drainage of ponds. Infrastructure facilities available.

Practicals: Understanding of soil characteristics. Use of survey instrument in the field, plotting of survey readings and preparations of survey map, visit to field and collection of data. Measurement of velocity and discharge of tidal channel. Determination of wind velocity, direction, velocity of waves and currents and solar heat.

FE. 3. SELECTION OF MATERIAL AND EQUIPMENT 10 + 6

Materials for enclosures, support, retention and other structures; choice of material, properties and strength of materials; surface floating units, anchorages; water flow and level instrumentation; flow measurements through notches and orifices; hydrological parameters, water flow and level instrumentation; pumps and accessories; filtration, aeration and aerators. Simple machines, liverages; work power and energy.

Practicals: Use of a few level sensing equipments, construction of model surface floating units, observation on pumps, aerators etc.

FE. 4. FARM CONSTRUCTION 10 + 12

a) Brackishwater fish farm - laying out the bottom of pond, design and construction of dike; and water control structures; draining installation, spilway, monk; by-pass channels, water inlet channel - its design and construction; sedimentation basin, desilation, weir; designs of different farms.

b) Design consideration and construction of raceways, cages and pens.

c) Consideration of design and construction of hatcheries.

Practicals: Field visit to study the design of farm, sluice gates etc.

FE. 5. OPEN-SEA FARM ENGINEERING 5 + 8

Selection of site; factors to be considered for site location; selection of material; marine corrosion and its control; marine fouling and its control; design, fabrication and construction of rafts, net retaining structures; constraints and prospects of open-sea farming.

Practicals: Study of materials used for open-sea farming; design, fabrication and construction of rafts, floating or bottom cages, net retaining structures.

SEMESTER III

CULTURE OF CRUSTACEA

CC. 1. AN OVERVIEW OF CRUSTACEAN CULTURE 4 + 10

Historical background; general review of culture of prawns, lobsters and crabs in India and abroad; important areas of culture; species of crustaceans cultured in different regions of the world; production and its trend.

CC. 2. SPECIES SUITABLE FOR CULTURE 10 + 8

Species of prawns, lobsters and crabs available in India for cultivation; important exotic species. Characteristics and criteria for selection of species; comparative reproductive habits, feeding habits, growth, adaptability to environmental changes; disease resistance; seed availability; genetical consideration and socio-economical consideration.

Practicals: Identification of eggs, larvae and juveniles of important cultivable species. Dissection of reproductive system of typical penaeid prawn. Examination of sperms and mature ova. Analysis of prawn samples for maturity stages.

CC. 3. SEED PRODUCTION 10 + 10

Natural seed resource - availability and abundance; seed grounds and methods of collection of seed; seed requirement for culture. Hatchery production of seed - fishing for breeders, transportation, breeding under controlled conditions; broodstock development and management; techniques of induced breeding and hatchery production of seed; problems encountered in large-scale production of seed in hatcheries.

Practicals: Collection of prawn, lobster and crab seed from nature using different gears; technicques of induced breeding and rearing of eggs through larval and post-larval stages to stocking size.

CC. 4. NUTRITION 8 + 5

Live food organisms used in rearing of larval stages; mass culture of live food organisms. Nutritional requirements of cultivable species; artificial feed development for mass rearing in hatcheries, nurseries and field culture; and discussion on recent developments in the field.

Practicals: Feed compounding and its preparation; exercises on feed conversion rates and feed evaluation.

CC. 5. DISEASES AND THEIR CONTROL 3 + 2

Causative factors for the occurrence of diseases; important diseases in cultivated crustaceans (bacterial, viral, fungal, protozoans, worms); aetiology, symptoms and organs affected; environmental diseases; nutritional diseases; mortality due to toxic blooms. Effects of diseases on growth and reproduction; production and economic loss. Control measures for diseases, treatment, prophylactic measures; pond sanitation.

Practicals: Identification of important pathogenic organisms from cultivable prawns, lobsters and crabs.

CC. 6. FIELD CULTURE 10 + 5

Traditional culture practices prevailing in India and in other countries; the advantages and disadvantages of these practices. Semi-intensive and intensive culture; culture of prawns in ponds, raceways, cages, pens, saltpan reservoirs, and in recirculating system. Culture in rice fields and along with compatible species. Culture site and its requirements; preparation of the field; eradication of undesirable organisms;

nursery techniques; manuring, fertilisation; stocking, determinations of stocking density, stocking manipulation, monitoring of stocked prawns, feeding techniques; recent advances in the field culture of prawns.

Practicals: Determination of stocking density, techniques of field culture operation and monitoring of the stocked prawns through demonstration and field visits.

CC. 7. PRODUCTION AND ECONOMICS 5 + 1

Appropriate size and weight for harvesting, methods of harvesting; post-harvest technology - preservation, processing and quality control. Economics of prawn culture in extensive, semi-intensive and intensive systems; paddy-prawn cultivation.

Practicals: Field visits to observe harvesting operation, recording of data, production estimation.

CULTURE OF MOLLUSCA

MC. 1. AN OVERVIEW OF MOLLUSCAN CULTURE 5 + 0

World aquaculture production of marine molluscs; Major species of oysters, pearl oysters, mussels, clams, cockles, scallops and abalones in aquaculture - countries - culture systems; general principles; modern developments, culture of molluscs in India - present status and potential.

MC. 2. SELECTION OF CANDIDATE SPECIES 5 + 0

Criteria for selection of species for culture with special reference to Indian species; Biological - reproductive potential, growth, percentage edibility, disease resistance, seed availability; Environmental: Adaptability to different environmental conditions; Socio-economic: Consumer acceptance, marketability.

MC. 3. SEED PRODUCTION 10 + 15

Utilisation of natural seed resources: Ideal conditions for seed fall in nature, distribution of seed in space and time, seed abundance, seed collection techniques for different species, seed quality and seed selection. Hatchery production of seed: Need for hatcheries for molluscs, broodstock management, induced maturation, natural and induced spawning, larval rearing, spat settlement, ideal spat collectors, juvenile rearing to stocking size, water quality management, disease control, transportation.

Practicals: a) Observations on planktonic larvae of cultivable molluscs, preparation and laying of spat collectors, observations on spat fall, field observations of wild spat.

b) Induction of spawning by physical, chemical, biochemical techniques, larval stages and rearing, spat collection, larval food production, techniques of water quality management.

MC. 4. FIELD CULTURE 12 + 15

Oyster Farming: Site selection and preparation, juvenile rearing and grow-out for market, farm structure and farming techniques, predator control, control of biofouling, monitoring of water quality, monitoring of growth and condition index, fattening for market, inventory of an oyster farm.

Pearl Culture: Site selection, collection of mother oysters, farming techniques, control of biofouling, boring organisms and predators, monitoring of growth. Selection of pearl oysters for cultured pearl production, conditioning, nucleus implantation, post-operative care, pearl-sac theory, growth of pearl, pearl production, inventory of pearl culture farm.

Practicals: Raft construction, fabrication of units for carrying oysters in the farm, observations on pearl oyster collection from pearl banks, pearl oyster surgery, identification of biofouling and boring organisms.

Mussel Culture: Site selection, methods of farming, seeding of ropes, tubing of seed, thinning of ropes and transplantation, monitoring of growth and condition index.

Clam and Cockle Culture: Site selection and preparation, methods of farming, stocking density, predation, monitoring of growth and condition Index.

Practicals: Analysing mud/sand/clay samples for estimating suitability for clam culture.

Culture of abalones (abroad): Principle of sea ranching in abalone culture, dependence on hatcheries for seed production, juvenile rearing, food for juvenile phase, transplantation, recovey rate.

Experimental culture of Cephalopods: Spawning behaviour of squids and cuttlefish, collection of egg culsters, hatchling, feeding of hatchlings and young.

MC. 5. NUTRITION 5 + 5

Nutritional requirements of cultivable molluscs; larval nutrition and its problems, mass culture of nannoplankters - recent advances.

Practicals: Identification and culture of nannoplankters.

MC. 6. DISEASES AND THEIR CONTROL 3 + 2

Important diseases of molluscs particularly in culture systems; causative agents; causative factors, effects of pathogenic organisms on the growth and reproduction of cultivable organisms; mass mortality due to toxic blooms; control and prophylactic measure.

Practicals: Identification of important pathogens from cultivable molluscs.

MC. 7. PRODUCTION AND ECONOMICS 5 + 5

Harvesting techniques for different species of molluscs under culture, size and condition index at harvest, depuration techniques, transportation, processing and product development, shelf life of products quality control. Cost of production, market trends of products.

Practicals: Depuration of oyster, estimation of bacterial load, pathogenic bacteria.

CULTURE OF SEAWEEDS

SW. 1. AN OVERVIEW OF SEAWEED CULTURE 5 + 0

Introduction to marine plants, general taxonomy, morphology, reproduction, life cycle and distribution. Commercial marine plants; production and utilisation; a review of marine plants in India and abroad, prospects of culture.

SW. 2. SYSTEMATICS AND BIOLOGY 15 + 5

Taxonomy of economic seaweeds; distribution - zonation; succession; morphology; histology; reproduction; life cycle; growth; physiology; factors affecting the growth; predation; general chemistry of seaweeds.

Practicals: Identification of seaweeds, reproductive bodies, in situ measurements of production.

SW. 3. CULTURE TECHNOLOGY 15 + 10

Species cultured; selection of sites; design of culture plots, culture operation, rearing, transplanting, monitoring of growth; monitoring of environmental changes and causes of mortality.

Practicals: Collection of seed material; construction of frames, seeding, measurement of growth.

SW. 4. PRODUCTION AND ECONOMICS 10 + 10

Harvesting size, weight; harvesting methods; production; post-harvest technologies of cleaning, washing, drying, storage, processing; extraction of products; cottage and large-scale

seaweed culture. Production, technology for higher yields, economics of culture operation.

Practicals: Field visits to observe culture of seaweeds in coir nets; techniques of harvesting; demonstration of algin and agar extraction.

RESEARCH METHODOLOGY

RM. 1. INSTRUMENTATION 10 + 20

(Note: The Theoritical instructions will be contained to basic principles so as to enable the students to understand the operation of the equipments mentioned below).

Basic electronic theory; atomic structure; electronic emission; diodes; triodes; photo tubes; photo multipliers; amplifier, semi conductor devices; circuit components and power supply devices. Basic principles of operation and the application of the instruments - microscopes (light, flourescent, phase contrast, electron); photo micrographic equipment, (slide projector, close circuit T.V., vedeo cassette); colorimeters; photometers; spectrophotometers (ultraviolet and visible, infrared, single beam and double beam); refractometer; scintillation counter; gas ionisation counter (Geiger Counter); pH meter; bomb calorimeter; chromatographic instruments (liquid, paper, thin layer, column, gas-partition, absorption); electrophoretic instruments (electrochromatograph or continuous electrophoresis, normal electrophoresis - supported and unsupported). Accoustic/electronic instrument system for behaviour studies of underwater animals as applicable to mariculture.

Practicals: Practicals using colorimeters, spectrophotometers, pH meter; chromatographic instruments. Demonstration of the operation of gas chromatography; electrophoretic unit, photomicrographic equipment, Geiger Counter and bomb calorimeter.

RM. 2. MICROTECHNIQUES 10 + 20

Introduction to microtechniques and microtomy, microscopic preparation and need for thin and ultra-thin sections.

Fixation: Anaesthetising and killing, fixation of invertebrates, fixation of larvae, embryos, organs, tissues, monolayers of cells, isolated cells, bacteria. Time and temperature of fixation; fixation and dehydration methods (embedding media and methods); stains; stained whole mounts; section cutting; affixing and processing the sections; mounting; histochemical methods for carbohydrates, lipids, proteins.

Practicals: Preparation of tissue blocks, section cutting; affixing and processing the sections, staining, mounting; analysis and reconstruction; preparation of whole mounts.

RH. 3. CULTURE TECHNIQUES 5 + 15

Culture media, preparation, and culture of phytoplankters, zooplankton; mass culture and its problems. Use of laboratory animals in toxicity studies.

Practicals: Preparations of important culture media and demonstration of mass culture of phytoplankton; and other live food organisms.

SEMESTER IV

MANAGEMENT OF MARICULTURE FARMS AND EXTENSION

MM. 1. HATCHERY MANAGEMENT 10 + 0

Spawner collection, spawning under controlled conditions, water quality control; fertilisation, feeds and nutrition; control of parasites, harvesting of fry, pre-transport treatment of fry and packing, small-scale hatchery operation.

MM. 2. NURSERY MANAGEMENT 15 + 0

Nursery fields, construction, preparation, stocking, stocking manipulation, effects of physico-chemical factors, feeding, control of parasites and predators.

MM. 3. FARM MANAGEMENT 20 + 0

Pond management in tropical waters, pond construction, preparation, eradication of predators, fertilisation, stocking, its manipulation, monitoring, feeds and feeding rates, production, harvesting, pond technology for higher yields. Concept of intergrated farming of crop-livestock and fish. Selection of organisms. Techniques of farming; management of integrated farming system; benefits; concept of blending culture and capture fisheries; advantages and management.

MM. 4. FISHERY EXTENSION 5 + 0

Principles of extension; theory of motivation; extension methods and evaluation; extension education. Status of extension activities in fisheries; transfer of technology; behavioural pattern of fishermen to structural changes; adoption of villages for integrated rural development, socio-economics.

6.4. M.Sc. DEGREE COURSE - INCUMBENTS

Sl. No.	Name of Fellow	State to which belongs	Result	Present Occupation
Ist. BATCH (1980-82)				
1.	Mr. K. Udayakumara	Karnataka	Ist Class Distinction	Employed in Tata Fisheries, Madras.
2.	Mr. P. Laksmikanthan	Karnataka	Ist Class	Higher studies abroad. Doing Ph.D. in Stirling University.
3.	Mr. P. Jayasankar	Kerala	Ist Class	Did Ph.D. in Mariculture - IIIrd Batch and now employed as Scientist S-I in CMFRI.
4.	Mr. Charles John Bhaskar	Tamil Nadu	Ist Class	Higher studies. Doing Ph.D. in Madras University.
5.	Mr. P.K. Asokan	Kerala	Ist Class	Did Ph.D. in Mariculture - IIIrd Batch and now employed as Scientist S-I in CMFRI.
6.	Mr. R. Srinivasan	Tamil Nadu	Ist Class	Employed in Tata Fisheries, Madras. Now selected for Technical Officer, Larval rearing in MPEDA.

7.	Mr. Eswara Prasad	Kerala	Ist Class	Employed in Tata Fisheries, Madras. Now selected for Technical Officer, Laral rearing in MPEDA.
8.	Ms. Premila Rajan	Tamil Nadu	Ist Class	Married - house wife.
9.	Mr. K. Krishna Kumar	Kerala	Ist Class	**Did Ph.D. in Mariculture - IIIrd Batch and now got selected as Hatchery Biologist in MPEDA.**
10.	Ms. Lekshmi	Kerala	Discontinued.	

2nd BATCH (1981-83)

1.	Mr. T.N. Unnikrishnan	Kerala	Ist Class	Employed in MATSYAFED, Kerala.
2.	Mr. K.Kalyanaraman	**Tamil Nadu**	Ist Class	Employed in Tata Fisheries, Madras.
3.	Mr. Udaya Ram Jyothy	Tamil Nadu	Ist Class	Employed in Tata Fisheries, Madras.
4.	Mr. Kiron Viswanath	Kerala	Ist Class	Doing Ph.D. in Mariculture - IVth Batch.
5.	Mr. S. Vaitheeswaran	Tamil Nadu	Ist Class	Employed as Farm Manager in Vorion Chemicals, Madras.
6.	Mr. T. Rajagopalan	Kerala	Ist Class	Doing L.L.B. studies.
7.	Ms. Asha Narayan	Kerala	Ist Class	Employed in Corporation Bank, Cochin.

8.	Ms. Jeeju George	Kerala	Ist Class	Employed as Programmer in Hindustan Computers, New Delhi.
9.	Mr. S. Sugunan	Kerala	Ist Class	Doing Ph.D. studies at Kerala University, Trivandrum.
10.	Ms. T. Usha	Kerala	Ist Class	Doing Ph.D. studies at Kerala University, Trivandrum.
11.	Mr. N. Ravindran	Tamil Nadu	Ist Class	Joined in Ph.D. programme in Mariculture but discontinued. Studying for M.B.A. at Indian Institute of Management, Ahemedabad.
12.	Ms. Mary Varghese	Kerala	Ist Class	Married - house wife.
13.	Mr. Leenes Paul	Kerala	Discontinued.	
14.	Mr. A.P. Vijayan	Kerala	Discontinued.	
15.	Mr. S. Anilkumar	Kerala	Discontinued.	

3rd BATCH (1982-84)

1.	Mr. C.M. Muralidharan	Kerala	Ist Class	Employed in MPEDA as Field Supervisor.
2.	Mr. G. Gopakumar	Kerala	Ist Class	Employed in MPEDA as Hatchery Supervisor.
3.	Ms. V. Kripa	Kerala	Ist Class Distinction	Employed as Scientist S-1 in CMFRI.

4.	Mr. Parag B. Karia	Karnataka	Ist Class	Employed in Scientific Instrument Co., Bangalore.
5.	Ms. Annie Mathew	Kerala	Ist Class	Doing Ph.D. in Mariculture - VIth Batch.
6.	Ms. Puthran Prathibha	Karnataka	Ist Class Distinction	Joined Ph.D. programme in Mariculture - Vth Batch but discontinued as she got employed as Scientist S-1 in CMFRI.
7.	Ms. P.T. Sarada	Kerala	Ist Class	Joined Ph.D. programme in Mariculture - Vth Batch but discontinued as she got employed as Scientist S-1 in CMFRI.
8.	Mr. T. Sankara Pillai	Kerala	Ist Class	Employed in MPEDA as Field Supervisor.
9.	Ms. K. Rani	Tamil Nadu	Ist Class	Employed as Scientist S-1 in CMFRI.
10.	Mr. S. Alaguravi	Tamil Nadu	Ist Class	Employed as Deputy Farm Manager in Vorion Chemicals, Madras.

4th BATCH (1983-85)

1.	Mr. B. Rajesh	Tamil Nadu	Ist Class	Got U.G.C. Fellowship for Ph.D. in Marine Science, Cochin.

2.	Ms. N.C. Meenakshi	Kerala	2nd Class	Not known.
3.	Mr. George Thomas	Kerala	Ist Class	Employed in Aquaculture Consultancy.
4.	Ms. P. Laxmi Latha	Kerala	Ist Class	Doing Ph.D. in Mariculture - VIth Batch.
5.	Ms. Sally Anne Thomas	Kerala	Ist Class	Doing Ph.D. in Mariculture - VIth Batch.
6.	Mr. V. Surendran	Kerala	Ist Class	Got U.G.C. Fellowship for Ph.D. in Marine Science, Cochin.
7.	Mr. P.G. Joseph Gilbert	Kerala	Ist Class Distinction	Doing Ph.D. in Mariculture - VIth Batch.
8.	Mr. K. Suresh Kumar	Kerala	Ist Class	Doing Ph.D. in Mariculture - VIth Batch.
9.	Ms. Mary Mathew	Kerala	Ist Class	Doing Ph.D. in Mariculture - VIth Batch.
10.	Mr. A.P. Dinesh Babu	Kerala	Ist Class	Got U.G.C. Fellowship for Ph.D. in Marine Science, Cochin.

5th BATCH (1984-86)

1.	Ms. Mini Raman	Kerala	Ist Class	Not Employed.
2.	Mr. S.R. Ahirrao	Maharashtra	Ist Class	Employed in Hindustan Lever Ltd., Bombay.
3.	Mr. C. Mohandass	Tamil Nadu	Yet to get a paper	

4.	Mr. Deepak Narendra Chaudhari	Maharashtra	Ist Class	Hindustan Lever, Bombay.
5.	Mr. K. Madhu Sudan Reddy	Andhra Pradesh	Ist Class	Not known.
6.	Mr. A.K.V. Nasser	Kerala	Ist Class	Doing Ph.D. in Mariculture - VIIth Batch.
7.	Mr. N. Ravi	Tamil Nadu	Ist Class	Doing Ph.D. in Mariculture - VIIth Batch.
8.	Mr. P.N. Vinod	Kerala	Ist Class	Not known.
9.	Mr. B. Savadamuthu	Tamil Nadu	Discontinued	

6th BATCH (1985-87)

1.	Ms. S.K. Sheela	Kerala	Continuing
2.	Ms. Sheeba Susan Mathew	Kerala	Continuing
3.	Mr. Daljit Singh	Bihar	Continuing
4.	Mr. E. Appuchand	Andhra Pradesh	Continuing
5.	Mr. S. Muthukaruppan	Tamil Nadu	Continuing
6.	Mr. Saji Chacko	Kerala	Continuing
7.	Ms. K.V. Kalpana	Tamil Nadu	Continuing

8.	Ms. K. Preetha	Kerala	Continuing
9.	Ms. V.K. Usha Devi	Kerala	Continuing

7th BATCH (1986-87)

1.	Mr. D. Ramraj	Tamil Nadu	Just commenced
2.	Ms. Ambikadevi	Kerala	Just commenced
3.	Ms. Synthia Thomas	Kerala	Just commenced
4.	Ms. Imelda Joseph	Kerala	Just commenced
5.	Ms. Sheeba K. Thariyan	Kerala	Just commenced
6.	Ms. Sosamma Easo	Kerala	Just commenced
7.	Mr. P.R. Ramesh	Kerala	Just commenced
8.	Mr. K.C. Dinesh	Kerala	Just commenced
9.	Ms. Bindu R. Pillai	Kerala	Just commenced

6.5. DISSERTATION WORK ASSIGNED TO JUNIOR RESEARCH FELLOWS

Sl. No.	Name of Fellow	Supervising Teacher	Topic of Research
FIRST BATCH (1980-82)			
1.	K. Krishna Kumar	N.N. Pillai	Prawn seed transportation.
2.	R. Srinivasan	P.V. Rao	Studies on the abundance and distribution of benthos and hydrological parameters in prawn culture systems.
3.	K. Udayakumara	A.G. Ponniah	Metabolic and excretion rates of the prawn P. indicus fed on different types of natural and artificial feeds.
4.	P.K. Asokan	M.J. George	Comparative studies on protein, carbohydrates and fat contents in P. indicus during ovarian maturation in nature and induced maturation experiments.
5.	P. Easwara Prasad	V.K. Pillai	Studies on soils of some brackishwater prawn fields around Cochin.

6.	P. Jayasankar	M.S. Muthu	Studies on the effect of Ammonia, Nitrate and Nitrite on the larvae of P. indicus.
7.	K.P. Lakshmikantham	C. Suseelan	Salinity tolerance of post-larvae of P. indicus.
8.	T.I. Charles John Bhaskar	Syed Ahamed Ali	Nutritional requirement of post-larvae of P. indicus.
9.	Premila Rajan	K.H. Mohamed	Oxygen requirement of prawn larvae in the hatchery system.

SECOND BATCH (1981-82)

10.	N. Ravindran	V.K. Pillai	Studies on the diurnal variation of certain environmental parameters in culture pond.
11.	T. Rajagopalan	M.J. George	Food availability and selectivity in prawn culture pond.
12.	T.N. Unnikrishnan	A. Laxminarayana	Oxygen consumption and ammonia excretion of Penaeus indicus in different salinities.
13.	Udayaram Jyothy	D.C.V. Easterson	Food value of rotifer, brine shrimp and Moina to post-larvae of P. indicus reared in the laboratory.
14.	S. Vaitheeswaran	Syed Ahamed Ali	Studies on the use of growth promoting agents in the diets of Penaeus indicus.
15.	M. Kalyanaraman	R. Paul Raj	Effects of salinity on the growth, food intake, conversion efficiency and proximate composition of juvenile Penaeus indicus.

16.	Kiron Viswanath	A.D. Diwan	Endocrine control on osmoregulation in the prawn Penaeus indicus.
17.	V.S. Sugunan	P.P. Pillai	Ecology of meiobenthos in selected culture fields around Cochin.
18.	Mary Varghese	A.G. Ponniah	Serum cholestrol, protein and glucose content in Etroplus suratensis.
19.	T. Usha	A.D. Diwan	Mobilisation of some of the metabolite reserves during moult cycle in the prawn Penaeus indicus.
20.	Jeeju George	A.G. Ponniah	Comparative karyological studies on prawns Penaeus indicus and P. monodon.
21.	Asha Narayan	K.C. George	Studies on the pituitary gland of selected cultivable finfishes.

THIRD BATCH (1982-84)

22.	Annie Mathew	C.P. Ramamirtham	Carbon dioxide equilibria and nutrient availability in culture ecosystem.
23.	G. Gopakumar	M.S. Muthu	Effect of hydrogen sulphide on juvenile P. indicus.
24.	S. Alaguravi	V. Chandrika	Studies on sulphur bacteria in the prawn culture ecosystems.
25.	V. Kripa	A. Laxminarayana	Influence of hypoxia on metabolism and activities of P. indicus.

26.	K. Rani	Syed Ahamed Ali	Effect of particle size in the compounded diets on the pellet stability and food conversion efficiency in P. indicus.
27.	R. Sankara Pillai	L. Krishnan	Effect of certain environmental factors on developing eggs and early larvae of the mullet Liza parsia.
28.	P.T. Sarada	V.K. Pillai	Studies on the effects of temperature and pH on the post-larvae of Penaeus indicus (H. Milne Edwards).
29.	C.M. Muraleedharan	M.S. Rajagopalan	Colonisation of the mangrove, Acanthus ilicifolius in the sea accreated regions near Cochin.
30.	Parag B. Karia	A.G. Ponniah	Genetic variation in the fish Liza parsia.
31.	Puthran Prathibha	N. Neelakanta Pillai	Electrophoretic studies on Penaeus monodon.

FOURTH BATCH (1983-85)

32.	K. Suresh Kumar	D.C.V. Easterson	Study on the protein budget in different size groups of Penaeus indicus.
33.	George Thomas	A.D. Diwan	Relation between growth rate and RNA - DNA protein ratio in Penaeus indicus (H. Milne Edwards).

34.	A.P. Dinesh Babu	C.P. Ramamirtham	Calcium exchange between sediments and water in some culture ponds with stress on carbonate and bicarbonate alkalinities.
35.	P. Laxmilatha	M.S. Muthu	Studies on the thelycum and spermatophore of the prawn Penaeus indicus.
36.	V. Surendran	V. Chandrika	Studies on the Heterotrophic Bacteria in the Mangrove ecosystem near Cochin.
37.	Mary Mathews	A.G. Ponniah	Electrophoretic studies on Mugil cephalus and Liza Parsia.
38.	B. Rajesh	A. Laxminarayana	Metabolic effects of eyestalk removal in Penaeus indicus.
39.	N.C. Meenakshi	M.S. Rajagopalan	Observation on the germination and growth of Avicennia officianalis.
40.	P.C. Joseph Gilbert	V.K. Pillai	A comparative study of the chemical composition of soils from aquaculture systems in the Cochin estuarine areas.
41.	Sally Anne Thomas	R. Paul Raj	Evaluation of nutritive value of mangrove leaves as a feed component for juveniles of Penaeus indicus.

FIFTH BATCH (1984-86)

42.	P.N. Vinod	A. Laxminarayana	Effect of some pesticides on Penaeus indicus.

43.	Mini Raman	V. Chandrika	Studies on rhizosphere microflora of Acanthus ilicifolius.
44.	A.K.V. Nasser	S. Muthusamy	A comparative study of sediment nutrients in seasonal and perennial prawn culture ponds during the south-west and immediate post-monsoon months.
45.	K. Madhu Sudhan Reddy	V.S.K. Chennubhotla	Photosynthesis in relation to some selected environmental parameters in prawn culture fields.
46.	Dipak Narendra Chaudhari	A.R. Thirunavukkarasu	Changes in haemolymph constituent in the resting (or non-active) and activity stressed Penaeus indicus.
47.	S.R. Ahirrao	D.S. Rao	Seawater analysis with particular reference to dissolved organic matter during premonsoon and monsoon months.
48.	C. Mohandass	C.P. Ramamirtham	Studies on N-P-K ratios in soil and overlying water in some culture ponds in relation to plankton biomass.
49.	N. Ravi	A.G. Ponniah	Studies on lactic dehydroganase isozymes in Mugil cephalus and Liza parsia.

SIXTH BATCH (1985-87)

50.	K.V. Kalpana	P.S.B.R. James	Osmotic pressure of haemolymph in juvenile and adult Metapenaeus dobsoni acclimated in different salinities.

51.	K. Preetha	A. Noble	Investigations on the fishes caught in Cochin backwaters in and around south-west monsoon months.
52.	Saji Chacko	M.M. Thomas	Studies on the occurrence of clams in the culture fields and its effect on the production of prawns.
53.	A. Muthukaruppan	S. Sivakami	Studies on the biochemical aspects of ovarian maturation in Liza parsia.
54.	Daljeet Singh	N.G. Menon	Comparative studies on the ecology of bottom macrofauna in seasonal, perennial fish ponds and in the adjacent backwaters.
55.	Eluri Apuchand	Mary K. Manisseri	Studies on the influence of lunar periodicity on the migration of juvenile Penaeus indicus in the Cochin backwaters.
56.	Sheeba Susan Mathews	C.S.D. Selvaraj	Observations on the size distribution and abundance of cultivable penaeid prawn seeds in the Cochin backwater during south-west monsoon and post-monsoon months.
57.	S.K. Sheela	George John	Cytogenetic studies on Meretrix casta and M. meritrix.
58.	V.K. Ushadevi	M. Peer Mohamed	Low ambient oxygen tolerance in mullet and milkfish.

6.6. SYLLABUS FOR I SEMESTER-COURSE WORK ON MARICULTURE Ph. D. PROGRAMME

MR. 1. An overview — Credit Hours 3 + 0

Present status of mariculture: at global, regional and national levels; species involved; current level of practices; production and prospects.

MR. 2. Current concept on the biology of cultivable finfishes and shellfishes. — 15 + 0

Species identity; distribution; reproduction and behaviour; development-egg, larval, post-larval and juvenile stages; recruitment; food, feeding and digestion; age and growth; migration; mortality; ecological adaptations; community structure and behaviour - all above of cultivable finfishes, crustaceans and molluscs.

MR. 3. Finfish culture — 5 + 0

Cultivable finfish resources; selection of species for culture; monoculture and polyculture; breeding under controlled conditions; recent advances on breeding and broodstock development of milkfish, mullets and other important cultivable fishes; seed production; nursery rearing; culture systems - ponds, cages, pens-raceways; stocking density; monitoring; feeding; production; economics.

MR. 4. Prawn culture — 5 + 0

Prawn resources; selection of species; seed production; culture of prawns in different grow-out system; monoculture

and mixed culture; controlled reproduction; seed production; stocking densities; monitoring; feeding, management; production; economics; problems and bottlenecks of large-scale culture; prospects.

MR. 5. Lobster culture 3 + 0

Lobster resources; breeding of lobsters under controlled conditions; rearing of phyllosoma larva; seed collection from nature; culture of pueruli to marketable size; feeding; problems of lobster culture.

MR. 6. Crab culture 3 + 0

Crab resources; species for culture; recent advances in crab culture; induced breeding; rearing of zoea larva and megalopa; feeding; production; problems and prospects.

MR. 7. Mussel culture 4 + 0

Mussel resources; different culture methods; raft culture of mussels; seed collection; seeding; monitoring; biofouling; production; economics; problems and prospects.

MR. 8. Oyster culture 4 + 0

Edible oyster resources; different culture methods; rack culture; spat collection techniques; stocking density; growth grounds and fattening grounds; predators and fouling organisms; production; probelms and prospects.

MR. 9. Pearl culture 4 + 0

Pearl oyster resources; species for culture; collection methods; farming technology; mother-oyster culture - spat collection and rearing; culture for pearl production - nucleus implantation techniques, post-operative care; pearl production; economics; problems and prospects.

MR. 10. Clam culture 3 + 0

Clam resources; culture methods; collection of seed clams; stocking density; production; economics; problems and prospects.

MR. 11. Seaweed culture 6 + 0

Resources of cultivable seaweeds; their identity; distribution; morphology; reproduction; development, growth, environmental requirements; culture methods - vegetative and by spores; seeding; monitoring; predation; production; economics and prospects.

MR. 12. Site selection and grow-out structures 12 + 0

Topography; criteria for site selection; water supply; tidal gradient; soil structure; productivity; pollution; infrastructural facilities; survey methods; holding devices - retention nets, cages, pens, ponds, rafts, racks etc., selection of material; designing, fabrication, construction in consideration of envirionmental factors; devices to maintain water quality and circulation; harvesting systems; development of low-cost farm structures; open-sea farming technology.

MR. 13. Production, Economics and Extension 5 + 0

Current production rate of fishes, prawns and other crustaceans, mussels, oysters, seaweeds etc., through culture source in the traditional, extensive and intensive culture system in different regions of the world and in India; production concepts, form of production function and their characteristics; factors influencing production; choice of products and resource use. Economics of culture operation cost-benefit analysis; risk involved in mariculture systems, system improvement and management.

Need for extension of mariculture, extension techniques; transfer of technology; pilot scale demonstration projects; operational research projects; pattern, methods, types and techniques of organisational communication.

BS. 1. Biostatistics I 28 + 7

Elementary Mathematics: Symbols, algebric identities, indices, variables, functions; simultaneous equations and quadratic equations; permutations and combinations. Graphical representation, equation of st. lines, trigonometric ratios; transformations; logarithms (natural and common); derivatives - their connection with tangent and slope of lines - derivative of simple functions, integration as the reverse process of differentiation and integrals of simple functions.

Statistical Methods

Summarisation of data: Pictorial representation, frequency tables, distributions and curves; measures of central tendency-

mean, median mode; measures of dispersion - range, variance, standard deviation; coefficient of variation.

Concept of probability : Experiments, events - simple and compound, independent, mutually exclusive, exhaustive; additive and multiplicative properties; coin tossing experiments; standard distributions - bionomial, Poisson and normal.

Correlation and regression : Linear regression, method of least squares, fitting of curves, concept of correlation, multiple regression and correlation and partial regression and correlation.

Tests of significance : Normal deviate test, paired 't' test, 't' test, Chi-square test, tests of correlation and regression coefficients; 'F' test.

RT. 1. Research Techniques 0 + 15

Knowledge and practice of analytical methods for estimation of protein, carbohydrates and lipids; phosphates, silicates and nitrates; salinity, hydrogen ion concentration, dissolved gasses such as O_2, CO_2, NH_3 and important elements like phosphorus, calcium etc.; BOD; suspended dissolved solids; soil analysis; productivity.

6.7. Ph.D. DEGREE PROGRAMME - INCUMBENTS

Sl. No.	Name of Fellow	State to which belongs	Result	Present Occupation
1st BATCH (1980-83)				
1.	Mr. D. Vincent	Tamil Nadu	Thesis under preparation	Employed as Technical Assistant in CMFRI.
2.	Ms. Shoba P. Shere	Maharashtra	Degree awarded	Not Employed.
3.	Mr. B.S. Ajitha Kumar	Tamil Nadu	Degree awarded	Employed as Fisheries Officer (Aquaculture) in TATA Fisheries, Madras.
4.	Ms. Ammini Joseph	Kerala	Degree awarded	Employed as Lecturer in the School of Marine Sciences, Cochin University of Science and Technology.
2nd BATCH (1981-84)				
1.	Mr. Gopal Prasad Mahobia	Madhya Pradesh	Synopsis submitted	Employed as Senior Research Assistant in Cental Serriculture Research Institute, Mysore.

2.	Ms. Anuradha Krishnan	Tamil Nadu	Thesis submitted	Employed as Senior Research Assistant in Central Serriculture Research Institute, Mysore.
3.	Mr. A. Silas Ebenezer	Tamil Nadu	Degree awarded	Temporarily employed in a social and religious organisation.
4.	Mr. C. Gopal	Andhra Pradesh	Thesis submitted	Employed as Scientist S-1 in CMFRI.
5.	Ms. Elizabeth Joseph	Kerala	Thesis submitted	Employed as Lecturer in Fisheries College, Kerala Agricultural University, Cochin.
6.	Mr. Subhash Chandra Soni	Madhya Pradesh	Degree awarded	Employed in own jewellery business.
7.	Mr. Subhash Chander	Chandigarh	Thesis submitted	Employed as Lecturer in Government College, Punjab.
8.	Mr. A.S. Ninawe	Maharashtra	Thesis under preparation	Employed as Senior Scientific Officer-II, Ministry of Science and Technology, New Delhi.
9.	Mr. Mohana Rao	Andhra Pradesh	Work completed	Whereabouts not known.

3rd BATCH (1982-85)

1.	Mr. K. Krishna Kumar	Kerala	Thesis under preparation	Got selected as Hatchery Biologist in MPEDA.
2.	Mr. K.K. Vijayan	Kerala	Thesis under preparation	Employed in MATSYAFED, Kerala.

3.	Ms. M. Hemambika	Kerala	Thesis under preparation	Married - house wife.
4.	Mr. P. Jayasankar	Kerala	Thesis under preparation	Employed as Scientist S-I in CMFRI.
5.	Mr. Sunilkumar Mohamed	Kerala	Thesis under preparation	Employed as Scientist S-I in CMFRI.
6.	Mr. Harry Cletes	Kerala	Thesis under preparation	Employed as Lecturer in St. Albert's College, Ernakulam.
7.	Mr. P.K. Asokan	Kerala	Thesis under preparation	Employed as Scientist S-I in CMFRI.
8.	Ms. T.N. Sarasu	Kerala	Thesis submitted	Got selected for a college lecturer's post in Kerala Govt. Service.
9.	Mr. T.R. Udaya Sankar	Tamil Nadu	Discontinued	
10.	Mr. J.E. Prabhakar Raj	Tamil Nadu	Discontinued	

4th BATCH (1983-86)

1.	Ms. Mini Thomas	Kerala	Work in final stage	Already selected by Kerala Public Service Commission for a clerical job. Desires to join after the Ph.D. work.
2.	Mr. K. Palanisamy	Tamil Nadu	Work in final stage	
3.	Ms. S. Srisudha	Kerala	Work in final stage	Already selected as a Technical Officer (Live Feed Organisms) in MPEDA.

4.	Mr. Kiron Viswanath	Kerala	Work in final stage	
5.	Mr. G. Pandian	Tamil Nadu	Work in final stage	
6.	Mr. Bhaskar Laxman Jadhav	Maharashtra	Work in final stage	
7.	Mr. P. Philip Samuel	Tamil Nadu	Work in final stage	
8.	Mr. Swarndeep Singh	Punjab	Discontinued	
9.	Mr. M.S. Jaffar Sait	Tamil Nadu	Discontinued	
10.	Mr. N. Ravindran	Tamil Nadu	Discontinued	Doing M.B.A. in Indian Institute of Management, Ahemedabad.
11.	Mr. Mukul Rajan	New Delhi	Discontinued	

5th BATCH (1984-87)

1.	Mr. A. Gopalakrishnan	Kerala	Work in progress	
2.	Mr. Joslet Mathew	Kerala	Work in progress	
3.	Mr. R. Devapiriyan	Tamil Nadu	Work in progress	
4.	Mr. Sait Sahul Hameed	Tamil Nadu	Work in progress	

5.	Mr. K.K. Joshi	Kerala	Work in progress	
6.	Ms. P.T. Sarada	Kerala	Discontinued	Employed as Scientist S-1 in CMFRI.
7.	Ms. Puthran Prathibha	Karnataka	Discontinued	Employed as Scientist S-1 in CMFRI.
8.	Mr. N. Vasudevan	Kerala	Discontinued	Employed in Federal Bank in Kerala.
9.	Mr. T.J. Johnson	Kerala	Discontinued	Employed in MATSYAFED, Kerala.
10.	Mr. Mohamed Iqbal Ashraf Ghan	Utter Pradesh	Discontinued	

6th BATCH (1985-88)

1.	Mr. P.G. Joseph Gilbert	Kerala	Work commenced	
2.	Mr. S. Vijaya Kumar	Tamil Nadu	Work commenced	
3.	Mr. Kuldeep Kumar Lal	Haryana	Work commenced	
4.	Mr. Gulshad Mohamed	Kerala	Work commenced	
5.	Mr. Suresh Kumar	Kerala	Work commenced	
6.	Ms. P. Laxmi Latha	Kerala	Work commenced	

7.	Ms. Annie Mathew	Kerala	Work commenced
8.	Ms. Mary Mathews	Kerala	Work commenced
9.	Ms. Sally Anne Thomas	Kerala	Work commenced
10.	Mr. S. Selvaraju	Tamil Nadu	Discontinued

6.8. TOPICS OF RESEARCH ALLOTTED TO THE SENIOR RESEARCH FELLOWS

Sl. No.	Name of Fellow	Supervising Teacher	Topic of Research
	FIRST BATCH (1980-83)		
1.	Ammini Joseph	P.V.R. Nair	Culture and growth kinetics of selected nano-plankters.
2.	B.S. Ajitha Kumar	K. Alagarswami	Reproductive physiology of Indian species of the genus Perna (Family Mytilidae).
3.	Shobha P. Shere	P.V.R. Nair	Studies on sporulation and propagation of selected Agarophytes.
4.	D. Vincent	M.J. George	Studies on environmental stress in the prawn, Penaeus indicus H. Milne Edwards in culture system.
	SECOND BATCH (1981-84)		
5.	Silas A. Ebenezer	P.P. Pillai	Studies on the ecology and productivity of saline lagoons.

6.	Subhash Chandra Soni	P.V. Rao	Pathological investigations in penaeid prawns.
7.	C. Gopal	R. Paul Raj	Nutritional studies in juvenile Penaeus indicus with reference to protein and vitamin requirements.
8.	Subhash Chander	A.D. Diwan	Studies on ecophysiology of Penaeus indicus H. Milne Edwards in the grow-out systems.
9.	Elizabeth Joseph	P.V. Rao	Studies on histological and biochemical changes during spermatogenesis in Mugil cephalus (Linnaeus) and related species.
10.	Anuradha Krishnan	K. Alagarswami	Studies on larval nutrition in the pearl oyster Pinctada fucata (Gould).
11.	Gopal Prasad Mahobia	K.C. George	Studies on Indian Cichlids.
12.	Arunkumar Ninawe	R. Paul Raj	Studies on certain nitrogen cycle bateria in the prawn culture fields of Kerala.
13.	D. Mohana Rao	A.D. Diwan	Studies on endocrine control of growth and reproduction of the tiger prawn Penaeus monodon Fabricius.

THIRD BATCH (1982-85)

14.	T.N. Sarasu	M.J. George	Larval biology of the spiny lobsters of the genus Panulirus.
15.	M. Hemambika	R. Paul Raj	Studies on the digestive enzymes of the Indian white prawn, Penaeus indicus H. Milne Edwards.

16.	Harry Cleetus	P.V. Rao	Studies on protein metabolism in the spiny lobster, Panulirus homarus (Linnaeus).
17.	K. Krishna Kumar	P.V. Rao	Studies on calcium metabolism in the spiny lobster, Panulirus homarus (Linnaeus).
18.	K.K. Vijayan	A.D. Diwan	Physiology of moulting in the penaeid prawn, Penaeus indicus H. Milne Edwards.
19.	P. Jayasankar	K. Alagarswami	Studies on the reproduction of Indian whiting, Sillago sihama (Forskal) (Percoidie, Sillaginidae).
20.	P.K. Asokan	K. Alagarswami	Environmental and neuroendocrine control of reproduction in pearl oyster.
21.	Sunil Kumar Mohamed	A.D. Diwan	Reproductive endocrinology of the penaeid prawn, Penaeus indicus H. Milne Edwards.
22.	P.R. Udaya Sankar	P.V.R. Nair	Studies on sea grass ecosystems around Mandapam south-east coast of India.

FOURTH BATCH (1983-86)

23.	Jadhav Bhaskar Laxman	R. Paul Raj	Studies on the effect of steroid hormones on the growth and biochemical composition of the mullet Liza parsia (Hamilton).
24.	Kiron Viswanath	R. Paul Raj	Nutritional requirements of fry and fingerlings of the mullet, Liza parsia (Hamilton).

25.	P. Philip Samuel	M.J. George	Biochemical genetics of selected commercially important penaeid prawns.
26.	S. Srisudha	P.V.R. Nair	Role of trace elements on the growth and physiology of selected microalgae.
27.	G. Pandian	P.V.R. Nair	Ecology of some economically important marine algae from Mandapam region (South India).
28.	Mini Thomas	K. Alagarswami	Studies on pearl-sac formation in the Indian pearl oyster, Pinctada fucata (Gould).
29.	K. Palanisamy	P.P. Pillai	Studies on the digestive enzymes of the cultivable grey mullet, Liza parsia (Hamilton).

FIFTH BATCH (1984-87)

30.	Joslet Mathew	S.K. Pandian	Population biology and ecology of Artemia from salt marshes of south-east coast of India.
31.	K.K. Joshi	P.P. Pillai	Nature and ecological significance of nutrient regeneration in different prawn culture fields.
32.	A. Gopalakrishnan	P.P. Pillai	Studies on some aspects of the reproductive physiology of the female grey mullet, Mugil cephalus (L).
33.	A. Sait Sahul Hameed	P.V. Rao	Studies on the pathobiology of penaeid larvae and post larvae.

34.	R. Devapiriyan	P.P. Pillai	Studies on the ecology and production of algae in prawn and fish culture systems.

SIXTH BATCH (1985-88)

35.	Annie Mathew	A.G. Ponniah	Studies on selected isozymes in Crassostrea madrasensis.
36.	K. Suresh Kumar	V. Chandrika	Studies on microbiological decomposition and recycling of organic matter in brackish water culture ponds of Cochin.
37.	S. Vijayakumar	M.K. George	Electrophoretic studies on the grey mullet, Mugil cephalus (L).
38.	Sally Anne Thomas	L. Krishnan	Studies on the reproductive physiology of the mullet, Liza parsia (Hamilton) in relation to hormonal applications.
39.	Gulshad Mohammed	V.S.K. Chennubhotla	Studies on the effects of pollution on the distribution and physiology of selected seaweeds.
40.	P.G. Joseph Gilbert	P.S.B.R. James	Ecological characteristics of prawn culture fields in the Cochin area.
41.	Kuldeep Kumar Lal	P.S.B.R. James	Studies on the reproductive physiology of Lates calcarifer (Bloch).

42.	Mary Mathews	K.J. Mathew	Studies on penaeid prawn seed in some selected centres in the Cochin backwaters.
43.	P. Laxmi Latha	A. Laxminarayana	Studies on the haemolymph of Penaeus indicus H. Milne Edwards.

6.9. LIST OF FELLOWSHIPS AWARDED

1.	Dr. E.G. Silas	Study tour to Japan, U.S.A., U.K. and Italy for 2 months from 27.10.1979 to 24.12.1979.
2.	Mr. K. Nagappan Nayar	Study tour to Fisheries/Aquaculture R & D Institutes in Italy, France and Spain for 2 months from 16.9.1981 to 17.11.1981.
3.	Dr. P. Vedavyasa Rao	Study tour to Fisheries/Aquaculture R & D Institutes in Italy, France and U.K. for 1.5 months from 16.9.1981 to 3.11.1981.
4.	Dr. K. Alagarswami	Training in reproductive physiology of fish and shellfishes for 1 month from 31.5.1982 to 28.6.1982 at the University of California, Davis, California, U.S.A. and 2 months from 29.6.1982 to 29.8.1982 at Laboratoire-de-Physiologie des Poissons, INRA, Jouy-en-Jesas, France.
5.	Mr. S. Mahadevan	Training in fish disease for 2 months from 15.9.1981 to 15.11.1981 at Virginia Institute of Marine Sciences, Gloucester Point, Virginia U.S.A. and 1 month from 16.11.1981 to 16.12.1981 at the Fish Disease Laboratory, Waymouth, Min. of Agri., Fisheries and Food, England, U.K. and Marine Lab. at Aberdeen, Scotland, U.K.
6.	Mr. D. Kandaswamy	Training in fish and shellfish nutrition for 3 months from 25.5.1982 to 20.8.1982 at Faculty of Fisheries Kagoshima University, Japan.
7.	Dr. M.K. George	Training in endocrinology of fishes and shellfishes for 3 months from 27.5.1982 to 29.8.1982 at Marine Laboratory, Aberdeen, U.K.

8.	Mr. D.C.V. Easterson	Training in bioenergetics for 3 months from 10.6.1982 to 9.9.1982 at The Bodega Marine Lab., University of California, Bodega Bay, California-94923, U.S.A.
9.	Mr. K.M.S. Ameer Hamsa	Training in cage and pen culture of Tilapia for 2 months from 2.10.1982 to 6.12.1982 at SEAFDEC, Aquaculture Department, Buiangonan Research Station, Tapao Point, Phillippines.
10.	Mr. N. Neelakanta Pillai	Training in Macrobrachium culture and crustacean genetics for 2 months from 12.3.1983 to 15.6.1983 at Anuenue Fisheries Research Centre, Honolulu, Hawaii, U.S.A.
11.	Dr. S. Kulasekhara Pandian	Training in culture of live-feed organisms for 3 months from 3.5.1983 to 15.8.1983 at Artemia Research Centre, State University of Ghent, Ghent, Belgium.
12.	Ms. Geetha Bharathan	Training in seaweed culture and genetics for 6 months from 31.8.1983 to 4.3.1984 at Fisheries Research Station, Kagoshima, Japan.
13.	Dr. V.S. Kakati	Training in crustacean physiology for 3 months from 11.9.1983 to 28.12.1983 at Station Marine D'Endoume Ecole Pratique des Haules Marseille, France.
14.	Dr. L. Krishnan	Training in mullet culture for 4 months from 12.11.1983 to 15.3.1984 at Oceanic Institute, Waimanalo, Honolulu, Hawaii, U.S.A.
15.	Dr. N. Kaliaperumal	Training in Euchuema culture for 3 months from 1.1.1984 to 1.4.1984 at Marine Sciences Centre, University of Philippines, Manila.

16.	Mr. V. Kunjukrishna Pillai	Training in aquaculture and water quality management for 6 months from 27.3.1984 to 27.9.1984 at Department of Fisheries and Allied Aquacultures, Auburn University, Alabama, U.S.A.
17.	Mr. R. Marichamy	Training in fish seed production for 3 months from 5.3.1984 to 31.5.1984 at Kagoshima Fisheries Station, Tarumizu City, Japan.
18.	Mr. M. Vijayakumaran	Training in aquatic pathobiology for 5.5 months from 20.9.1984 to 3.3.1985 at Institute of Aquaculture, University of Stirling, Scotland, U.K.
19.	Dr. A.G. Ponniah	Training in marine fish genetics for 6 months from 10.10.1984 to 9.4.1984 at Fisheries Laboratory, Lowestoft, Suffolk, U.K.
20.	Mr. K.K.P. Panikkar	Training in aquaculture economics for 4 months from 13.1.1985 to 12.5.1985 at University of Pertanian, Serdang, Selangor, Malaysia.
21.	Mr. E.V. Radhakrishnan	Training in lobster culture for 6 months from 10.1.1985 to 9.7.1985 at Department of Biology, 2000 Percival, Stern Hall, Tulane University, New Orleans, Louisiana-70118, U.S.A.
22.	Mr. M. Kathirvel	Training in integrated fish farming for 4 months from 9.4.1985 to 23.8.1985 at Regional Lead Centre, Wuxi, Jiangsu Provice, People's Republic of China.
23.	Dr. A. Laxminarayana	Training in reproductive physiology of marine prawns for 4 months from 3.6.1985 to 3.10.1985 at Bodega Marine Laboratory, University of California, Bodega Bay, California 94923, U.S.A.

24.	Mr. V.S. Rengaswamy	Training in milkfish culture for 3 months form 16.6.1985 to 16.9.1985 at SEAFDEC, Tigbauan, Iloilo City, Philippines.
25.	Mr. M.S. Rajagopalan	Training in applied ecology of mangrove for 6 months from 7.8.1985 to 14.2.1986 at Australian Institute of Marine Sciences, Townsvillie, Australia.
26.	Mr. T.S. Velayudhan	Training in molluscan genetics for 4 months from 18.8.1985 to 20.12.1985 at Department of Biology Dalhousie University, Halifax, Canada.
27.	Mr. P. Muthiah	Training in oyster hatchery for 3 months from 16.9.1985 to 15.12.1985 at National Agency for Exploitation of Ocean Resources, Argenton Lab., Argenton, France.
28.	Dr. P.S. Kuriakose	Training in mussel culture for 4 months from 16.10.1985 to 15.2.1986 at Instituto de Investigariones, Pesqueras de Vigo, Spain.
29.	Mr. S. Dharmaraj	Training in invertebrate tissue culture for 2 months from 6.11.1985 to 23.12.1985 at National Research Institute of Aquaculture, Nansei-Cho, Japan.
30.	Mr. Syed Ahamed Ali	Training in biochemistry of steroids for 6 months from 7.4.1986 to 6.10.1986 at Zoological Lab., University of Utrecht, Netherlands.
31.	Dr. A.D. Diwan	Training in bioassay procedure and experimental design on toxicity studies for 6 months from 26.12.1986 to 25.6.1987 at School of Fisheries, University of Washington Seattle, Washington 98195, U.S.A.

6.10. FOREIGN CONSULTANCIES

Sl. No.	Name & Address of Consultant	Subject	Dates	Period
1.	Dr. Ching Ming Kuo, Senior Scientist, ICLARM, Manila, Phillippines.	Reproductive physiology of finfish and shellfish.	11.4.1981 to 30.11.1981	20 days
2.	Dr. Akio Kanazawa, Prof. of Nutritional Chemistry, University of Kagoshima, Kagoshima, Japan.	Fish and shellfish nutrition in India.	23.11.1981 to 31.1.1982	70 days
3.	Dr. R.J. Roberts, Director, Institute of Aquaculture, University of Stirling, Scotland.	Fish and shellfish diseases.	5.3.1982 to 11.3.1982	6 days
4.	Dr. Akira Machii, Head, 2nd Technological Research Lab., National Research Institute of Aquaculture, Japan.	Tissue culture of marine invertebrates.	20.12.1982 to 22.1.1983	34 days

5.	Dr. Allen L.S. Munro, Leader, Pathology & Biochemistry Team, Marine Laboratory, Aberdeen.	Fish and shellfish pathology in India.	18.12.1982 to 20.2.1983	65 days
6.	Dr. Victor John Bye, Head of Fish Cultivation Group, Fisheries Laboratory, Lowestoft, England.	Fish and shellfish genetics	10.2.1983 to 5.3.1983	23 days
7.	Dr. Hubert J. Ceccaldi, Director, Ministere DeL' Education Nationale, Ecole pratique Des Houtes Etudes, Laboratoire de Biochimie et Ecologie, Des invertebres Marins, Marseille, 13007, Station Marine d' Endoume, France.	Crustacean physiology and nutrition.	10.6.1983 to 8.7.1983	29 days
8.	Dr. Patrick Sorgeloos, Artemia Coordinator, State University of Ghent, Belgium.	Culture of live food organisms.	11.1.1984 to 1.2.1984	22 days
9.	Dr. Sammy M. Ray, Coordinator of Graduate Programme and Acting Dean, Moody College of Marine Technology, Texas A & M University, Galvesto, Texas, U.S.A.	Oyster biology and culture.	21.2.1984 to 21.5.1984	91 days

10.	Dr. Claude E. Boyd, Professor, Auburn University, Alabama, U.S.A.	Water quality management in aquaculture.	22.11.1984 to 18.12.1984	27 days
11.	Dr. Peter W. Hochachka, Professor, Department of Zoology, University of British Columbia, Vancouver, Canada.	Environmental physiology.	28.5.1985 to 10.6.1985	14 days
12.	Dr. Takeshi Watanabe Professor, Laboratory of Fish Nutrition, Tokyo University of Fisheries, Japan.	Fish/shrimp nutrition.	28.11.1985 to 24.12.1985	27 days
13.	Dr. Fred W. Wheaton, Professor, Department of Agricultural Engineering, College of Agriculture, College Park-20742, University of Maryland, U.S.A.	Aquaculture engineering.	10.2.1986 to 1.3.1986	22 days
14.	Dr. M. Fingerman, Professor of Biology, Department of Biology, 2000 Percival, Stern Hall, Tulane University, New Orleans, Louisiana-70118, U.S.A.	Finfish and shellfish endocrinology.	5.6.1986 to 9.7.1986	35 days

15.	Dr. D.J.W. Moriarty, Principal Research Scientist, Division of Fisheries Research, CSIRO Marine Laboratories, P.O. Box 120, Cleveland, Qld 4163, Australia.	Microbial ecology in growout ponds.	2.8.1986 to 16.8.1986	15 days

6.11. SEMINARS CONDUCTED BY EXPERT CONSULTANTS

Sl. No.	Name of Consultant	Topic of Seminar	Date
1.	Dr. Ching Ming Kuo	1. Circardian rhythm of oocyte responsivenesss to gonadotropins.	20.4.1981
		2. Control of ovarian maturation and ovulation in grey mullets.	21.4.1981
2.	Dr. Akio Kanazawa	1. Characteristics of lipids in marine organisms.	
		2. Crustacean nutrition.	
		3. Microparticulate diet and larval stage nutrition.	
		4. Sterol metabolism in shellfishes.	
		5. Steroid hormones in marine animals.	
3.	Dr. R.J. Roberts	1. Fish environment and diseases.	
		2. Gill and skin, the key organs in relation to fish diseases.	
4.	Dr. Akira Machii	1. Tissue culture in selected invertebrates.	4.1.1983
		2. Recent trends in tissue culture.	6.1.1983

		3. Fundamental structure of molluscan tissues.	12.1.1983
		4. Approaches and application of tissue culture.	13.1.1983
		5. Tissue culture investigations in Japan.	18.1.1983
5.	Dr. Allen L.S. Munro	1. Development and growth of Atlantic salmon - rainbow trout farming in Scotland.	15.1.1983
		2. Pathogenesis of bacterial diseases in fishes.	31.1.1983
		3. Recent developments in the study of furunculosis, a bacterial disease of salmon and other fishes.	2.2.1983
		4. Infectious pancreatic necrosis and virus disenses affected in cultured salmonoid fishes in Scotland.	5.2.1983
		5. U.K. experiences of fish diseases legislation and related legislation on the introduction of non-indigenous fishes.	16.2.1983
6.	Dr. Victor John Bye	1. Application of genetics to aquaculture.	17.2.1983
		2. Control of sex and its application in aquaculture.	26.2.1983
		3. Environmental control of reproduction.	3.3.1983
7.	Dr. Hubert C. Ceccaldi	1. Recent practices in oceanography and general organisation of aquaculture research in France.	17.6.1983

		2. Moulting and growth in crustaceans.	18.6.1983.
		3. Chronobiology in crustaceans.	22.6.1983
		4. Importance of free amino acids in the physiology of crustaceans.	23.6.1983
		5. Blood proteins in crustacea.	27.6.1983
		6. Digestive enzymes in crustaceans.	28.6.1983
		7. Importance of free amino acids and blood proteins in crustacean physiology.	4.7.1983
		8. Comparison of aquaculture practices in Japan U.S.A. and France.	6.7.1983
		9. Contribution to biochemistry and physiology in aquaculture.	7.7.1983
8.	Dr. Patrick Sorgeloos	1. Biology, ecology and distribution of artemia and the role of Artemia Reference Centre in artemia culture.	16.1.1984
		2. Artemia production and cyst/nauplii inducement.	27.1.1984
		3. Other live food organisms.	30.1.1984
9.	Dr. Sammy M. Ray	1. Paralytic shellfish poisioning.	
		2. Overview of oyster culture industry of the world.	

		3. Prospects and problems of oyster culture.	
		4. Role of marine micro-organisms in oyster culture.	
		5. Shellfish hatchery.	
		6. Bioaccumulation of Anthropogenic materials in ecosystem.	
		7. Red tides and shellfish poisoning.	
		8. Marine poisons other than shellfish poison.	
		9. Hazards and dangers of petroleum products to marine life.	
		10. Genetic improvement of shellfish stocks.	
		11. Oyster culture and depuration procedures in Australia.	
		12. Prevention and control of shellfish poisoning.	
10.	Dr. Claude E. Boyd	1. Water quality and aquaculture.	5.12.1984
		2. Water quality analysis and interpretation.	7.12.1984
		3. Liming and fertilization of ponds.	15.12.1984
11.	Dr. Peter W. Hochachka	1. Introduction of principles of environmental biochemistry and physiology: role of position in the marine water column - emphasised on temperature, pressure and food availability, oxygen availability and hydrogen sulphide in the ecosystem.	30.5.1985

		2. Defence strategies against hypoxia (invertebrate and vertebrate metabolism).	1.6.1985
		3. Lessons from an animal extremist on the importance of interacting stresses.	4.6.1985
12.	Dr. Takeshi Watanabe	1. Recent development of aquaculture in Japan.	2.12.1985
		2. Mass propagation of juvenile fish in Japan.	4.12.1985
		3. Recent problems in Japanese aquaculture - fish farming environment and quality of aquaculture product.	6.12.1985
		4. Brood stock nutrition in fish and shrimp.	9.12.1985
		5. Abalone culture in Japan.	13.12.1985.
13.	Dr. Fred W. Wheaton	1. Recent advances in aquacultural engineering.	15.2.1986
		2. Selection of sites, site surveys, farm design and construction.	21.2.1986
		3. Open sea farming.	26.2.1986
14.	Dr. M. Fingerman	1. Status of endocrinological research in fish and shellfishes.	11.6.1986
		2. Scope of neuroendocrinological studies in relation to aquaculture.	16.6.1986

		3. Pharmacological agents in relation to release of crustacean neurohormones.	19.6.1986
		4. Insecticides and their effects on neuroendocrine system.	1.7.1986
		5. Pheromones - role in reproductive behaviour.	8.7.1986
15.	Dr. D.J.W. Moriarty	1. Primary and microbial productivity in water columns and seagrass beds.	4.8.1986
		2. Biochemistry of DNA synthesis with special reference to measurement of bacterial growth rates with tritrated thyonidine.	5.8.1986
		3. Detrital composition on bacterial production in ponds.	13.8.1986
		4. Bacterial ecology of sulphur cycle with special special reference to anoxic and oxic interface environments.	14.8.1986

6.12. GROUP DISCUSSIONS ON VARIOUS SUBJECTS

Sl. No.	Name of Consultant	Subject of Discussion	Date
1.	Dr. Ching Ming Kuo	1. Application of genetics in Tilapia culture	21.4.1981
2.	Dr. Akio Kanazawa	1. Experimental designs, procedures and collection of data in nutritional experiments.	10.12.1981
		2. Formulation and preparation of standard test diets for nutrient requirement.	10.12.1981
		3. Nutrition and feeding of finfishes.	10.12.1981
		4. Methodology of digestibility studies in fishes and crustaceans.	14.12.1981
		5. Energy requirements and energy balance.	14.12.1981
		6. Protein and aminoacid requirements.	15.12.1981
		7. Bivalve larval nutrition.	15.12.1981
		8. Fatty acid requirement and metabolism of lipids in fishes and shellfishes.	16.12.1981

		9. Sterol and phospholipid requirements.	16.12.1981
		10. Nutrition and feeding of larval crustaceans.	17.12.1981
		11. Crustacean and Tilapia nutrition.	18.12.1981
		12. Vitamin requirements.	19.12.1981
		13. Use of antibiotics in fish and crustacean feeding.	24.12.1981
		14. Chitinase.	24.12.1981
		15. Optimum protein-energy ratio studies and utilisation.	31.12.1981
		16. Antioxidants.	31.12.1981
		17. Nutrition and feeding of eels (at Mandapam Camp).	4.1.1982
		18. Bivalve nutrition (at Tuticorin).	6.1.1982
3.	Dr. R.J. Roberts	1. Discussed with the scientists regarding facilities, priorities in research and training requirements of scientists.	
4.	Dr. Akira Machii	1. Planning and organisation of the system for conducting tissue culture.	27.12.1982
		2. Methods and applications of tissue culture.	28.12.1982
		3. Equipment and operation techniques.	29.12.1982

		4. Preparation of medium for tissue culture.	30.12.1981
		5. Cell viability studies, cell isolation and monolayer culture.	3.1.1983
		6. Culture media.	4.1.1983
		7. Staining techniques in tissue culture.	5.1.1983
		8. Tissue dissociation and dispersion of cells.	7.1.1983
		9. Colony formation in tissue culture.	8.1.1983
		10. Storage of cells.	10.1.1983
		11. Evaluation of culture dynamics; synchronous culture, mass culture and outline of organ culture.	11.1.1983
		12. Sandbeach culture of cell adhesion.	12.1.1983
		13. Application of tissue culture techniques in biological studies and other disciplines.	13.1.1983
		14. The layout of tissue culture laboratory, list of equipments with specification and other facilities and suggestions and formulation of research projects on tissue culture.	14.1.1983
5.	Dr. Allen L.S. Munro	1. Fungal and parasite diseases in the prawn hatchery.	11.1.1983
		2. Soft shell disease of penaeid prawns.	12.1.1983

		3. Polyculture fish farming and disease problems.	13.1.1983
		4. Parasite problems in Penaeus indicus and other penaeids.	17.1.1983
		5. Nutritional diseases of culture ponds.	18.1.1983
		6. Procedures for investigations and mortality and morbidity in field situation.	19.1.1983
		7. Virus diseases.	20.1.1983
		8. The importance of epidemiological factors in disease control.	21.1.1983
		9. Use of electron microscope in pathology studies.	21.1.1983
		10. Public health aspects on the development of mussel culture.	1.2.1983
		11. Parasite pathology investigations in penaeid prawns.	6.1.1983
		12. Host defence mechanism.	2.2.1983
		13. Organochlorine residues as a cause of disease in cultured prawns.	2.2.1983
6.	Dr. Victor John Bye	1. Concepts in cytogenetics and its application to genetics of culture organisms.	11.2.1983
		2. Scope for gynogenesis and polyploidy in realising faster genetic gain (Chromosome engineering).	15.2.1983

		3. Design and experiments and analysis of data.	16.2.1983
		4. Principles of hybridisation and cross breeding and achieving better breeds.	16.2.1983
		5. Collection of basic genetic data in breeding programme.	18.2.1983
		6. Mass selection for improving genetic stock.	18.2.1983
		7. Methods for manipulation and chromosome numbers.	22.2.1983
		8. Mechanism of sex determination in fishes.	24.2.1983
		9. Techniques for sex reversion and methods for manipulation of chromosome number.	25.2.1983
		10. Hormonal control of reproduction in fishes.	26.2.1983
		11. Allo enzyme studies and their application in population genetics in culture pratices.	3.3.1983
		12. Principles and methods of selective breeding and ways of avoidance of inbreeding de-presseion in breeding practices.	23.2.1983
		13. Techniques for rearing marine fish larvae.	24.2.1983
		14. Conservation of genetics resources.	4.3.1983
7.	Dr. Hubert J. Cecaldi	1. Osmoregulation.	15.6.1983

		2. Lipid metabolism.	17.6.1983
		3. Optimum conditions in growth of larvae.	20.6.1983
		4. Carotenoids, carotenoproteins and pigments in crustacea.	20.6.1983
		5. Excretion in crustacea.	21.6.1983
		6. Digestive enzymes.	5.7.1983
8.	Dr. Patric Sorgeloos	1. Artemia cysts - cyst quality analysis.	17.1.1984
		2. Techniques for catching - methods of enrichment to improve quality of Artemia.	17.1.1984
		3. Artemia production in natural habitats.	18.1.1984
		4. Methods of exploiting Artemia from habitats.	18.1.1984
		5. Biomass production in controlled condition - cyst/nauplii inducement.	19.1.1984
		6. Cyst/nauplii inducement.	19.1.1984
		7. Algal culture as feed for Artemia.	20.1.1984
		8. Yeast culture and utility of yeast as Artemia feed.	20.1.1984
		9. Moina and Daphnia culture.	20.1.1984

		10. Rotifer culture.	20.1.1984
		11. Influence of pollutants and pesticides in Artemia culture.	28.1.1984
		12. Artemia diseases.	28.1.1984
		13. Artemia genetics.	28.1.1984
		14. Selection of suitable strains of Artemia for culture purpose.	28.1.1984
9.	Dr. Sammy M. Ray	1. Oyster production systems.	
		2. Production of oyster spat.	
		3. Role of environment in oyster production.	
		4. Oyster nutrition.	
		5. Fattening of oysters.	
		6. Energy sources, reserves and utilisation in oysters.	
		7. Reproductive physiology of oysters.	
		8. Management of oyster hatchery.	
		9. Shellfish diseases - a general view.	
		10. Bacterial diseases in oysters.	
		11. Parasites of oysters.	

		12. Dinoflagellate caused toxicity of oysters.	
		13. Paralytic shellfish poisoning.	
		14. Dinoflagellate toxins.	
		15. Ecological interactions, toxic dinoflagellates and molluscan.	
		16. Population, growth and development of toxicity in cultures of dinoflagellates.	
		17. Diagnosis, treatment and control of shellfish diseases.	
		18. Pharmacology of shellfish toxins.	
		19. Larval diseases in hatcheries and their control.	
		20. Modern depuration techniques and standards.	
		21. Extension work in U.S.A. in oyster culture.	
10.	Dr. Claude E. Boyd	1. Importance of hydrological measurements in fish culture ponds and relationship between hydrology and fish culture.	5.12.1984
		2. Water quality and aquaculture.	5.12.1984
		3. Pond fertilization.	6.12.1984
		4. Liming and management of acid sulphate parameter.	6.12.1984
		5. Water quality analysis, sampling and interpretation of results.	7.12.1984

		6. Fish feed and water quality.	14.12.1984
		7. Oxygen demand, chemical treatment and dose calculation.	14.12.1984
		8. Design of water quality experiments for aquaculture.	15.12.1984
11.	Dr. Peter W. Hochachka	1. Physiological regulatory mechanisms: salinity osmoregulation, pH and pressure.	30.5.1985
		2. Physiological regulatory mechanisms: responses to temperature, effects of maintenance and activity, metabolism.	31.5.1985
		3. Physiological regulatory mechanism: temperature, light, food availability, symbiotic solution to potential environmental stresses.	31.5.1985
		4. Responses to varying oxygen availability, environment verses metabolism, hypoxia; oxygen conformers verses oxygen regulators - explanations on alternative responses.	1.6.1985
		5. Turnover rates and fluxes; their methods of determination and why they are such useful measurements.	5.6.1985
		6. Pollution complicating interacting effects.	6.6.1985
12.	Dr. Takeshi Watanabe	1. Evaluation of protein quality in fish and shrimp feeds.	2.12.1985

2.	Essential amino acid requirements of fish and shrimp.	3.12.1985
3.	Protein requirements of fish and shrimp.	3.12.1985
4.	Protein energy ratio of fish and shrimp feeds.	4.12.1985
5.	Protein sources for practical fish/shrimp feed formulation.	5.12.1985
6.	Lipid nutrition in fish and shrimp.	5.12.1985
7.	Lipid nutrition in fish and shrimp.	6.12.1985
8.	Importance of water soluble vitamins in shrimp and fish diets.	7.12.1985
9.	Mineral requirements of fish and shrimp with special reference to phosphorus.	9.12.1985
10.	Mineral requirements of fish/shrimp with special reference to availability of minerals in fish meal.	10.12.1985
11.	Bio-energetics-I Digestibility coefficient.	10.12.1985
12.	Bio-energetics-II Energy metabolism.	11.12.1985
13.	Negative aspects of dietary lipids.	11.12.1985
14.	Effects of fish on histamin compounds.	12.12.1985
15.	Ongoing research programmes on fish and shrimp nutrition.	13.12.1985

		16. Role of nutritional research in the advancement of aquaculture.	16.12.1985
		17. Prospects of using microparticulate compounded diets for the large-scale production of shrimp and fish.	17.12.1985
13.	Dr. Fred W. Wheaton	1. Selection of sites and site survey for aquaculture in the coastal zone.	17.2.1986
		2. Design and construction of ponds.	17.2.1986
		3. Design and construction of water control structures and water management techniques.	19.2.1986
		4. Design and construction of hatcheries.	19.2.1986
		5. Equipment for feed manufacture, mechanised feed dispencers, automatic and demand feeders.	20.2.1986
		6. Engineering aspects of culture in running water and recirculating systems.	20.2.1986
		7. Design and construction of cages, pens, raft and other structures for mariculture.	22.2.1986
14.	Dr. M. Fingerman	1. Evolution of neuroendocrine system in crustaceans.	10.6.1986
		2. Histomorphology of neurosecretory cells and their classification.	10.6.1986

3.	Environmental factors controlling hormone production.	12.6.1986
4.	Influence of photoperiod on moulting and reproduction in crustaceans.	12.6.1986
5.	Neuroendocrine control of growth in crustaceans.	13.6.1986
6.	Neuroendocrine control of osmoregulation in fishes and shellfishes.	13.6.1986
7.	Hormonal control of circadian rhythm in crustaceans.	17.6.1986
8.	Biosynthesis of crustacean hormones.	17.6.1986
9.	Neurotransmitters - their role in crustacean hormone release.	18.6.1986
10.	Hormonal control of metabolism in fishes and shellfishes.	18.6.1986
11.	Hormonal regulation of colour changes in crustaceans.	20.6.1986
12.	Induced maturation in crustaceans.	21.6.1986
13.	Isolation, purification and characterization of neurohormones.	30.6.1986
14.	Hormone assay-I Enzyme-linked immuno-sorbent assay, immunocytochemistry and radioimmunoassay.	30.6.1986

		15. Hormone assay-II. High pressure liquid chromatography, bioassay of hormonal fractions.	2.7.1986
		16. Neurosecretion in molluscs.	2.7.1986
15.	Dr. D.J.W. Moriarty	1. Interrelationship of major nutrients and micro-organisms in aquaculture ponds.	4.8.1986
		2. Variation in bacterial biomass and productivity in seagrass bed and in mangrove ecosystems.	14.8.1986

6.13. WORKSHOPS CONDUCTED

Sl. No.	Theme	Place	Dates	Organisers
I.	National Workshops Organised by Centre of Advanced Studies in Mariculture of CMFRI alone and jointly with Other Agencies.			
1.	Mussel Farming	Madras	25.9.1980 to 27.9.1980	CAS in Mariculture of C.M.F.R.I.
2.	Crustacean Biochemistry and Physiology	Madras	8.6.1981 to 20.6.1981	CAS in Mariculture of C.M.F.R.I. and Department of Zoology, University of Madras.
3.	Fish and Shellfish Nutrition	Cochin	11.1.1982 to 16.1.1982	CAS in Mariculture of C.M.F.R.I.
4.	Marine Invertebrate Reproduction	Madras	25.10.1982 to 10.11.1982	CAS in Mariculture of C.M.F.R.I. and Department of Zoology, University of Madras.
5.	Invertebrate Endocrinology	Cochin	18.10.1983 to 24.10.1983	CAS in Mariculture of C.M.F.R.I. and Department of Zoology, Marathwada University, Aurangabad.

II. Workshops Organised by Expert Consultants.

1.	Methodology and techniques of induced breeding of finfish.	Cochin	22.4.1981	Dr. Ching Ming Kuo
2.	Fish and shellfish Nutrition.	Cochin	11.1.1981 to 16.1.1982	*Dr. Akio Kanazawa
3.	Approaches of finfishes and shellfish pathology investigastions.	Cochin	10.2.1983 and 11.2.1983	Dr. Allen L.S. Munro
4.	Application of genetics in aquaculture.	Cochin	28.2.1983 and 1.3.1983	Dr. Victor John Bye
5.	Physiology and moulting in crustacea.	Cochin	24.6.1983 and 25.6.1983	Dr. Hubert J. Ceccaldi
6.	Culture of live feed organisms with special reference to Artemia.	Cochin	24.1.1984 and 25.1.1984	Dr. Patrick Sorgeloos
7.	Marine toxins.	Cochin	3.5.1984 to 5.5.1984	Dr. Sammy M. Ray
8.	Water quality management in mariculture.	Cochin	10.12.1984 to 13.12.1984	Dr. Claude E. Boyd

9.	Methods and design of experiments in environmental biochemistry and	Cochin	7.6.1985 and 8.6.1985	Dr. Peter W. Hochachka
10.	Nutritional quality of live food organisms and their enrichment.	Cochin	20.12.1985 and 21.12.1985	Dr. Takeshi Watanabe
11.	Hormone isolation and assay.	Cochin	25.6.1986 to 28.6.1986	Dr. M. Fingerman
12.	Techniques for estimation of bacterial growth rates and productivity in aquaculture pond system.	Cochin	5.8.1986 to 9.8.1986	Dr. D.J.W. Moriarty

Note:- * The workshop on fish and shellfish nutrition during 11 to 16 of January, 1982 was organised by the CAS in Mariculture of C.M.F.R.I. and Dr. Akio Kanazawa got himself asociated with it during its course.

6.14. SPECIAL LECTURES/TALKS

Sl. No.	Name and Address	Date		Subject
1.	Dr. C. Sommerville, Specialist on Parasitology, University of Stirling, U.K.	6.4.1981	1.	Research activities on fish pathology in the University of Stirling.
		7.4.1981	2.	Life cycles of fish parasites.
		8.4.1981	3.	Fish diseases in relation to fish farm management.
2.	Dr. M.H. Ravindranath, Department of Zoology, University of Madras Madras.	11.4.1981	1.	Diurnal variation in blood constituents of green lagoon crab Scylla serrata.
		11.4.1981	2.	Effects of starvation and injury on blood chemistry of Scylla serrata.
3.	Dr. K. Gopalakrishnan, Aquaculture Specialist, Department of Natural Science, Hawaii.	26.6.1981	1.	Aquaculture in Hawaii.
		29.6.1981	2.	Aquaculture technology programme.
		30.6.1981	3.	Ecology, development and pond management.
		30.12.1985	4.	Aquaculture in Hawaii.

4.	Mr. T.K. Sivadas, Scientist-in-Charge, Electronic and Instrumentation Division, C.I.F.T., Cochin.	30.11.1981	1.	Recent advances in marine instrumentation.
5.	Dr. A.K. Mondal, Scientist, Central Inland Fisheries Research Institute, Barrackpore.	18.1.1982	1.	Frog culture.
6.	Mr. P.A. Ramachandran, Regional Environmental Engineer, Water Poilution Control Board, Calicut.	27.1.1982	1.	Hazardous waste management and stream sampling.
7.	Dr. K.V.K. Nair, Scientific Officer, Bhabha Atomic Research Centre, Health Physics Division, Environmental Survey Laboratory, Kalpakkam, Madras.	3.9.1982	1.	Impact of nuclear power on the environment.

8.	Dr. K.J. Juancey, Institute of Aquaculture University of Stirling, U.K.	18.11.1982	1.	Techniques in fish nutrition and their application to crustacea and other invertebrates.
9.	Prof. P. Kuchukutta Menon, Rtd. Professor of Zoology, Presidency College, Madras.	6.1.1983	1.	Life in molecular terms.
10.	Dr. C.W. Powell, Expert Consultant, Indian Institute of Horticultural Research, Bangalore.	24.1.1983	1.	Fisheries in New Zealand.
11.	Dr. C.A. Reddy, FAO/UNDP Consultant.	29.10.1983	1.	Nitrogen fixation.
12	Dr. M.A. Ali, Professor, University of Montreal, Canada.	24.1.1983	1.	Vision in fish.
13.	Dr. M.M. Hanumante, Research Specialist, Department of Biology, Tulane University, New Orleans, U.S.A.	20.2.1983	1.	Neuroendocrinology.

14.	Dr. J.P. Flash, Head, Molluscan Cultivation Group, Centre Oceanologique de Bretagne, COB., CNEXO., Brest, France.	11.11.1983	1.	Molluscan aquaculture in France.
15.	Prof. R. Nagabhushanam, Head, Dept of Zoology, Marathwada University, Aurangabad.	30.3.1983	1. 2.	Invertebrate endocrinology. -do-
16.	Dr. B.L. Bayne, Joint Director, National Environmental Research Council, Plymouth, U.K.	19.11.1983	1.	Mussel culture.
17.	Prof. Wallis H. Clarke, Jr., Director, Aquaculture Programme, University of California, Davis, Californmia, U.S.A.	31.1.1984	1.	Crustacean reproduction.
18.	Dr. Gerald J. Bakus, Associate Professor, Biology, Univ. of South California, California.	31.1.1984	1.	A multidisciplinary marine fisheries management for developing countries with comments on the Indian Ocean.

19.	Dr. K. Renga Rao, Professor of Biology, Univ. of West Florida, U.S.A.	7.2.1984	1.	Endocrine regulation of crustacean pigmentary effectors.
		7.2.1984	2.	Physiology and histopathological evaluation of pollutant toxicity.
20.	Dr. D. Desaiah, Associate Professor, Department of Neurology, Univ. of Mississippi Medical Centre, U.S.A.	10.2.1984	1.	Neurotoxicity studies on marine organisms.
21.	Dr. Daniel E. Morse, Professor of Genetics and Biochemistry, Marine Science Institute, University of California, California 93106, U.S.A.	17.2.1984	1.	Biochemical control of molluscan reproduction and metamorphosis.
22.	Dr. Aileen Morse, Marine Science Institute, University of California, California 93106, U.S.A.	17.2.1984	1.	Purification and characterisation of biochemicals from red algae that control larval metamorphosis.
23.	Dr. Martha Vannucci, Chief Technical Advisor, UNDP/UNESCO Regional Project on Mangrove Ecosystem, New Delhi.	21.4.1984	1.	Mangrove ecosystem.

24.	Dr. Mary T. Dimond, Prof. Emeritus of Biology, Trinity College, Wasgington DC., U.S.A.	29.5.1984	1.	Temperate zone turtles.
		29.5.1984	2.	Particular problems of sea turtles.
25.	Dr. Albert G.J. Tacon, Fish Feed Technologist, Aquaculture Department and Coordination Programme, Fisheries Department, FAO., UN.	27.2.1985	1.	Nutritional aspects of fishes and shellfishes.
26.	Dr. Peter W. Hochachka, Professor, Department of Zoology, Univ. of British Columbia. Vancouver, Canada.	3.6.1985	1.	Best **defence** strategies against stress combinations,
		4.6.1985	2	Animal activity as dominant determinant of energy turnover: Why the right feeds are used at right times and the right rates.
		5.6.1985	3.	An alternative way of dealing with chronic hypoxia: Sustain high flux aerobic function despite reduced oxygen availability.
27.	Dr. T. Subramoniam, Reader in Zoology, University of Madras, Madras.	26.7.1982	1.	Gametogenesis.
		27.7.1982	2.	Sperm morphology and sperm transfer mechanism.
		28.7.1982	3.	Hormonal control of reproduction.
		29.7.1982	4.	Reproductive ecology.

30.7.1982	5.	Genetic activation and interaction.
30.9.1985	6.	Vitellogenesis and controlling mechanism.
1.10.1985	7.	Spermatophores and sperm tranfer mechanism.
3.10.1985	8.	Crustacean egg production and development.

6.15. EQUIPMENTS

Sl. No.	Items	Value US $
1.	Spectronic 2100 Clinical Analyser.	5,295.24
2.	Xerox 3107 Reduction Copier.	13,047.00
3.	A.O. Salinity Refractometer.	3,093.00
4.	Buchi-Rotavapor-R.110.	1,275.00
5.	Tecator Fibretec-System.	30,350.00
6	Tecator Soxtec System.	
7.	Tecator Kjeltec System.	9,180.00
8.	Tecator DS.40 Digestive System.	
9.	Jurgens Continuous Flow Centrifuge.	4,250.00
10.	LKB-4400 Amino Acid Analyser.	61,370.00
11.	Spares for Amino Acid Analyser.	5,021.00
12.	Hewlet Packard-Gas Chromatograph.	22,600.00
13.	Spares for Gas Chromatograph.	3,800.00
14.	Gonotec Osmometer.	2,600.00
15.	U.V. Products. Inc. U.V. Lamp.	339.82
16.	Sorval RC-5 B Centrifuge.	28,895.00
17.	Cuno Centrifuge Filters.	2,000.00
18.	Olympus Vanox Research Microscope.	10,813.00
19.	Pharmacia Column Chromatography System.	17,310.00
20	Spares for Pharmacia System.	4,840.00
21.	Mettler Electronic Balance.	17,060.00
22.	Spares for M3 Mettler Balance.	1,100.00
23.	Waring Blender.	1,763.00
24.	Salinity Meter SCT.	
25.	A.O. Cryostat Microtome.	8,542.00
26.	Philipson Micro Bomb Calorimeter.	2,507.00

27.	Chemlab SB-5 Freeze Drier.	6,000.00
28.	A.O. Phase Star Microscope.	5,200.00
29.	Hitachi-H. 600 Electron Microscope.	118,000.00
30.	Accessories to Electron Microscope.	18,000.00
31.	L.K.B. Ultra Microtome.	20,000.00
32.	Polarographic Analyser.	26,939.00
33.	Sartorias Microbalance.	5,849.00
34.	Potentiometric Recorder.	4,100.00
	Total	461,140.06

6.16. HIGHLIGHTS OF RESEARCH

6.16.1. Prawn Seed Transportation.

JRF: K. Krishna Kumar
ST: N.N. Pillai

The optimum density of seeds of Penaeus indicus which could be transported in a unit volume of water in closed system for different duration of time was studied and the environmental factors contributing to mass mortality in transportation investigated.

With water to oxygen ratio at 1:1 and bottom areas of container to volume of water inside at 1:6.7, 250 seeds of 14 to 18 mm size per litre could be transported for 24 hours with 70% survival; for 48 hours transportation the density per litre should be 100. For larvae of 8 to 12 mm size, 70% survival during 24 and 36 hours of transportation would be maintained when the density of seed per litre is 300 and 150 numbers respectively. At a density of 150 seeds per litre 70% survival was obtained with 13-15 mm size for 48 hours.

Transportation of 8 to 12 mm size for more than 36 hours is not advisable. Survival rate of small sized seeds was relatively low especially for longer periods of transportation mainly due to cannibalism. When pH of the medium fell below 6.6 and ammonia level exceeded 70-80 ppm, mortality was high. With 1:1 ratio of oxygen to water, depletion of oxygen was not found to be the main cause of mortality.

6.16.2. Studies on Benthos in Prawn Culture Fields of Vypeen Islands, Cochin, Kerala.

JRF: R. Srinivasan
ST: P. Vedavyasa Rao

The macrofaunal constituents of benthos in certain prawn culture fields of Vypeen along with important hydrological and sedimentological parameters which influence them were studied in ecosystems like perennial culture system, canals in coconut groves and seasonal culture fields. From mud samples collected fortnightly, wet weight, dry weight and density of macrobenthos were estimated. From bottom water samples temperature, salinity, dissolved oxygen, nitrate, nitrite, turbidity and pH were measured. From sediment samples organic carbon, Eh and grain size were analysed.

Different ranges of values were observed in the hydrological and sediment characteristics between ecosystems. Seasonal variations in polychaetes, nematodes and tanaidaecids, amphipods and bivalves were recorded in the three ecosystems. Relation between environmental parameters like temperature, pH of mud and water, and nitrate is not statistically significant (at 5% level) with the benthic biomass. Salinity and organic carbon had a positive correlation at 1% level. The redox potential and nitrite, however, showed negative correlation with biomass at 5% level of significance.

Main factors which limit the abundance and distribution of benthic fauna, according to multiple analysis assessed by standard partial regression coefficient, are salinity followed by organic carbon, redox potential and nitrite-nitrogen in the perennial fields and in one canal in the coconut grove. In another canal, redox-potential acted as the main limiting factor. In the 'pokkali' (seasonal) fields, however, nitrite was the principal limiting factor followed by organic carbon, salinity and redox-potential.

6.16.3. Metabolic and Excretory Rates of the Prawn Penaeus indicus H. Milne Edwards fed on Different Types of Natural and Artificial Feeds.

JRF: K. Udayakumara
ST: A.G. Ponniah

Metabolic, excretory and growth rates in juvenile P. indicus (30-60 mm) were studied in relation to a natural diet (muscle of P. indicus and 3 pelleted feeds of varying protein contents (20, 40 and 70%). Studies were conducted on starved and fed animals.

The metabolic rate in starved prawn (ml O_2/animal/hr) was logarithmically linear to body weight with a value of 0.613, but the 'fed rates' were invariably higher than the 'starved rates'. The specific dynamic action (SDA) was influenced by starved metabolic rate, prior feeding level, wet body weight and considerably by the protein fed during the experiment. The fed excretion rate was primarly a function of starved excretory rate followed by protein consumed during the experiment. The diets significantly affected growth. When fed ad libitum on pelleted diets the optimum protein level was 40% and under restricted rations there was a positive linear increase in growth with increasing protein content. Among the parameters influencing growth rate, the initial body weight had great influence followed by the amount of protein consumed, fed excretion rate of ammonia and SDA. Also the present study reveals that the growth rate is negatively influenced by routine metabolism and SDA and positively by percentage of protein in diet.

6.16.4. Comparative Studies on Protein, Carbohydrates and Fat Contents in Penaeus indicus during Ovarian Maturation in Nature and Induced Maturation Experiments.

JRF: P.K. Asokan
ST: M.J. George

To understand the reproductive physiology of Penaeus indicus, biochemical changes taking place during reproductive cycle in the ovary, hepatopancreas and muscle were monitored through estimates of proteins, non-protein nitrogen, total free amino acids, oligosaccharides, polysaccharides and total lipids.

Unilateral eyestalk ablation caused an increase in the gonado-somatic index. As ovary develops and vitellogenesis sets in, the organic reserves are also built up by the gradual accumulation of protein, non-protein nitrogen, lipids, free amino acids and carbohydrates. As protein and lipid are the major energy rich compounds of yolk, large quantities were accumulated in the ovary. Organic reserves in hepatopancreas show a decline probably due to mobilization of the reserves, especially lipids, towards the development of ovary as gonadial maturity sets in. Compared to ovary and hepatopancreas the muscle of prawn is characterised by high content of proteins and low levels of lipids which are relatively stable.

6.16.5. Studies on Soils of Some Brackishwater Prawn Culture Fields Around Cochin.

JRF: P. Easwara Prasad
ST: V.K. Pillai

Fertility status of soil in three different ecosystems such as a seasonal field, two perennial fields (commercial and experimental), and brackishwater canals in coconut groves, where prawns are cultured, were investigated. Data were collected on organic carbon, exchangeable calcium, sodium and potassium. Grain size analysis was also carried out on representative samples. Other than the soil samples, water samples were also collected and analysed for temperature, pH, salinity and dissolved oxygen.

The seasonal field where paddy and prawns are cultured, showed the highest fertility status with the commercial perennial field coming next, followed by the canal system in the coconut groves. Fertility was least in the perennial field. The grain size composition of the soil had an important bearing on the fertility status of the soil; and greater fertility coincided with the predominance of clay and silt in soil composition. Core samples taken from surface and subsurface layers of the soil showed clear indication of stratification of the organic carbon, calcium, sodium and potassium. In relation to the fertility of brackishwater and freshwater fish pond soils in other parts of India, the four ecosystems studied showed comparable or greater fertility status.

6.16.6. Studies on the Effect of Ammonia, Nitrate and Nitrite on the Larvae of Penaeus indicus.

JRF: P. Jayasankar
ST: M.S. Muthu

Laboratory experiments to study chronic and acute toxicity of ammonia, nitrite and nitrate to the prawn larvae were conducted. Nitrate was toxic to the larvae, only in very high concentrations which are not ecologically significant. The tolerance to ammonia and nitrite was the least in nauplius stage and the former was nearly 3 times more toxic than nitrite at this stage. Tolerance to ammonia and nitrite increased progressively as the larvae metamorphosed into protozoea and mysis stages. However, nitrite turned out to be more toxic than ammonia in the late protozoea and mysis stages.

Larvae from the wild spawners were more sensitive to nitrite and ammonia than the larvae from eye-ablated spawners. In the former case, the survival of the larvae was poorer and their rate of development slower, and more deformed nauplii were observed in the toxicity experiments.

The incipient LC50 values were 11.99 ppm of ammonia-N and 3.29 ppm of NO_2-N. The EC50 values were 3.23 ppm of ammonia-N and 1.9 ppm of NO_2-N. Based on these experiments the safe levels of ammonia and nitrite for rearing the larvae of Penaeus indicus were estimated as 0.32 ppm ammonia-N (0.025 ppm NH_3-N at pH 8.1) and 0.18 ppm NO_2-N.

6.16.7. Salinity Tolerance of Postlarvae of Penaeus indicus H. Milne Edwards.

JRF: K.P. Lakshmikantham
ST: C. Suseelan

Optimum salinity ranges, relative survival rates at various levels of salinity, lethal salinity levels and effect of salinity acclimation on different size groups of the postlarvae were worked out.

On sudden exposure from a preacclimation salinity of 20 ppt, the range of tolerance observed was 4-40 ppt for 8-9 mm size, 3-49 ppt for 13-15 mm size and 2-50 ppt for 18-19 mm size groups, with optimum at 10-25 ppt, 5-35 ppt and 5-40 ppt respectively. The lower and upper limits increased as the postlarvae increased in size.

Lower lethal level of salinity was 3 ppt for 8-9 mm size, 2 ppt for 13-15 mm size and 1 ppt for 18-19 mm size. At upper level 50 ppt salinity was lethal to 13-15 mm size. In salinity acclimation experiments, 13-15 mm postlarvae yield 81.7% survival in the observed lethal salinity at the end of 120 hours of exposure. When 18-19 mm postlarvae were subjected to salinities of decreasing and increasing strengths over a range of 0-95 ppt more than 50% survival was recorded at a minimum salinity of 0.33 ppt and a maximum of 85 ppt at the end of 24 hours of exposure, indicating the possibility of a wide tolerance range between these levels.

6.16.8. Nutritional Requirements of Postlarvae of the Prawn Penaeus indicus.

JRF: T.I. Charles John Bhaskar
ST: Syed Ahamed Ali

Studies were carried out on the postlarvae of Penaeus indicus to determine the protein requirement using six purified diets (Protein content in them increasing by tens from 20 to 70%) and on the possibility of rearing them using six semi-purified diets (with protein content of 20, 32, 42, 51, 61 and 71%). These diets were tested in postlarval stages 1 to 41. A control group was fed on rotifers and cladocerans.

The protein requirement in diets for postlarvae decreased with the increase in their size. The postlarval stage from 1 to 10 were found to require 40% protein in the diet in combination with 35-40% carbohydrates and 12% lipid. Postlarval stages from 1 to 42 required 30% protein in the diet in combination with 35-40% carbohydrate and 10% lipid. Postlarvae could be successfully reared using compounded feeds up to stocking size, and the growth and survival obtained by the compounded feed were superior to that of the control group fed on rotifer and cladocerans.

6.16.9. Oxygen Requirement of Prawn Larvae in the Hatchery System.

JRF: Pramila Rajan
ST: K.H. Mohamed

The oxygen consumption and respiratory rate in nauplius, protozoea and mysis stages of Penaeus indicus was determined and found to be 0.0533 µl/hr, 0.1361 µl/hr and 0.2969 µl/hr respectively. The respiratory rate in them respectively was 4.4375 µl/mg/hr, 3.3191 µl/mg/hr and 2.8011 µl/mg/hr. The oxygen consumption increased with increase in size and progress in developmental stages of the larvae. The respiratory rate declined with increase in body weight of the individual. The increase in oxygen uptake in each stage is of the order of 2.55 times from nauplius to protozoea and 2.18 times from protozoea to mysis. The hourly variation of oxygen uptake was insignificant in all the 3 stages during the 12 hours of experimentation. There was significant difference in the rate of oxygen uptake between the stages. In hatchery system high concentrations of phytoplankton though forming food of the larval stages can cause their mass mortality due to oxygen depletion at night owing to cessation of photosynthesis.

6.16.10. Studies on the Diurnal Variation of Certain E[illegible] al Parameters in Culture Pond.

JF Ravi
V.K.

Diurnal variations in temperature, oxyge[illegible], [illegible], salini nitrite, nitrate, phosphate and ammonia in the brac[illegible]shwater cul[illegible] ecosystems near Cochin were studied by sampling two ponds an[illegible] feeder canal.

Tidal effect in Cochin backwater is semi-diurnal. The evening high water was slightly higher than the morning hig[illegible]ater an[illegible] its influence on the environmental parameters were negl[illegible]ble. Diur[illegible] variations of temperature, pH, Eh and dissolved oxygen of water during premonsoon periods with time (hour intervals) were regular, significant and marked. Bottom values coincided with the surface readings i[illegible] the case of temperature, pH, Eh and oxygen throug[illegible]out the period. The relationship between the atmospheric and bottom water temperature was positive. In most of the hours, the surface concentration exceeded that of the bottom water whereas in the late night hours the phenomenon reversed in the case of temperature, pH, Eh and oxygen during the sampling period. Temperature was maximum at 16.00 hrs and minimum at 4.00 hrs. throughout the period in the ponds and canal. pH and Eh were maximum at 16.00 to 18.00 hrs and minimum at 6.00 and 8.00 hrs. Changes in salinity gradients were high and fluctuating with the time and depth. The difference between premonsoon and monsoon seasons was marked. The concentrations of the nutrients, including ammonia, neither followed any definite pattern nor showed any correlatio[illegible]ith time and tide at any depth. Th[illegible] nutrient concentrations [illegible]he [illegible]ter were not directly related to the physical parameters studie[illegible] environmental parameters in the pond ecosystem showed a complex p[illegible]rn of diurnal fluctuations.

6.16.11. Food Availability and Selectivity in Prawn Culture Ponds.

JRF: T. Rajagopalan
ST: M.J. George

An attempt to study the selectivity of food organisms by prawns in natural culture environments was made. The food of prawns in relation to availability in the culture areas were analysed and inferences drawn.

In Penaeus indicus, crustaceans formed the major food constituent. In Metapenaeus dobsoni and M. monoceros, detritus and vegetable matter (including filamentous algae and angiosperm tissues) respectively were the most important components. Among the 3 species, competition for food was not likely. Though the stomach contents showed dominance of certain food items, it was not indicative of definite selectivity and availability of food in the environment determined the dominance. Statistical analysis of food selectivity in P. indicus and M. monoceros did not suggest that these species were selective with regard to the choice of their food items.

6.16.12. Oxygen Consumption and Ammonia Excretion of Penaeus indicus H. Milne Edwards in Different Salinities.

JRF: T.N. Unnikrishnan
ST: A. Laxminarayana

Metabolic, excretory and behavioural response of adult Penaeus indicus (130-138 mm in length) were studied as a function of different salinities. Rate of oxygen consumption increased with decrease in salinity and it was the highest in 2.1‰ and lowest in 25-5‰. The rate of ammonia excretion also increased with decrease in salinity as it was the highest in 2.1‰ and lowest in 25.5‰. The ammonia quotient also exhibited similar trend. Random activity also was highest in 2.1‰ and lowest in 34‰.

P. indicus spent least energy in 25.5‰ and maximum in 2.1‰ salinity. The minimum rate of ammonia excretion in 25.5‰ also indicated relatively lesser utilisation of protein. Relative protein degradation was also minimum at 25.5‰ and maximum at 2.1‰ salinity. P. indicus thus spends more energy for activity in lower salinity.

6.16.13. Food Value of Rotifer, Brine Shrimp and Moina to Postlarvae of Penaeus indicus H. Milne Edwards Reared in the Laboratory.

JRF: Udaya Ram Jothy
ST: D.C.V. Easterson

Moina sp., rotifer, Artemia nauplii and decapsulated cysts of brine shrimp were tested to determine their suitability as live feed for postlarval stages (1 to 50) of Penaeus indicus. Percentage survival, increase in length and weight were determined in the experiments and proximate composition of feeds was also estimated.

Although all the postlarval groups fed with live feed gave comparable results in terms of survival, none showed better growth than those fed with decapsulated Artemia cyst. All the live feed used had optimal protein and carbohydrate ratio. While the protein and carbohydrate were above optimal level, the lipid content was found to be the key limiting factor in enhancing the growth rate of prawn postlarvae.

6.16.14. Studies on the use of Growth Promoting Agents in the Diets of Penaeus indicus H. Milne Edwards.

JRF: S. Vaitheeswaran
ST: Syed Ahamed Ali

Substances like oxytetracycline (antibiotic), orabolin, testosterone and thyroid (hormones), glucosamine, chitin and alfalfa extract were tested at various levels to determine their potential as growth promoting agents in the diets of juveniles of Penaeus indicus and to fix the optimum dosage of these chemical substances.

Testosterone, glucosamine, chitin and alfalfa extract when supplemented in the diet at 5 mg, 0.98g, 1.5g and 1.5ml/100 g respectively enhanced growth and improved food conversion ratio and hence considered as growth promoters. Testosterone and chitin were found to have a **synergistic** effect as growth promoters when used in combination at 5 mg and 1.5 g/100g respectively. Only tetracycline, orabolin and thyroid failed to enhance growth in the experiments conducted.

6.16.15. Effect of Salinity on Food Intake, Growth, Conversion Efficiency and Proximate Composition of Juvenile Penaeus indicus H. Milne Edwards.

JRF: M. Kalyanaraman
ST: R. Paul Raj

Nutritional studies were carried out to determine the effect of salinity (5-35‰) on 2 size groups (13-14 mm and 26-32 mm) of P. indicus. The effect of hyper salinity 40-60‰ on food intake and interaction between salinity and varying feeding levels (10, 20 and 30% of body weight) were also estimated.

Salinity had profound influence on the food consumption, growth, conversion efficiency and proximate composition of the tissues of the P. indicus. The small size group required an optimum salinity of about 25‰ and the larger size group about 20‰. The intake was independent of the quality of food supplied but was dependent on the salinity of the media. The minimum growth at 5‰ in both size groups might be related to lower metabolic rate at that salinity and least food intake. At the extreme levels of salinity listed (5 and 35‰), the ammonia excretion was high indicating increased catabolism of amino acids. It appears that considerable amount of energy derived from ingested food was spent in excretion rather than tissue building.

6.16.16. Endocrine Control of Osmoregulation in the Prawn Penaeus indicus H. Milne Edwards.

JRF: Kiron Viswanath
ST: A.D. Diwan

In order to understand the origin of endocrine factor and their control/role on osmoregulation in Penaeus indicus, the effects of eyestalk ablation on sodium, potassium and chloride levels in haemolymph and on ammonia excretion were studied.

The sodium, chloride and potassium ions in the haemolymph and the ammonia excretion rate increased with unilateral eye stalk ablation and was further enhanced by bilateral ablation. In the destalked animals injected with eye stalk extract, the levels decreased and approached normal values. The regulatory pattern exhibited by the experimental animals indicated that the eyestalk contains factors affecting ionic balance.

6.16.17. Ecology of Meiobenthos in Selected Culture Fields Around Cochin.

JRF: V.S. Sugunan
ST: P.P. Pillai

Studies were carried out on the ecology of meiobenthos in 3 types of prawn fields around Cochin viz. a temporary field, a canal in the coconutgrove and a permanent pond. Sediment core samples (1 x 4 cm) and overlying water were collected. The water sample was analysed for dissolved oxygen, salinity, turbidity, pH and Eh. From the sediment sample particle size, mean diameter, available phosphorus, chlorophyll 'a' and meiobenthic faunistic composition were studied.

Temporal and spatial variation in the above parameters were observed in the 3 types of fields between February and August.

The results of statistical analysis showed that salinity followed by dissolved oxygen influence the abundance and distribution of meiofauna in the canals of the coconutgrove. In the permanent pond, available phosphorus followed by temperature acted as the controlling factors. It was also noted that the available phosphorus and temperature of the medium might influence the meiofauna independent of other environmental parameters studied.

6.16.18. Serum Cholesterol, Protein and Glucose Content in Etroplus suratensis (Bloch).

JRF: Mary Varghese
ST: A.G. Ponniah

Biochemical parameters like cholesterol, glucose, free amino-acids and lipid were estimated in the serum, muscle and liver of adult Etroplus suratensis to determine their normal ranges, variations due to environmental parameters and starvation. The monthly variation in most of the biochemical parameters were not statistically significant probably due to the short period for which the study was carried out. Statistically significant decrease in all the estimated biochemical parameters was observed with increasing periods of starvation. The positive correlation between the biochemical parameters within a tissue and between tissues indicated that depletion due to starvation was uniform in all tissues and not tissue specific. The minimum values of lipid and protein during June and July would be attributed to the second spawning season of E. suratensis.

6.16.19. Mobilisation of some of the Metabolite Reserves during Moult Cycle in the Prawn Penaeus indicus H. Milne Edwards.

JRF: T. Usha
ST: A.D. Diwan

Biochemical studies were carried out in different tissues of P. indicus as a function of different moult stages. The ranges of lipid, cholesterol, protein, glycogen and water content were estimated in the muscle, hepatopancreas and haemolymph.

The maximum value for the organic reserves in the muscle, hepatopancreas and haemolymph occurred in early premoult stage indicating marked storage. In the following late premoult stage it reduced probably as it got utilised. The minimum values occurred in early postmoult stage indicating depletion in the reserves just after moulting. High percentage of water content was observed in the muscle during early postmoult stage and low percentage in early premoult stage in contrast to the pattern observed for the organic reserves, clearly indicating replacement of water by organic reserves during intermoult stages.

6.16.20. Comparative Karyological Studies on Prawns Penaeus indicus H. Milne Edwards and Penaeus monodon Fabricius.

JRF: Jeeju George
ST: A.G. Ponniah

To understand the basic genetic make-up of culturable species of prawn, karyological investigations were carried out on juveniles (50-90 mm) of Penaeus indicus, P. monodon, Metapenaeus monoceros and M. dobsoni and their diploid chromosome numbers determined. The squash method of studying karyotype was standardized with respect to prawns; 50 to 100 metaphase spreads were counted and the mode established and the diploid number fixed. The diploid chromosome number of P. indicus, P. monodon and M. monoceros were 66, 84 and 92 respectively. The modal diploid number for M. dobsoni was found to be betweeen 80 and 86. The difference in chromosome number between P. indicus and P. monodon indicated that the chance of a fertile hybrid betwen these species is less.

6.16.21. Studies on the Pituitary Gland of Selected Culturable Finfishes.

JRF: Asha Narayan
ST: K.C. George

The morphological details of the pituitary gland of three economically important mullets, namely Valamugil cunnesius, Liza parsia and Mugil cephalus and the catfish Tachysurus maculatus were studied. Specimens used were immature and in Ist or IInd stage of maturity. The gross morphology of the dissected pituitary gland was drawn and transverse sections were stained using different procedures to determine the different cell types.

Morphologically the pituitary in the 4 species of fish studied were leptobasic type in their general pattern of position and dorsobasic with regard to the point of entry of pituitary stalk into the brain.

Histologically also a common pattern was observed in the 4 species. The prolactin and TSH cells were observed in the rostral pars distalis and the ACTH cells in the interphase between the neurohypophysis and the rostral pars distalis. The STH cells and gonadotrops were observed in the proximal pars distalis and the MSH cells in the pars intermedia. The neurohypophysis was found to be composed of the neurosecretory nerve fibres arising in the preoptic nucleus and pituicytes were also observed.

6.16.22. Carbon Dioxide Equilibria and Nutrient Availability in Culture Ecosystem.

JRF: Annie Mathew
ST: C.P. Ramamirtham

Hydrological parameters such as salinity, free carbon dioxide, dissolved oxygen, pH, water temperature, phosphate, nitrate and nitrite in two prawn culture ponds near Cochin were studied during peak monsoon and early postmonsoon (June-September) period. The salinity values were uniformly low in both the ponds during the period. Intermittent, low and nigh temperature values were observed, which mainly depended on the monsoon precipitation. Supersaturation with respect to dissolved oxygen was observed in both the ponds and these high oxygen values corresponded to low carbon dioxide contents. The time of observation during day time was significant, especially with respect to carbon dioxide and dissolved oxygen contents. The pH values showed a general decrease with time, although intermittent high values were also observed. The bicarbonate alkalinity was found to be high during the peak monsoon season. However, the overall alkalinity of the pond waters was low during the peak monsoon. The nutrient availability in the ponds did not show a definite pattern. Nitrite content showed an inverse relationship with that of nitrate. The carbon dioxide equilibria were mostly dependent on water temperature, pH and time of observation and very little correlation was observed with the biological cycle of nutrients. Studies on diurnal variation in the ponds also, more or less confirmed the relationship between carbon dioxide content, dissolved oxygen, and pH especially in the observations at night.

6.16.23. Effect of Hydrogen Sulphide on Juvenile of P. indicus.

JRF: G. Gopakumar
ST: M.S. Muthu

Twenty-four hour LC_{50} experiments were conducted on H_2S toxicity to juveniles of P. indicus in flow-through apparatus at pH 8.1 - 8.3, temperature 28.0°C - 28.5°C and salinity 33 ppt. Lethal concentration of H_2S (LC_{50}) for 20-25 mm size group was 7.22 ppm, for 40-45 mm size group 6.44 ppm and for 80-85 mm group 3.35 ppm. The 24-h LC_{50} H_2S level for 40-45 mm juveniles declined with decrease in pH. It was 6.83 ppm at pH 8.9 - 9.3; 6.44 ppm at pH 8.1 - 8.3; 3.1 ppm at pH 6.9 - 7.3 and 0.47 ppm at pH 5.9 - 6.3. The experimental animals exposed to H_2S for 24 hours suffered an average loss of weight 7.3% at 30 ppt salinity and 2.5% at 15 ppt salinity. In aquarium experiments, P. indicus juveniles of 80-85 mm size avoided resting or burying in pond soil rich in total sulphides. Further, a filamentous sulphur bacterium was found to grow on the gills and pleopod setae of the prawns exposed to H_2S.

6.16.24. Studies on Sulphur Bacteria in the Prawn Culture Ecosystem.

JRF: S. Alaguravi
ST: V. Chandrika

Studies on short-term variations in sulphate reducers with respect to heterotrophic populations and physicochemical parameters were carried out from 2 prawn culture ecosystems (one perennial and a seasonal field) near Cochin from June to September 1984 to find out the factors responsible for the quantitative variations in hydrogen sulphide production in the culture ecosystem.

Multiple regression analysis of the counts obtained showed that in both the ecosystems salinity, sediment Eh and total heterotroph to have significant correlation with sulphate reducers. Standard partial regression analysis of the sulphate reducers in the perennial pond showed correlation with environmental parameters such as Eh of sediment, salinity and total bacterial counts in sediments and water. In seasonal field also there was significant correlation between sulphate reducers and total heterotrophs in water and sediment, sediment Eh and salinity.

Biochemical tests revealed that the species involved in the process of sulphate reduction in both perennial and seasonal fields were Desulphovibrios desulfuricans and Desulphovibrios aesticarii.

6.16.25. Influence of Hypoxia on Metabolism and Activity of Penaeus indicus.

JRF: V. Kripa
ST: A. Laxminarayana

The oxygen consumption and randon activity of P. indicus decreased with increasing body size (40-140 mm) at temperature 28, 32, and 36^{o}C. The rate of ammonia excretion increased with increasing body weight. The ammonia quotient (AQ) values also increased with increase in body weight indicating relatively enhanced protein utilisation in larger prawns. However, the rate of oxygen consumption, ammonia excretion and random activity increased with increase in temperature, while the AQ values showed a reverse trend suggesting less utilisation of protein in higher temperature. P. indicus is found to be an oxyconformer. The asphyxial level of the prawns was influenced by body size and temperature, the level being lower in smaller prawns and higher with increase in temperature.

6.16.26. Effect of Particle Size in the Compounded Diets on the Pellet Stability and Food Conversion Efficiency in Penaeus indicus.

JRF: K. Rani
ST: Syed Ahamed Ali

A purified diet and a practical feed were prepared with ingredients containing particle size of 50, 100, 212, 250, 300, 400 and 500 microns. The prepared pellet diets were immersed in water at different time intervals to study the stability of nutrients such as proteins, lipid, carbohydrate and ash. Results revealed that the leaching of nutrients from feeds decreased with decrease in particle size upto 212 microns but further decrease in particle size resulted in increased loss of nutrients. The highest growth and the best food conversion ratio were obtained with the diets containing particle size of 212 microns. Digestibility also improved with decrease in particle size up to 212 microns. There was continuous loss of the nutrients with time in both sets of foods; highest loss occurred in carbohydrate but the lowest in lipid. A comparison of nutrients leaching from the pellets with and without aeration in the water showed that the nutrient loss was 20% higher with aeration.

6.16.27. Effect of Certain Environmental Factors on Developing Eggs and Early Larvae of the Mullet Liza parsia (Hamilton Buchanan).

JRF: R. Sankara Pillai
ST: L. Krishnan

Influence of salinity, pH and light on developing embryos and early larvae of L. parsia spawned in the laboratory was studied. Viable eggs fertilized in normal seawater and transferred to the test salinity ranges 0-51 ppt showed hatching success increasing with increase in salinity to an optimum of 26.63 ppt and then decreasing with further salinity increase. Extremes of salinity caused mortality of developing stages and abnormalities of the larvae. Survival of larvae further reared in the same test ranges and freshly hatched larvae transferred afresh in the test ranges for a period of 72 hours, was in the ranges 6 - 39 and 3 - 39 ppt, respectively.

When eggs fertilized in seawater of pH 8.15 were transferred to pH test ranges 5 - 10, hatching was observed in 5 - 9. Here again the extreme pH ranges caused maximum mortality to developing eggs. So also hatching success increased with an increase in pH to an optimum of 7.5 and then decreased with further increase. Optimal survival of these larvae further reared in the test ranges, and larvae freshly hatched and transferred afresh in test ranges of pH studied, was observed in pH 7.8 and 7.03 respectively.

When viable eggs were exposed to different light intensities from 0 to 1700 Lux and normal sunlight, in spite of hatching taking place in all, optimal hatching was observed in 109 Lux. Direct sunlight proved to be harmful for larval survival. Light intensities of 0 - 500 Lux alone gave 72 hour survival of newly hatched larvae.

6.16.28. Studies on the Effects of Temperature and pH on the Post-larvae of Penaeus indicus.

JRF: P.T. Sarada
ST: V.K. Pillai

The objective of the study was to examine the effect and tolerance limits of temperature and pH on P. indicus postlarvae under simulated conditions in the laboratory. This study was aimed also at determining the LC-50 and LD-50 values of pH and temperature respectively. Short-term (4 days) experiment to study acute toxicity and long-term (15 days) ones to know the effect of temperature on growth of postlarvae were conducted. Postlarval stages 1 to 25 were used in test solutions with different pH and temperature ranges and a control 26 to 28°C.

In general, the pH between 6 and 9 was not directly lethal to the postlarvae. The low pH values between 6 and 7 although not lethal, had an indirect effect on growth, metabolic rate, swimming activities, etc. The pH values below 6 and above 9 increased the mortality rate rapidly. In pH 3 and pH 10 complete mortality was recorded within 45 minutes. Chromatophores on the cuticle were concentrated on the larvae reared in acidic waters, and it was in expanded condition in high pH ranges. The postlarvae survived even after 96 hours of exposure in low pH but were unhealthy showing retarded growth. In pH 10, the swimming activity was very slow and the pleopods of the dead animals were not free as the larvae were subjected to low pH.

Results of temperature experiment indicated that extremes were lethal to the postlarvae and the rate of mortality at different temperatures were directly proportional to the period of exposure and inversely proportional to age. The optimum temperature for postlarvae was between 30°C to 32°C. The LD-50 values of postlarvae No. 1 to 25 were 32.27°C to 38.51°C.

6.16.29. Colonization of the Mangrove Acanthus ilicifolius Linnaeus in the Sea Accreted Regions near Cochin.

JRF: C.N. Muraleedharan
ST: M.S. Rajagopalan

Acanthus ilicifolius, a prominent mangrove vegetation of Cochin estuarine system showed a varied distribution pattern in the sea accreted regions of Vypeen island near Cochin - occured as large colonies, or in association with Avicennia, or else forming small patches along tidal canals. The biological aspects such as standing crops and shoot density were observed to be controlled by environmental parameters. A moderate soil salinity, tidal inundation, low redox potential and fine grained soil with silt and clay were found to be favourable to the colonization of the species. A lowering of soil salinity was found to trigger the vegetative and sexual reproduction in the species. The average standing crop in the vegetation patches was seen to be 3.951 - 11.29 kg/m^2 which showed varied percentage of dying over the period contributing to the organic load.

6.16.30. Genetic Variation in the Fish Liza parsia.

JRF: Parag B. Karia
ST: A.G. Ponniah

The present study was carried out to understand ontological and tissue expression of protein and selected isoenzymes as well as to understand if any genetic polymorphism occurs in the population of L. parsia in Cochin backwaters.

No difference in the muscle protein pattern between juveniles and adult L. parsia was observed. Three groups of esterase enzyme system with a total of 6 bands were identified in liver, kidney, heart, eye, muscle and brain. Lactate dehydrogenase isoenzyme showed two loci, Ldh-1 and Ldh-2 with 5 bands in the eye; while in heart, muscle, liver and brain tissue, the Ldh-1 was expressed in equal intensities, and a faint expression of the Ldh-2 along with one or two interlocus hybrids were present. The ontological development of the Ldh-isoenzyme system showed that it develops in the stage between 1.4 mm larvae and 24 mm juveniles. At the initial stage of hatchling (2.4 mm) only the Ldh-1 locus was expressed. The faster locus Ldh-2 was found polymorphic with 2 alleles, Ldh-2 (100) and Ldh-2 (125). These allelic frequencies were 0.649 and 0.341 which were not significantly different from the expected values. Average heterozygosity ($\bar{H}$) obtained from the analysis of polymorphic loci Ldh-2 was 0.452.

6.16.31. Electrophoretic Studies in Penaeus monodon.

JRF: Puthran Prathibha
ST: N.N. Pillai

The total number of electrophoretic fractions of general proteins in P. monodon varied from tissue to tissue and the muscle, eye, hepatopancreas and serum produced 16, 15, 23 and 27 bands respectively. Besides, electrophoretic mobilities of different bands varied from tissue to tissue and these differences reveal tissue specific nature of muscle protein in P. monodon.

A comparison of muscle protein pattern in postlarvae, juveniles, subadults and adults; showed 4, 6 and 8 bands respectively in zone I of the gel. The muscle myogen electrophoretic patterns of both male and female were identical. But the fast moving fractions in the male was less intensely stained than that of the female. There were 16 identical bands in both sexes. There were 17 bands in serum protein in females measuring 175 - 190 mm and it was different from that of smaller females having only 15 bands.

The muscle protein pattern in postlarvae, juvenile and subadults/adults collected from Cochin and Madras showed identical electrophoretic pattern, with the exception that a few postlarvae raised in the hatchery at Madras had 3 bands less than that of the normal pattern.

A close comparison of lipoprotein and glycoprotein in different tissues of P. monodon revealed their tissue specific electrophoretic pattern. A comparison of lipo and glycoprotein patterns with that of general protein pattern in different tissues showed that lipoprotein and glycoprotein bands had the same electrophoretic mobility as that of general proteins in the corresponding tissue.

The muscle protein pattern of P. monodon when compared with other penaeid prawns, was found to be species specific.

6.16.32. Study on the Protein Budget in Different Size Groups of Penaeus indicus.

JRF: K. Suresh Kumar
ST: D.C.V. Easterson

Experiments were conducted to estimate the protein budget of juvenile P. indicus ranging in size form 25 to 55 mm total length, using isocaloric diets containing 0 to 60% protein content. Daily food consumption by the prawn was found to range from 11.4 to 3.3 in percentage body weight. The prawns fed with relatively higher and lower protein diets consumed more food than those fed with the diet having 35% protein. Observations on the efficiencies of assimilation for overall nutrients and for protein showed that when prawns were fed with optimum levels of protein, the difference between both assimilation efficiencies narrowed down, the capacity to assimilate protein tending to improve in larger sized juveniles. It was observed that the protein was used more for metabolism rather than building up of flesh. On the basis of the results obtained, the optimum requirement of protein for metabolism for juvenile P. indicus of size 25 to 55 mm was estimated.

6.16.33. Relationship Between Growth Rate and RNA, DNA Protein Ratio in Penaeus indicus.

JRF: George Thomas
ST: A.D. Diwan

The study was carried out to find if any correlation exists between RNA concentration, DNA concentration, RNA/DNA ratio, and RNA/DNA ratio to protein content and growth rate in different size groups of the penaeid prawn.

RNA and DNA contents, and RNA and DNA ratio showed high profile in small sized prawns with increased amount of protein. The RNA concentration, however, declined as the size of the prawn increased showing an inverse relationship between them. But in the DNA content there was a tendency for conservation in larger prawns. RNA/DNA ratio has been found useful in correlating growth in terms of protein increase in small sized prawns. But as the prawn grows to larger size, there was no correlation, due to fluctuations in the values of RNA and DNA. The protein values showed a steady increase as the size of the animal increased. Starvation induced significant decline in RNA and protein contents. But the DNA content remained unchanged. In the bilateral eye-stalk ablated prawns, the RNA, DNA and protein contents increased steadily, while the RNA/DNA ratio remained more or less unchanged.

6.16.34. Calcium Exchanges Between Sediment and Water in Some Culture Ponds with Stress on Carbonate and Bicarbonate Alkalinities.

JRF: A.P. Dinesh Babu
ST: C.P. Ramamirtham

This investigation pertained to a short-term study of the calcium and nutrient contents in the bottom sediments and overlying water in the prawn culture ponds near Cochin during the pre-monsoon and monsoon months (May - September). The calcium exchanges between the soil and overlying water were relatively higher during monsoon in the ponds subjected to tidal influence; whereas in the pond located away from the mainstream, the retention of calcium in the bottom sediments was found to be higher during early monsoon months also. An inverse relationship between carbonate and bicarbonate alkalinities was observed. Carbonate alkalinity was found invariably when exchange processes were active between the sediment and the overlying water during early monsoon and pre-monsoon seasons. The release of phosphorus from sediments to overlying water was observed under low oxygenated condition.

6.16.35. Studies on the Thelycum and Spermatophore of the Prawn Penaeus indicus.

JRF: P. Laxmilatha
ST: M.S. Muthu

The morphology, histology and histochemistry of the spermatophore and thelycum of P. indicus were studied to understand the structure and role of these organs in reproduction. The spermatophore of P. indicus consists of chitinous sperm bag and wings, with a sticky mass of granules rich in sulphate AMP at the anteriomedial corner of the sperm bag. The sticky substance appears to serve to cement the two spermatophores as they come out of the gonadial openings into one unit. Inside the sperm bag, the sperm mass is embedded in a spongy matrix rich in carboxylated AMP. The spematozoa appears to have a glycogen store for endogenous energy metabolism.

The thelycum of P. indicus is complex, consisting of lateral plates hiding the posterior projection of the folds of the 13th sternite which forms a 'trident' with a conical median process having a median ventral keel and two lateral horns covered with minute setae on the ventral lips, the surface of which is covered with numerous villi. The ventral surface of the conical median process of the 'trident' also bears villi. The dorsal margin of the lips bears a row of stiff rounded teeth which guard the entrance to the seminal receptacle which is single chambered. The villi, the keel and the stiff blant teeth and the lateral horns have a secretory epithelium covered by cuticle. On the ventral margin of the lips numerous minute cuticular pores are seen. The epithelial secretion of the thelycum is rich in carboxylated AMP. The structural significance of the thelycum and the role of epithelial secretion of the thelycum are discussed.

6.16.36. Studies on Heterotrophic Bacteria in the Mangrove Ecosystem Near Cochin.

JRF: V. Surendran
ST: V. Chandrika

Quantitative and qualitative analysis of heterotrophic bacterial population in 3 fixed stations in the mangrove ecosystem were carried out for a period of 6 months (March - August, 1985). Seasonal variations of some important environmental parameters such as rainfall, soil temperature, soil pH, soil Eh, electrical conductivity of soil, organic carbon, available nitrate and available phosphorus were also investigated.

The correlation between different environmental parameters and total heterotrophic bacterial count was statistically analysed. Available phosphorus alone showed significant relationship with total heterotrophs in all the 3 stations. The Z-test carried out to know the homogenity of relationship between the environmental parameters and bacterial count among the 3 stations gave values well below 1.96 at all places indicating them to be more or less homogenous.

Alcaligenes dominated in the generic composition of bacteria in all the seasons followed by Pseudomonas, Flavobacterium Cytophoga vibris and Micrococcus.

6.16.37. Electrophoretic Studies on Mugil cephalus and Liza parsia.

JRF: Mary Mathews
ST: A.G. Ponniah

Electrophoretic studies were carried out in Mugil cephalus and Liza parsia to determine the tissue specific expression of acid phosphatase, tetrazolium oxidase, esterase, alcohol dehydrogenase, malate dehydrogenase and maleic enzyme. Also the presence of genetic polymorphism at lactic dehydrogenase loci were determined in fingerlings of M. cephalus. Tissue specific expression was obtained with the tested enzymes in muscle, liver, eye, heart, brain, kidney and stomach. In M. cephalus there were indications of ontological development of acid phosphatase and presence of 8 co-dominant alleles of lactic dehydrogenase. From the above study, the base line information on biochemical genetics of the 2 species was obtained.

6.16.38. Metabolic Effects of Eyestalk Removal in Penaeus indicus.

JRF: B. Rajesh
ST: A. Laxminarayana

Oxygen consumption, ammonia excretion, random activity and carbohydrate levels in hepatopancreas and muscles of adult intermoult P. indicus were studied immediately after eyestalk removal and in normal prawns at 3 temperature and 5 salinity levels. The oxygen consumption of P. indicus increased immediately after eyestalk ablation. The rate was found to increase with increase in temperature. The eye ablated females showed a higher rate of oxygen consumption than males. The rate of O_2 consumption in eyestalk ablated P. indicus decreased with increase in salinity and found to be minimum at 25.7‰.

The rate of ammonia excretion increased after eyestalk ablation and with increase in temperature. However, it showed a decreasing trend with increase in salinity, the minimum rate being at 27°C and 32.4‰. The ammonia quotients also decreased after eyestalk ablation in all the test salinities and temperatures. The random activity of eyestalk ablated prawn was relatively low in higher temperature, and high in increasing salinity levels; the minimal activity being at 25.7‰. The eyestalk ablation resulted in an increase in the level of carbohydrates in the muscle tissue and a decrease in the hepatopancreas.

6.16.39. Observation on the Germination and Growth of Avicennia officianalis.

JRF: N.C. Meenakshy
ST: M.S. Rajagopalan

Experiments were conducted on the germination of the seed of A. officianalis, one of the dominant mangrove plant near Cochin with reference to salinity and duration of immersion in the brackishwater. It was found that A. officianalis germinated best in salinities lesser than 15‰. The seeds failed to grow while kept immersed in the water throughout the day. The percentage of germination of seeds of the mangrove plant in low and high tide levels in nature was found to be 45 and 60 respectively. The seeds grown in darkness in an inert medium reached 2-leaf stage in 40 days, indicating that the food reserve in the seed is sufficient for the plant to grow to the 2-leaf stage. Experiments on the germination of the seed in the beach sand beds showed better rate of germination in the sand enriched with minerals. Preliminary studies on the biochemical composition of the seed at different germination and early developmental stages showed an increase of lipid, ash and fibre content and decrease of protein and carbohydrate during the development of the seed from the radicle stage to the 2-leaf stage.

6.16.40. A Comparative Study of the Chemical Composition of Soils From Aquaculture Systems in the Cochin Estuarine Area.

JRF: P.G. Joseph Gilbert
ST: V.K. Pillai

Soil samples from both seasonal and perennial prawn culture fields around Cochin and adjacent areas were collected in pre-monsoon and monsoon periods and exchangeable sodium, potassium and calcium, total phosphorus and the lime requirement analysed based on the estimations of both exchange acidity as well as potential acidity. Grain size analysis of soil was also carried out on representative samples.

The exchangeable cations showed wide variation in space and time. The cations registered lower values during the monsoon period. Total phosphorous also showed wide variations in concentration with a definite pattern of distribution, with the northern and north central regions recording higher values. Both wet and dry pH showed an acidic trend in the monsoon than in the pre-monsoon. Grain size analysis revealed 3 textural classes - clayey sand, silty sand and sandy silt. Significant correlations were obtained between the grain size and the concentration of exchangeable cation as well as total phosphorous. Lime requirement calculated from potential acidity showed high values although the pH values were moderate. The northern and north central regions of the backwaters ranked higher in fertility due to the predominance of the fine grained fractions of the sediment in the soil. The intense circulation of water by tidal action, and the deposition of silt, clay and nutrients by the river add to the fertility of this area. The fertility status of this system is comparable to those studied in other parts of India as well as in the South East Asian countries, where aquaculture operations are in vogue.

6.16.41. Evaluation of the Nutritive Value of Mangrove Leaves as a Feed Component for Juveniles of *Penaeus indicus*.

JRF: Sally Anne Thomas
ST: R. Paul Raj

The main objective of the study was to find out the possibilities of utilisation of mangrove leaves either in fresh or decomposed form, as a feed component in the diet for culturing juvenile *P. indicus* in grow-out systems. Initially, the biochemical constituents (total nitrogen, non-protein nitrogen, crude protein, total lipid, nitrogen free extract, crude fibre, ash, moisture, sodium, postassium, calcium and phosphorus) of the green, yellow and fallen (withered) leaves of mangrove plants, *Rhizophora mucronata*, *Avicennia officianalis*, *Acanthus ilicifolius* and *Broguiera gymnorhiza* were determined. Besides, the changes in the biochemical constituents of the green leaves of all the 4 species at the end of 2nd and 4th week of decompositional period was found out. The biochemical composition of the 4 species of mangrove leaves showed the green leaves of *R. mucronata* to have the highest crude protein, and those of *B. gymnorhiza* the lowest protein content. *A. officianalis* had the highest non-protein nitrogen content. The crude fibre content was highest in *A. ilicifolius*.

The total nitrogen, non-protein nitrogen and crude protein contents showed significant increase after 30 days of decomposition. The overall increase in the crude protein content was highest for *B. gymnorhiza* and *R. mucronata*. The total lipid, crude fibre and nitrogen-free extract significantly decreased after decomposition. On the basis of this analytical results, 2 sets of feeding experiments were conducted on the juveniles of *P. indicus*, using green leaves of *R. mucronata*, *A. officianalis* and *A. ilicifolius* at various percentage levels (protein content) in the compounded feeds. The results of the experiments indicate that fresh and decomposed mangrove leaves can be incorporated in the diets of juvenile *P. indicus* without any significant alterations in growth.

6.16.42. The Effect of Pesticides on Penaeus indicus H. Milne Edwards.

JRF: P.N. Vinod
ST: A. Laxminarayana

An attempt to study the lethal and sublethal effects of some selected pesticides on P. indicus was made and the effects of malathion and ekalux on its larvae, postlarvae and juveniles were investigated.

The median lethal concentration of malathion on mysis stage of P. indicus was 2.97 ppt at 36 hrs while the lethal concentration of ekalux was 2.62 ppt at 24 hours. The median lethal concentrations of malathion and ekalux on postlarvae were at 2.35 ppt at 48 hrs and 2.70 ppt at 24 hrs respectively. The postlarval stages of P. indicus were more sensitive to ekalux than malathion. The oxygen consumption and ammonia excretion of juveniles reduced when exposed to sublethal concentration of malathion. The study indicated that P. indicus was susceptible to the tested pesticides and the susceptibility varied with the stages in the life-cycle.

6.16.43. Studies on Rhizosphere Microflora of Acanthus ilicifolius.

JRF: Mini Raman
ST: V. Chandrika

Study was made in 2 stations in the estuarine ecosystem around Cochin on the quantitative and qualitative distribution of microflora from rhizosphere and non-rhizosphere mangrove environment. Variations of environmental parameters such as temperature, pH, Eh, organic carbon content, available nitrate and available phosphate in the rhizosphere were also analysed to explore their relationship in the distribution of microflora in these environments.

A significant negative correlation was observed between the bacteria and actinomycetes. Statistical analysis revealed no significant relationship between microflora and chemical factors studied. Clustering of the samples in some ranges of the counts of microflora were encountered indicating overdispersion. The relationship between the physico-chemical parameters and bacterial counts revealed both stations to be more or less homogeneous. The biochemical potential of rhizosphere microflora of A. ilicifolius soil revealed that the rhizosphere microflora of A. ilicifolius has greater ability than the non-rhizosphere soil population to effect rapid biochemical changes like greater mineralization of organic matter. The loss of photosynthate as root exudates enhances the growth of chelate producing microbes and facilitates the solubilisation of primary minerals which act through a positive feed back mechanism to increase the productivity of the ecosystem.

6.16.44. Comparative Study of Sediment Nutrients in Seasonal and Perennial Prawn Culture Ponds During the Southwest and Immediate Post-monsoon Months.

JRF: A.K.V. Nasser
ST: S. Muthusamy

Study to determine the quality and abundance of sediments in seasonal and perennial prawn culture ponds and its relation to heterotrophic communities living therein was made.

The hydrophysical conditions of the overlying water in both seasonal and perennial ponds were almost similar during southwest and post-monsoon months. The higher concentration of organic carbon and carbohydrate content of the sediment in seasonal ponds could be due to decaying organic manure and hay. The reactive phosphorus was at its peak in seasonal ponds corresponding to a drop in dissolved oxygen. There was no correlation between total phosphorus and hydrophysical condition of overlying water. Total nitrogen in the seasonal ponds was found to be low mainly due to withdrawal by growing paddy.

6.16.45. Photosynthesis in Relation to Some Selected Environmental Parammeters in Prawn Culture Fields.

JRF: K. Madhusudhan Reddy
ST: V.S.K. Chennubhotla

Effect of environmental parameters on photosynthesis and productivity in prawn culture ponds was studied to assess the biogenic capacity of the pond water and to determine the stocking strategies.

Three different ponds with slightly different ecological characters were selected for the study. The pond water temperature, salinity and dissolved oxygen did not show much variation and the pH was around 7.5 in all the ponds. The pond nutrients concentration was higher than in natural brackishwater environment, due to leaching from fertilized agriculture fields. The relation between primary production and chlorophyll was found to be negative. The areas of study were highly productive (7.5 g $C/m^3/d$) which can be used for prawn/fish culture practices without artificial fertilization.

6.16.46. Changes in Haemolymph Constituents in the Resting (or Non-active) and Activity Stressed Penaeus indicus H. Milne Edwards.

JRF: Dipak Narendra Chaudhary
ST: A.R. Thirunavukkarasu

An attempt to study the physiology of stress imposed by salinity and hyperactivity on P. indicus and its consequences on the individual and the population as a whole was made.

The usually encountered stress, salinity, mechanical chasing and **transportation** may lead to lethal and sublethal effects and increased succeptibility to diseases. Three different experiments were set up to access the effect of stress caused by salinity, mechanised chasing in ponds and transportation in high densities. In lower salinities the protein in the haemolymph showed high values and decreased gradually at higher salinities with time. Magnesium concentration in the haemolymph also showed a similar trend. By chasing the prawns constantly in the pond, the calcium and magnesium concentration in the haemolymph increased suddenly after the stress and then decreased below normal after 43 hours and 32 hours respectively. When prawns were transported to a distance of over 70 km in 25 litre containers the values of calcium and magnesium rose up initially and later dropped gradually to normal or below normal concentration by 43 hours after transportation.

6.16.47. Seawater Analysis with Particular Reference to Dissolved Organic Matter During Premonsoon and Monsoon Months.

JRF: Sandip Ramesh Ahirrao
ST: D.S. Rao

To understand the possible effects of dissolved organic matter present in stored seawater on the success of spawning of brooder prawns and proper development of their eggs and larvae the study was undertaken.

The dissolved organic matter (DGM) and particulate organic matter (POM) were found to be more in fresh seawater than in the stored seawater. The percentage extracellular release was found to be more in stored seawater, possibly due to the passive release of DOM by disintegration of algal cells rather than by excretia. The peak values of DOM in fresh and stored seawater were found during the premonsoon and immediate postmonsoon period. The POM values were generally **higher in fresh seawater and they were at maximum during postmonsoon** months. The chlorophyll concentration was maximum during the monsoon in both fresh and stored seawater. Amongst the other plant pigments, phaeopigments dominated distinctly with a concentration as high as 254.4 mg/m^3 in the fresh and stored seawater in the postmonsoon month of September. Dissolved oxygen and salinity showed positive correlation with DOM and POM, but was not statistically significant. Strong correlation was observed in between DOM and POM and also chlorophyll and POM in both fresh and stored seawater. It is concluded that freshly collected seawater will be more beneficial for the survival and growth of the newly hatched larvae, whereas for the postlarvae and subsequent stages, stored seawater will not make much significant difference rendering the required energy through heterotrophic uptake.

6.16.48. Studies on N-P-K Ratios in Soil and Overlying Water in Some Culture Ponds in Relation to Plankton Biomass.

JRF: C. Mohandas
ST: C.P. Ramamirtham

A study on the concentration of nitrogen, phosphorus and potassium in the sediment and overlying water of culture ponds and its relation to plankton biomass was made.

The available forms of nitrogen in the sediment showed higher values than in the overlying water without any appreciable seasonal fluctuations. On the other hand, the concentration of available phosphorus was higher in overlying water than in the sediment. High concentration of nitrogen in monsoon months was accompanied by an increase in the plankton biomass. The relation between the available potassium and plankton biomass was not very significant.

6.16.49. Studies on lactate dehydrogenase isozymes in Mugil cephalus and Liza parsia.

JRF: N. Ravi
ST: A.G. Ponniah

For biochemical characterisation of lactate dehydrogenase isozymes (LDH) in M. cephalus and L. parsia extensive polyacrilamide electrophoresis was carried out. The effect of gel cross linkage, concentration of substrate, cofactor and storage were studied. Also the activity of LDH and the genetic variation of LDH loci were examined.

The lactate dehydrogenase system was expressed with all the 5 isozymes at 7% acrylamide and 4% bisacrylamide. When the substrate lithium lactate and cofactor NAD were held constant at 5 mg and 1 mg/ml of staining solution the LDH system was optimally expressed. Increasing hours of storage and frequency of thawing affected differently the sub units of LDH loci. No significant genetic variation was observed in the adult specimens of L. parsia. The enzymes activity measurements indicated tissue specific and species specific differences. This study has indicated the scope of biochemical characterisation of isozymes using electrophoretic methods.

6.16.49. Culture and Growth Kinetics of Selected Nannoplankters.

SRF: Ammini Joseph
ST: P.V. Ramachandran Nair

Ph.D. Degree awarded

Development of mass phytoplankton cultures as live food, forms an integral part of hatchery systems in mariculture. Among microalgae, nannoplankters are the right type of food for early larval stages of bivalve molluscs, and hence isolation and development of them in axenic cultures in in vitro conditions have been taken up. Two new species of nannoplankters namely, Chromulina freiburgensis and Isochrysis galbana formanova were isolated and developed in unialgal cultures. The growth kinetics of these two species were studied along with that of two other nannoplankters, Synechocystis salina and Tetraselmis gracilis. These cultures, raised in the laboratory grew asymptotically completing the exponential phase within 4 to 6 days of innoculation with a mean doubling time of 9 hours. The pigment content and physiological activity of these two species were found to be high in the exponential phase of growth and declined as the culture aged. Analyses of the biochemical composition of these species reveal that they synthesize 45 to 58% protein during the exponential period and the proportion of which gets reduced in older cultures. The rate of excretion of organic metabolites was observed to be minimum during the exponential period of growth. Salinity and pH tolerance studies indicate that S. salina requires an optimum of 34 ppt salinity and pH 8 for maximum growth. The rate of carbon fixation was found to increase up to a density of 0.18 million cells/ml in C. freiburgensis, 0.5 million cells/ml in I. galbana, and in S. salina it was 1.25 million cells/ml.

The response of nannoplankton to different temperature conditions was also tested. The thermal death point was 45°C for S. salina and 40°C for C. freiburgensis and I. galbana. However, the physiological activity was maximum at 25°C for S. salina and 30°C for the other two species. The growth rate did not vary noticeably within the temperature range of 20-35°C. Cultures maintained on a light-dark cycle of 10-14 hrs exhibited high growth rates, when exposed to constant illumination. The nutrients (nitrate and phosphate) utilization capacity of S. salina and C. freiburgensis was higher than that of I. galbana.

Mass culture of two species, C. freiburgensis and I. galbana, was carried out under artificial illumination with a temperature range of 28-33°C in the laboratory. The cultured nannoplankton were fed to the larvae of edible oyster, Crassostrea madrasensis to evaluate their food value. The larvae accepted both the species of nannoplankters and settled as spat within 17-19 days. The rate of survival and rate of growth were higher than the control feed (I. galbana Parke - a temperate water strain). C. freiburgensis seems to be the most potent species for development as live food in oyster hatcheries.

6.16.50. Reproductive Physiology of Indian Species of the Genus Perna (Family Mytilidae).

SRF: B.S. Ajitha Kumar
ST: K. Alagarswami

Ph.D. Degree awarded

The study was carried out on the brown mussel Perna indica and the green mussel Perna viridis collected fortnightly from Vizhinjam and Calicut along the southwest coast of India for a period of 15 months from October, 1981 to December, 1982. P. indica as per this study spawns during July-September and P. viridis during September-October. Reproductive activity of these mussels seems to be controlled by both exogenous and endogenous factors. Sexual maturity coincides with the peak in phytoplankton production. This relationship is further confirmed by the feeding experiments in the laboratory. The morphology and physiology of the gametes of the two species are almost similar. Egg and sperm viability studies reveal that the sperms of P. indica and P. viridis survive for a period of about 4 hours and the eggs up to 7 hours in the seawater of 32 to 35‰ salinity. None of the gametes survived at salinities below 20.5‰ and above 43.8‰. Biochemical studies reveal that the composition of tissues vary with the stages of maturity and also with seasons. Protein is selectively stored in the adductor muscle, carbohydrates (as glycogen) in the mantle and lipids in the digestive gland. Accumulation of these components is high during the non-reproductive season. The female gonad had relatively higher lipid than the male, where glycogen was dominant. The lipid stored in the digestive glands was observed to be mobilized during active vitellogenesis. Histochemical studies on gonads show that they are mainly constituted by glyco-lipo-protein. The occurrence of acid mucopolysaccharides was also noted. Scanning Electron Microscopic studies

showed that the sperm of P. indica has 4 distinct parts, viz. acrosome, nucleus, middle piece and a tail. The neurosecretory cells of pyriform type have been observed in cerebral and visceral ganglia of both the species. Cytochemical studies showed the neurosecretory material to be acidic and glyco-lipo-protein in nature. The seasonal changes in the reproductive cycle synchronize with the changes in the neurosecretory cycle. Experimental evidence had been obtained as to the role of neurosecretion in the spawning of the mussels through extirpation of the ganglia of central nervous system. Bilateral cerebralectomy elicited greater spawning response than unilateral extirpation. Visceralectomy too yielded spawning response, but on a much lower scale. The processes of gametogenesis, maturation and spawning appear to be triggered by progressive decline in salinity. Heavy rainfall seems to accelerate spawning.

6.16.51. Studies on Sporulation and Propagation in Selected Agarophytes.

SRF: Shobha P. Shere
ST: P.V. Ramachandran Nair

Ph.D. Degree awarded

Studies on sporulation of 4 commercially important red algae, (Agarophytes) namely Gelidiella acerosa, Gracilaria corticata, G. edulis and Hypnea musciformis, growing in the vicinity of Mandapam Coast, were carried out from October, 1981 to September, 1983. During this period fruiting behaviour in the natural population of these species was investigated. Laboratory experiments were carried out with the four algae to collect information on seasonal aspects of spore production and diurnal variation of spore shedding. Studies were also carried out to understand the effect of some selected environmental factors such as desiccation, salinity, temperature, light intensity and photoperiod on spore output in the above four species.

Population of all the four species occurred throughout the year along the coast of Mandapam. Tetrasporic plants of these species were observed in all the months of the year. The carposporophytes of G. corticata and G. edulis were seen throughout the year. In H. musciformis, however, they were found only in some months. Cystocarpic plants were not found in the population of G. acerosa.

Maximum output of tetraspores and carpospores were observed mostly on the first day of the experiment in the four red algae studied. The tetraspore output decreased from 2nd day onwards. Rhythmic liberation of carpospores, with peak shedding of spores at intervals on different days was also observed. In the laboratory conditions, the tetraspore output was observed for a period of 6-14 days in G. acerosa; 6-27 days in G. corticata; 3-30 days in G. edulis and 3-23 days in H. musciformis during different months of the year. Carpospore liberation was found for 6-30 days in G. corticata; 10-30 days in G. edulis

and 2-24 days in H. musciformis. Seasonal periodicity was not observed in the liberation of tetraspores and carpospores in the four algae studied. Diurnal periodicity in the liberation of tetraspores with a prominent peak between 2 p.m. and 6 p.m. was observed in G. acerosa. A definite peak at a period of the day in the shedding of tetraspores and carpospores was not seen in G. corticata, G. edulis and M. musciformis and the maximum liberation of spores occurred in these three species from 10 10 a.m. to 2 p.m. Peak shedding of spores was seen in 30‰ S in G. edulis and H. musciformis, at 40‰ S in G. acerosa, and at 30-40‰ S in G. corticata. Peak sporulation was observed at low light intensity of 500 lux in G. acerosa, G. corticata and G. edulis, and of 1000 lux in H. musciformis. Maximum spore output in G. acerosa was observed at 25°C, and in H. musciformis at 30°C, and in G. corticata and G. edulis between 25°C and 30°C.

6.16.52. Studies on Environmental Stress in the Prawn Penaeus indicus.

SRF: D. Vincent
ST: M.J. George

Research completed
Thesis under finalisation

Effects of environmental parameters such as light, salinity, pH, duration of water change and crowding on the growth of juvenile P. indicus were studied. The stress caused by excretory products of nitrogen metabolism (ammonia, nitrite and nitrate) in P. indicus was also studied.

Comparative evaluation of polyethylene and perspex aquaria as rearing tanks for the juveniles revealed that in polyethylene the survival and growth are superior and significant at 5% level. The rate of ammonia excretion was higher in those reared in perspex tanks. Juvenile prawns reared in dark tanks showed significantly superior growth compared to light tanks. In prawns reared in light, the rate of ammonia excretion was higher than from those maintained in darkness. Diurnal observations on rate of ammonia excretion reveal the occurrence of 2 peaks regardless of the size studied. Uptake of ammonia by the juveniles from ambient waters was observed and confirmed. Juveniles showed maximum growth and best percentage survival at a salinity of 20‰ and minimum at 35‰. Ammonia excretion was minimum at 20‰ but increased in other salinities. Dry weight of prawns reared at 10‰ was lower than those reared in other salinities. Optimum pH for maximum growth was observed to be 7 and extremes of pH (5 and 9) showed poor growth and survival and enhanced the respiratory and excretory rate

considerably. Percentage of dry matter increased gradually from lowest tested pH of 5 and reached maximum at 8 and reduced sharply at 9. Growth, survival and percentage dry matter in juveniles were inversely related to stocking density (best at 10/2054 cm^2 and least at 60/2054 cm^2). The rate of excretion and final biomass were directly related. Density did not affect the respiration much. More frequent change of water significantly decreased the growth. Excretion of ammonia and build-up of nitrogenous wastes increase with less frequent water change up to a particular level, beyond which it declined. The study will be useful in designing high intensive economically viable prawn culture systems.

6.16.53. Studies on the Ecology and Productivity of Saline Lagoons.

SRF: A. Silas Ebenezar
ST: P. P. Pillai

Ph. D. Degree awarded

In order to elucidate the suitability of a derelict saline lagoon for the culture of finfish and prawns, investigations were carried out on the ecology and productivity of a coastal lagoon at Mandapam, south-east coast of India. The lagoon has monsoonal freshwater flow. The level of water in the lagoon oscillates between 10 and 100 cm with the highest level in November and lowest in April. The distribution pattern of temperature of the air and the surface water of the lagoon showed a more or less similar trend, being minimum in December-June and thereafter increasing gradually. The dissolved oxygen content was low during May-September and increased thereafter. During the period of study, hypersaline condition of the water was observed during July--October in 1982 and April-October in 1983. In other months, the lagoon water was generally brackish. The pH of the water varied between 7.7 and 8.7. Soluble reactive phosphate content was high during November-June and low during July-October. A similar trend was noticed in the distribution of nitrate and nitrite contents. However, a reverse condition was recorded in H_2S. While the temperature of the sediment remained high, the sediment pH was relatively low during July-October period. Productivity of the water was rather low during July-October, increased during November-December, and then decreased. A secondary period of higher productivity was recorded in May. Coelenterates, cladocerans, ostracods, amphipods, isopods, mysidaceans, decapod larvae, lucifers, chaetognaths, polychaetes, lamellibranchs, heteropods, pteropods, gastropods, appendicularians, fish eggs and larvae, copepod nauplii, fish scales, copepod eggs, ophiopluteus larvae and insect larvae constituted the zooplankton of the lagoon waters. The benthic macrofauna was composed principally of bivalve spats, Perineres, Chironomus, Pulliella armata and amphipods. The bottom sediment of the lagoon was found to be a mixture of sand and mud.

Nutrient enrichment experiments were conducted to understand the effect of fertilisation on the primary productivity of the lagoon waters. When NPK complex and organic manure were used, the primary productivity of the water was found to increase seven to ten folds in experiment. Addition of D-glucose, however, significantly decreased the net production, thereby indicating increased rate of heterotrophic production. Although chemical fertilizers were found to increase the gross production rate, it was significantly less as compared to the use of commercial grade fertilizers. Enrichment with urea resulted in significant increase in production when compared with supersulphate and potash treatments.

The above studies on the lagoon indicated that this lagoon falls under the category of "Ultra-oligotrophic type", and that when the freshwater and seawater inflow ceases, the lagoon becomes more anoxic. It was observed that the concentration of hydrogen sulphide in the water was not detrimental to the organisms inhabiting the area. The results of the investigations indicated that the major deterrents for mariculture operation in the lagoon were the low rate of primary production and periodical recurrence of low water level in the lagoon when it gets isolated from the sea, poor plankton production, hypersaline condition, and vulnerability of culture organisms to predation. In order to augment plankton production, fertilization of the lagoon by NPK and culture in the deeper water areas of more than 30 cm level are suggested. Further the construction of a water channel of about 2 km long connecting the Gulf of Mannar and the lagoon is also suggested.

6.16.54. Pathological Investigations in Penaeid Prawns.

SRF: Subhash Chandra Soni
ST: P. Vedavyasa Rao

Ph.D. Degree awarded

A survey on the diseases of penaeid prawns from Cochin, Mandapam and Tuticorin revealed the occurrence of six diseases namely, microsporidosis, ciliate infestation of gills, soft prawn disease, helminth parasitization, isopod parasitization and red rostrum disease. Microsporidosis was studied in detail. Whereas the remaining five have been studied briefly.

Three new species of microsporidian parasites have been identified from Penaeus semisulcatus and Metapenaeus affinis. The first microsporidian is a new species of the genus Thelohania. The disease is chronic and debilitates the host and is observed throughout the year in prawns above 60 mm in length. Infection occurs mainly in muscle, gonad, hepatopancreas and midgut wall, where the host cells are eventually replaced by masses of spores. The parasite multiplies by vegetative growth and forms spores during sporulation. Sporulation is a series of three binary fissions producing eight spores covered in a membrane. Spores are ovoid, 5.0-5.5 x 2.5-3.5 μm in size with an isofilar polar tube 14-22 μm in length. The disease has experimentally been transmitted to normal prawns by direct ingestion of spores with food. Lipid, protein and carbohydrate contents of infected prawns are not significantly different from normal ones.

The second microsporidan has been identified as a new genus of family Thelohanidae based on its ultrastructure. Parasite is site specific affecting ovary and blood vessels. Fecundity of heavily infected ovary is reduced or completely destroyed. Spores are produced in groups of eight covered in a membrane. They are pyriform, 3.0-4.2 x 1.5-2.0 ,um in size with an anisofilar polar tube.

The third microsporidan is a new species of Nosema infecting muscle, ovary and digestive tract. It is a disporoblastic species producing two spores without any membrane. Spores are egg shaped measuring 2.0-2.5 x 1.0-1.5 ,um in size and possess an isofilar polar tube, 25 ,um long. Spores lie singly in masses among the muscle fibres and cause lysis of myofibrils when infection is heavy.

6.16.55. Nutritional Studies in Juvenile Penaeus indicus With Reference to Protein and Vitamin Requirements.

SRF: C. Gopal
ST: R. Paul Raj

Thesis submitted
Result awaited

Nutritional studies were carried out in the juveniles of Penaeus indicus to determine the optimal protein requirements, to evaluate the nutritional value of cheaply available protein rich ingredient sources, to study the deficiency symptoms associated with the exclusion of water soluble vitamins from diets and to determine the dietary requirement of ascorbic acid, choline, thiamine, pantothenic acid, pyridoxine, and niacin. Preliminary experiments indicated that the prawn prefers semi-moist diets, when compared to moist and dry pellets. From the results of the experiments it is evident that survival, growth, food intake, food conversion and biochemical composition of prawns vary depending upon the concentration of the tested nutrients (proteins & vitamins) in the diet. In general, survival was greatly affected by the nutrient deficient diets. Sub-optimal and supra-optimal concentrations of the tested nutrients in the diets significantly affected the survival, growth, food conversion and body composition of the prawns. At optimal concentrations of the nutrients in diets the highest survival, growth and protein content were observed. Deficiency of nutrients in the diets induced high mortality rates in the form of postmoult deaths.

Experiments with isocaloric diets containing graded levels of protein showed that juvenile P. indicus has a dietary protein requirement of 35-40% for maximum growth. The ammonia excretion rates of prawns were found to be high on high protein diets, when compared to low protein diets. Studies on the nutritive value of protein rich ingredients showed that individual animal protein sources have superior

biological values when compared to plant protein sources. Also a mixture of animal protein sources were found to be superior in compounded diets to individual animal protein sources. Among the plant protein sources, soyabean meal was found to promote better growth and feed efficiency indicating that the aminoacids profile of soyabean meals might meet almost the aminoacids requirements of juvenile prawns. Purified diet also promotes relatively good growth when supplemented with a mixture of aminoacids containing phenylalanine, lysine, cysteine, tryptophan, taurine, glycine, glutathione and proline.

The water soluble vitamins that were tested for the nutritional requirements in prawns have shown that they are indispensable for good survival and growth. However, choline can be dispensed with if lecithin is supplemented in the diet in adequate levels as choline is a precursor molecule for lecithin. Deletion of ascorbic acid and panthothenic acid in the diets not only affected survival and growth but also induced severe deficiency symptoms in the form of black lesions or partial moulting. Supra-optimal concentrations of the tested vitamins inhibited growth in prawns.

Wide variations in the biochemical composition (the percentage of moisture, protein, lipids, carbohydrates, ash, minerals and nucleic acids) were observed in prawns when they were subjected to different experimental diets. Besides, the food conversion ratios and protein efficiency ratios were found to be significantly low at sub-optimal and supra-optimal concentrations of the vitamins. At supra-optimal concentrations of the tested vitamins the ammonia excretion rates were high as a result of enhanced metabolic rate. The dietary requirement of the various vitamins for the prawns ranged from 0.4 - 0.8 g ascorbic acid/100 g of diet, 0.5 - 0.79 g choline chloride, 0.01 - 0.02 g thiamine hydrochloride, 0.75 - 0.1 g calcium panothenate, 0.02 - 0.03 g pyridoxine and 0.025 - 0.05 g nicotinic acid.

6.16.56. Studies on Ecophysiology of Penaeus indicus H. Milne Edwards in the Grow-out System.

SRF: Subhash Chander
ST: A.D. Diwan

Thesis submitted
Result awaited

Availability of maturing and mature P. indicus in the estuarine area is meagre, as compared to inshore marine area, especially during monsoon and post-monsoon period when freshwater run-off and local precipitation, presumably, cause drastic alteration in its physico--chemical factors. Seasonal variation of physico-chemical parameters and some of the metals in water and sediment in the marine and the estuarine areas were hence studied. Role of season and ecosystem--specific variations of calcium, magnesium, phosphorus, copper and zinc in the water and the sediment in altering the concentration of these elements in different tissues of P. indicus from the estuarine and the marine ecosystems was studied.

The results of seasonal variation study of two years (Nov. 1982 to Oct. 1984) showed that the physico-chemical conditions, in general, remained same in both ecosystems during non-monsoon period but major noticeable variations occurred during the monsoon and post-monsoon periods. The physico-chemical parameters generally recovered to their pre-monsoon level by the end of post-monsoon period.

Both the ecosystems showed decrease in temperature of water and sediment during monsoon and post-monsoon; but the quantum of decrease was considerably higher in the marine system than in the estuarine ecosystem. The pH of water and sediment showed stable values in the marine ecosystem with a little decrease during monsoon period, whereas considerable increase of pH was noticed during monsoon and post-monsoon period in the estuarine ecosystem. The Eh in both

the ecosystems behaved in a similar fashion all round the year. The level of dissolved oxygen was considerably higher in the estuarine than in the marine ecosystem and the quantum of seasonal decrease of dissolved oxygen was relatively mild in the estuarine ecosystem. The salinity, calcium and magnesium of the water and the sediment showed considerable decrease to almost freshwater values during monsoon and post-monsoon in the estuarine ecosystem, in contrast to the stable seasonal values recorded in the marine ecosystem. The net primary production rate and contents of nutrients (total phosphorus, copper and zinc) in water and sediment were similar in both the ecosystems.

The results of the present study showed that variations of bio-elements, in different tissues of male and female P. indicus, were insignificant during non-monsoon period and the variations, whatsoever, recorded, occurred mainly during monsoon and/or post-monsoon period only. During non-monsoon period, the variations in contents in water, sediment and various tissues of the prawn was little, i both ecosystems. However, considerable decrease was noticed in the water, sediment and haemolymph, muscle, hepatopancreas and gonad of male and female P. indicus during monsoon and post-monsoon period in the estuarine ecosystem. The exoskeletal calcium showed little decrease during monsoon and post-monsoon period. The seasonal magnesium values in water, sediment and various tissues of P. indicus from marine ecosystem were relatively stable. Calcium was found to be always higher in the haemolymph than in the ambient medium but the reverse was true for magnesium.

The haemolymph phosphorus showed erratic seasonal variation in both the ecosystems. Relatively low values of exoskeletal phosphorus were noted during monsoon and post-monsoon, in both the ecosystems. Muscle phosphorus was variable in both the ecosystem., though slightly higher values were noted in the monsoon and post-monsoon especially in the estuarine ecosystem. Phosphorus values of hepatopancreas and

gonads were low during monsoon and post-monsoon period in the estuarine ecosystem, whereas in the marine ecosystem there was not much change in the values.

The contents of copper and zinc in various tissues of male and female P. indicus were similar in both the ecosystems. Increased levels of these metals in haemolymph and muscle were noted during monsoon and post-monsoon in both the ecosystems. Exoskeletal copper and zinc levels were more or less, seasonally uniform in both the ecosystems. The hepatopancreatic copper and zinc showed minor decrease during monsoon and post-monsoon period in both the ecosystems. Copper and zinc levels in the gonads remained seasonally uniform in the marine ecosystem. In the estuarine ecosystem, relatively low levels of copper and zinc were noted during monsoon and post-monsoon period. The seasonal variation of copper and zinc in the haemolymph and the muscle are significantly correlated to variations of the same in water and sediment in both the ecosystems.

6.16.57. Studies on the Histological and Biochemical Changes During Spermatogenesis in M. cephalus and Related Species.

SRF: Elizabeth Joseph
ST: P. Vedavyasa Rao

Thesis submitted
Result awaited

Studies were conducted on M. cephalus and L. parsia. Data collected indicate that in M. cephalus there are two distinct peaks of maturation (maximum GSI) during May-June and November-December, while in L. parsia no distinct peak is observed. Relatively higher salinity coincides with the maximum GSI, while temperature has no significant effect.

Morphologically, the testes in both the fishes were found to exhibit cyclic volumetric changes and have been classified into six maturity stages. Histological studies reveal that the basic structure of the testes in both the species is of the 'unrestricted spermatogonial' type, showing developing cysts of different cell types all along the length of the seminiferous lobule. Electron microscopic studies reveal that the sperm of both the species lack an acrosome. The ultrastructure of the spermatozoa and the other germcells of both the species are similar, but the size of the cell types and the sperm of M. cephalus is smaller than that of L. parsia.

Biochemically, the protein and lipid levels increase in the gonad from stage I to IV while that of carbohydrate decreases. Liver protein decreases with maturity while carbohydrate shows initial increase and then a decrease. Muscle protein increases from stage I to IV while carbohydrate decreases. The pattern is similar in both the species.

Cryopreservation experiments were carried out with the milt of both the species. Of the 10 extender solutions tried, successful fertilization and hatching of the larvae (80%) could be obtained in 4 extender media after a period of 19 days in the case of L. parisa.

6.16.58. Studies on Larval Nutrition in the Pearl Oyster Pinctada fucata (Gould).

SRF: Anuradha Krishnan
ST: K. Alagarswami

Thesis submitted
Result awaited

Several species of micro-algae, viz. Isochrysis galbana, Pavlova lutheri, Chromulina freiburgensis, Tetraselmis chui. Tetraselmis gracilis, Synechocystis salina and Chlorella sp. were tested for their usefulness in larval rearing either singly or in combinations. Quality was judged on the basis of better growth and percentage of spat settlement. Pure cultures of I. galbana, P. lutheri and C. freiburgensis have been identified as good food for pearl oyster larvae, whereas, S. salina and the Tetraselmis spp. did not result in any spat settlement. A food value index was prepared and the algal diets ranked in order of their nutritional value to pearl oyster larvae. The alga I. galbana was used as reference. Combinations of more than 2 algae, viz. Isochrysis, Tetraselmis and Chlorella and open culture of phytoplankton have individually given better results than feeding on pure cultures of Isochrysis alone.

Optimum larval density and feeding concentration of Isochrysis have been identified, i.e., 5 larvae/ml and 25 cells per /ul. An increase in cell concentration from 15 to 35 cells per /ul from the D stage to the eyed umbo stage is advocated. Substitute microencapsulated diet did not result in any spat settlement. Freeze dried algal cells were of some nutritional potential to the pearl oyster larvae.

On studying the effects of various environmental parameters it has been concluded that maintaining the larvae at $32^{O}C$, at ambient pH and at salinities from 28‰ - 34‰ are ideal for larvae.

The biochemical changes that occur in the pearl oyster larvae through the different stages of larval life history up to metamorphosis were studied. Staining larvae with Sudan Black for lipid was carried out for assessing the quality of pearl oyster larvae. Lipid seems to play an important role in larval development.

Conditions for maintaining larvae in the laboratory, such as for aeration, constant flow rearing system, necessity of antibiotics and drip feeding were experimented with. Aeration during the eyed umbo stage, maintaining larvae in a flow-through system after the 'eyed' stage, washing with antibiotics during every water change and direct feeding have been found conducive for larval development.

6.16.59. Studies on Indian Cichlids.

SRF: Gopal Prasad Mahobia
ST: K.C. George

Synopsis submitted

Studies on systematic and phenotypic and genotypic character variations, in different populations of Etroplus suratensis and E. maculatus were carried out from 8 different estuarine populations of east and west coast of India and a landlocked freshwater habitat of Hyderabad. Electrophoretic studies showed that the protein patterns of blood serum, blood haemoglobin, gonads and liver varied with size, sex and maturity stages of the specimens but the protein pattern of muscle and eye lens remained the same. Muscle protein pattern variation in E. suratensis and E. maculatus were recorded from different geographical areas. The effects of storage, heating and urea inhibition on protein patterns of these species were also recorded.

Six isoenzymes - lactate dehydrogenase, malate dehydrogenase, alcohol dehydrogenase, acid phosphatase, esterase and catalase, were separated on polyacrylamide and starch gel electrophoresis. Chromosome numbers were recorded as 48 in E. suratensis and 46 in E. maculatus.

Biochemical studies showed that the protein, lipids and moisture contents decrease in the muscle, and increase in liver with the advancement of gonadial maturity. Carbohydrate content increase in the liver of both males and females, but in the muscle it increased in males and decreased in females. E. suratensis was found to spawn in Cochin backwater throughout the year with peaks in November-January and March-April periods.

6.16.60. Studies on the Nitrogen Cycle Bacteria in Prawn Culture Fields of Kerala.

SRF: Arun Shivnath Ninawe
ST: R. Paul Raj

Research completed
Thesis writing in progress

With a view to elucidating the turn over of nitrogen in the prawn culture fields of Kerala, studies were carried out on the various bacterial groups associated with the nitrogen cycle by selecting two perennial and two seasonal prawn culture fields. The bacterial population in the perennial as well as seasonal prawn culture fields near Cochin showed maximum numbers during the pre-monsoon season as compared to the post-monsoon season and minimum numbers in the monsoon season.

Significant variations were observed in the occurrence and abundance of the total heterotrophs, proteolytic, ammonifying, nitrifying, denitrifying and nitrogen fixing bacteria in both the sediments and water in each of the ponds. The pH of the water and sediment, and the water temperature were observed to be the most important among factors influencing the distribution and abundance of most of the bacterial groups.

The rate of bacterial nitrogen fixation was found to be more in sediments than in water in all the 4 ponds, and it varied during the different seasons. The bacterial nitrogen fixation rate was significantly affected by water temperature, water and sediment pH, dissolved oxygen content, salinity, nitrite, nitrate, ammonia and total phosphorus contents in almost all the ponds. In the case of seasonal ponds, the sediment Eh also significantly influenced the bacterial nitrogen fixation rate.

Nitrogen fixation rate was relatively more in seasonal prawn culture fields compared to that of perennial ponds. A direct relationship was noticed between the nitrogen fixing bacteria and the rate of nitrogen fixation. Characterization of 30 different aerobic nitrogen fixing Azotobacter strains were carried out after their isolation and purification up to the species level; of which 13 strains belonged to A. chroococcum, 9 strains to A. vinelandii and 8 strains to A. beijerinckia.

Experimental studies on the nitrogen fixing ability of 30 isolated strains showed that the nitrogen fixation was higher in 3 strains, of which 2 belong to A. chroococcum and one to A. beijerinckia. The nitrogen fixing ability of the other strains was relatively low.

The effect of 4 vitamins, viz. cyanocobalamine, biotin thiamine and ascorbic acid on 9 strains of selected Azotobacter strains were studied. Three strains belonging to A. chroococcum were able to show maximum growth at 4 µg/l cyanocobalamine, 60 µg/l biotin, 80 µg/l thiamine and 130 µg/l ascorbic acid, whereas 3 strains belonging to A. beijerinckia were able to show maximum growth at 6 µg/l cyanocobalamine, 60 µg/l biotin, 40 µg/l thiamine and 100 µg/l ascorbic acid. The 3 strains belonging to A. vinelandii showed maximum growth at 5 µg/l cynocobalamine, and 50 µg/l biotine. In the case of thiamine one strain showed maximum growth at 50 µg/l and the remaining 2 at 40 µg/l. In the case of ascorbic acid, 2 strains showed maximum growth at 120 µg/l and one strain at 140 µg/l.

Studies on the effect of cobalt showed that among the tested concentration of 50 to 500 µg/l, increasing growth was noticed up to 350 µg/l in A. chroococcum, 250 µg/l in A. vinelandii and 300 µg/l in A. beijerinckia. Zinc showed a pronounced effect on the growth of all the 9 strains of Azotobacter with positive growth response with increasing concentration.

Salinity and pH of the medium were observed to have significant influence on the growth and nitrogen fixation in the different Azotobacter strains. The optimum salinity for maximum growth and nitrogen fixation ranged from 25-30 ppt in the various strains, whereas the optimum pH varied from 6.5 - 8.0.

6.16.61. Studies on Endocrine Control of Growth and Reproduction of the Tiger Prawn Penaeus monodon Fabricius.

SRF: D. Mohana Rao
ST: A.D. Diwan

Research Completed
Thesis writing in progress

Neurosecretory system and neurosecretory cells (NSC) which are the main component of hormonal events were traced and identified in P. monodon. The NSC cells were classified into 5 types considering their tinctorial properties. Mapping of these cells were done in various endocrine organs like eyestalk, brain, thoracic ganglion and abdominal ganglion. Neurosecretory cell activity in the brain and thoracic ganglion was observed to be high during the active phase of maturation and moulting. The process of oogenesis was studied in detail and the whole developmental events of ovary were classified into 5 stages. While classifying the ovarian stages, colour of ovary, GSI and oocyte diameter were also taken into account. Effect of eyestalk ablation on moulting and growth was assessed. Unilateral and bilateral eyestalk ablation shortened the moulting period when compared to non-ablated prawns. Effects of other environmental parameters like light, pH, salinity and starvation on moulting was carried out. Lengthening of photoperiod has delayed the moulting period. The pH values of 7.5 and 9.5 of the medium were found to be favourable for moulting as moulting period in both pH observed to be same. Salinity of 10‰ was found to be good enough for moulting in early stages of growth. Salinity of 20‰ and 30‰ considerably increased the moulting period. Starved animals did not respond to moulting.

Moult classification was done based on setae morphology and cuticle histology. Neurosecretory activity in different endocrine centres was correlated with different stages of moult cycle, establishing possible control of endocrine on growth. The variations in biochemical constituents such as moisture, protein, lipid, carbohydrates and cholesterol nave been followed in the tissues like gonad, hepatopancreas, muscle and haemolymph in relation to maturation cycle and found to have tremendous change in behaviour of these organic constituents with maturation process.

6.16.62. Larval Biology of Spiny Lobsters of Genus Panulirus.

SRF: T.N. Sarasu
ST: M.J. George

Thesis submitted
Result awaited

The objectives of the study were, to trace the larval history of Panulirus homarus by rearing the larvae in the laboratory to the maximum stages possible, determination of the effect of different environmental parameters such as salinity, pH, temperature and dissolved oxygen on larval moulting and growth; and collection, identification and description of different species of spiny lobsters of Panulirus from the wild.

Berried P. homarus were collected, their eggs hatched in the laboratory and the phyllosoma reared in seawater with different grades of salinity, pH, temperature and dissolved oxygen. Nitrogen was passed through the seawater to obtain desired levels of dissolved oxygen. For the wild collection of phyllosoma larvae, the zooplankton collections of the FORV Sagar Sampada were analysed.

The phyllosoma larvae of P. homarus were reared from the 1st stage to the 4th stage on Artemia nauplii and jelly fishes as feed. More than one moult was observed between stages. The optimum level of salinity for the phyllosoma larvae was found in between 28 and 32 ppt. The pH suitable for the larval survial and moulting was 8.0-8.6. Optimum temperature for better growth of the larvae was 31^{o}C. More larvae moulted and survived in seawater with 4 ml/l of dissolved oxygen. The phyllosoma larvae obtained from the zooplankton collection of the FORV Sagar Sampada were found to include different stages of

P. homarus, P. versicolor, P. ornatus, P. longipes, P. penicillatus and P. polyphagus in the south-east coast of India where P. homarus and P. versicolor predominate. P. polyphagus larvae were found mainly in the north-west and Bengal coast of India. P. penicillatus and P. longipes are obtained form both the coasts of India.

6.16.63. Studies on the Digestive Enzymes in the Indian White Prawn Penaeus indicus H. Milne Edwards.

SRF: M. Hemambika
ST: R. Paul Raj

Research completed
Thesis writing in progress

Studies on morphology, histology and histochemistry and ultra structure of the hepatopancreas of P. indicus was carried out. The most salient finding is the identification of five different types of cells in the hepatopancreas of the prawn.

A survey of the digestive enzymes showed that the hepatopancreas is the main organ, which produces most of the enzymes. The important carbohydrate hydrolysing enzymes identified in the digestive gland are alpha-amylase, maltase, lactase and sucrase. The relative activity of proteolytic and lypolytic enzymes, and their specific activity were studied. Detailed studies were carried out on the effects of hydrogen ion concentration (pH), substrate concentration, incubation time, incubation temperature, salinity, metallic ions, aminoacids and vitamins on the activity of alpha amylase. Results of these studies showed that the alpha amylase has a maximum activity at pH ranging between 5.5 and 6.5 at constant temperature. The maximum hydrolysis of starch occurred within 15-20 minutes of incubation. The rate of enzymes hydrolysis increased with the time, reaching the maximum between 50-60 minutes followed by an abrupt decline after 60 minutes of incubation. The optimum temperature required for maximum activity was found to be between 40 and 50^{o}C. Hydrolysis of starch increased with increase in substrate concentration upto 1%. Thereafter a decrease in the hydrolysis rate was observed.

Fifteen metalic chlorides were tested for their effect on enzyme activity. Of these, chlorides of copper, mercury, aluminium and antimony inhibited the activity of alpha amylase. Nickel and cobalt chlorides at lower concentrations were highly effective in activating the enzymes, but higher concentrations inhibited the activity. Chlorides of Mn, Ca, Sr, Ba, K, Na, Mg and NH_4 activated amylase at the various tested concentrations.

Unilateral and bilateral eyestalk extirpation studies revealed that the hormonal secretion from the eyestalk has a significant role in controlling the activity of the enzymes. Bilateral ablation induced relatively higher amylase activity than unilateral ablation. But proteolytic and lypolytic activities were not significantly altered by ablation. Studies on the influence of diet on enzyme activity showed that alpha-amylase activity increases linearly with the increase of percentage of starch, with the maximum activity between 5-20% of starch in the diet. Maltase activity showed an optimum at 10% starch. Sucrase activity was relatively low. Alpha amylase has been purified through molecular exclusion chromatography and its purity has been determined.

6.16.64. Studies on Protein Metabolism in the Lobster Panulirus homarus (L).

SRF: Harry Cleetus
ST: P. Vedavyasa Rao

Research completed
Thesis writing in progress

The protein content in the haemolymph, muscle, hepatopancreas and gonads was studied. In the haemolymph, gradual build up of protein was recorded before moulting and a sudden drop in the earlier premoult stage. Eyestalk ablation studies revealed that bilateral ablated lobsters were highly sensitive to oxygen depletion. Ablation resulted in preccocious ovarian development, causing the production of abnormal eggs. Studies on changes in protein content were also carried out with reference to moulting, maturation and diurnal variations.

6.16.65. Studies on Calcium Metabolism in the Spiny Lobster Panulirus homarus.

SRF: K. Krishna Kumar
ST: P. Vedavyasa Rao

Research completed
Thesis writing in progress

The calcium content in the muscle, hepatopancreas and exoskeleton were studied. Analysis of blood calcium showed that it increases during the premoult stage and about 220-80% of the calcium is in bound form. Haemolymph calcium content was found to be more in the fully ripe lobsters than in the spent lobsters. The calcium regulation in seawater of different salinities were studied. The lobster was found to regulate calcium even in 40% sea water. In all the dilute media the haemolymph calcium was found to be maintained above that of the environmental calcium. Exposure to low pH (6.0 - 6.5) increased the haemolymph calcium content during the first few hours but returned to normalcy after 12-24 hours. Eyestalk ablation experiments revealed that the ablated lobsters resorb more calcium from the exoskeleton than the controll unablated lobsters. The haemolymph calcium showed a rhythmic pattern with time of day, with highest content during the night.

6.16.66. Physiology of Moulting in the Penaeid Prawn Penaeus indicus H. Milne Edwards.

SRF: K.K. Vijayan
ST: A.D. Diwan

Research completed
Thesis writing in progress

Based on histological details of cuticle and morphological characters of setae the moult cycle of P. indicus was classified into 8 well defined stages and the distribution pattern of nucleic acids (RNA and DNA) in the hepatopancreas and muscles in different moult stages studied. The maximum RNA content was obtained in stage 'D' and minimum in the postmoult stages 'A and B'. The pattern of fluctuations of RNA was found to clearly follow that of protein. The RNA/protein ratio in different moult stages showed maximum tissue build up in stage 'C' to 'D'. In the case of DNA, no significant change in hepatopancreas was noticed in different moult stages while in the muscle, DNA showed relatively higher values in the early postmoult and late premoult stages than in the intermoult and early premoult stages.

Glucosamine levels in haemolymph in different stages of moult cycle were determined following the modified methods of Elson and Morgan (1937). Higher values of glucosamine were recorded in the late premoult stages D_{2-3}.

6.16.67. Reproductive Physiology of the Indian Whiting Sillago sihama (Forskal).

SRF: P. Jayasankar
ST: K. Alagarswami

Research completed
Thesis writing in progress

Reproductive biology, histology, histochemistry, biochemistry and induced breeding are investigated at Mandapam in South India.

Biologically advanced stages of maturity occur in most of the months. Spawning, hence is a prolonged one and the fish may breed more than once in a year. Maximum fecundity is 34500. Size at first maturity is 186 mm for females and 158 mm for males.

Histologically stages of ova in Sillago sihama are chromatin nucleus stage, perinuclear stage, early and late yolk vescicle; primary, secondary and teritary yolk, globule stage, migrating nuclear stage and hyaline stage. In oocytes, nucleus is large. Oocytes are basophilic. The sperms, on the other hand, are acidophilic. In histochemical studies, various parts of the oocytes and sperms reacted differently to different stages making the investigations handy.

Biochemical investigations showed marked decline in the muscle protein of female, as it matures. Lipids also follow the same trend. Glycogen and cholesterol values are also lower in the muscle of ripe fish compared to the immature fish. Variation in water content has been slight. On the other hand, liver protein and lipid values are higher in the ripe fish than in the immature fish. Liver protein in the mature stage is more than that in the ripe stage, may be due to vitellogenesis using up the protein. As ovary gets ripe, marked

variations exist in almost all its constituents, proteins and lipids lower perceptibly while water content increases. Glycogen decreases regressively from immature to ripe stage. Variation in total carbohydrate is less marked in the females as also in males. Muscle cholesterol in the male declines drastically while variations in other constituents are less marked in the muscle. Liver protein and lipids decline in mature fish while glycogen and water content register increase. Lipids in testes reduce as the fish matures. Protein and cholesterol on the other hand increase.

Salinity manipulation and hormone administration were tried for induced maturation and spawning experiments. In salinity manipulation, fishes from 15 ppt were gradually acclimated to 23 ppt, when they spawned. Pituitary hormone of carp, human chorionic gonadotropin and chorionic gonadotropin were used in induced breeding experiments. These hormones were administered separately as also in combinations. Using carp pituitary hormone as prime dose and human chorionic gonadotropin as spawning dose was effective. Males became mature on receiving hormone doses, however, attempts to fertilize the ova were unsuccessful both in dried and wet mixing methods.

6.16.68. Environmental and Neuroendocrine Control of Reproduction in the Pearl Oyster.

SRF: P.K. Asokan
ST: K. Alagarswami

Research completed
Thesis writing in progress

With a view to study the effect of environmental conditions on maturation of pearl oyster, data were collected from Tuticorin on the chlorophyll, productivity, major nutrients in the water as well as changes in the condition of the gonads of the pearl oyster. Studies were also made on heavy metal concentrations in the tissues of the pearl oyster as well as the biochemical composition of the pearl oysters at different stages in maturity.

Investigations on the ultra structure of the neurosecretory system of the pearl oyster was made. Electron microscopic studies showed that the visceral ganglion of the pearl oyster contained mitochondria. The size of the neurosecretory granules varied from 1000 A^{o} to 1250 A^{o}. The number of granules were found to be about 58. The calcium content of the various tissues were determined using an atomic absorption spectrophotometer. Qualitative and quantitative variations in the lipid component during the gonadial maturation was also studied. The ultra structure of the spermatozoa was studied using electron microscope. The total length of the sperm was about 37 microns, the length of the head about 2.2 microns and the tail 35 microns. The acrosome has 0.3 microns, the head about 1.6 microns and the mid region 0.23 microns. The head is roughly spherical in shape. The calcium content indicated that it was highest in the gonad and lowest in the adductor muscle. Gel electrophoresis of immature male gonads, adductor muscle and hepatopancreas showed 14, 13, 15 protein fractions respectively. Major difference in the protein pattern was observed in the gonad. The 14th and 8th protein fraction in the fully mature animal showed thick bands compared to immature animals.

6.16.69. Reproductive Endocrinology of the Penaeid Prawn Penaeus indicus H. Milne Edwards, 1837.

SRF: S. Sunilkumar Mohamed
ST: A.D. Diwan

Research completed
Thesis writing in progress

Investigations on the process of oogenesis and spermatogenesis and concurrent changes occurring in the reproductive ducts (oviduct and vas deferens) were studied in detail. Oogenesis in P. indicus involves two distinct processes viz. proliferative and differentiative process. The proliferative process is involved in the formation of primary oocyte from the primary oogonial cells. In the differentiative process the primary oocytes are transformed into fully mature ova. The ovary was classified into 5 maturity stages based on its colour, GSI and oocyte diameter. Stage I represents the previtellogenic phase and stages II, III, IV and V represent the active vitellogenic phase. The process of spermatogenesis and sperm formation were studied in detail. Spermatozoa are observed to be packed in spermatophores within vas deferentia and stored in terminal ampoules. Fine structural studies revealed that P. indicus has highly polarized unistellate sperms.

The neuroendocrine and endocrine centres controlling reproductive processes were appraised by using histological and histochemical techniques. The NSC cells were classified into 5 different types based on their size, shape and tinctorial properties. Mapping of these cells were done in different endocrine centres. The other endocrine glands like Y-organ and androgenic gland which have a direct role in the reproductive processes were studied in detail.

The mechanism of neuroendocrine control of reproduction was studied in female and found that during immature stage NSC of the eyestalk were in an active phase. In the eyestalk of mature female very few NSC were active. Conversely, in cerebral and thoracic ganglion the NSC had large quantities of PAF positive material in cytoplasm. Unilateral and bilateral ablation experiments conducted revealed that in the unilateral ablation group the process of gonadal maturation was significantly enhanced. Bilaterally ablated animals never attained full maturity. Precocious gonadal maturation was arrested when eyestalk extract was administered into both the ablated groups. Administration of vertebrate gonadotropin resulted in partial development of the ovary.

The variations in biochemical constituents such as moisture, protein, lipid, carbohydrates, cholesterol, DNA, RNA and carotenoids had been followed in the different tissues and haemolymph in relation to maturation process. In the gonad, major constituents showed an increase with progression of maturity. In testis, protein and carbohydrate content showed variation with the stages. Hepatopancreatic tissue also showed fluctuation in biochemical constituents with the maturity stages. Further evidence also exists for the accumulation of organic reserves in the hepatopancreas during the spent stages and resorption. Biochemical constituents of haemolymph also showed significant fluctuations with the maturation process.

Bilateral andrectomy was carried out successfully in 17 male P. indicus. Out of these, 8 did not regenerate their petasma and appendix masculina. In the control group all the animals regenerated their petasma and appendix masculina within a span of 3 moult cycles (25 days).

Histological examination of the andrectomized male testis revealed that, unlike the normal testis, the lobes were empty in appearance with few spermatocyte and spermatid cells, due to the decrease in activity of the peripheral germinal epithelium.

These experiments suggest that the androgenic gland in P. indicus is responsible for the regeneration and in turn maintenance of the secondary sexual characters. Furthermore, the testicular activity is also under the control of this hormone.

6.16.70. Studies on Sea Grass Ecosystems Around Mandapam, South-East Coast of India.

SRF: T.R. Udhaya Shankar
ST: P.V. Ramachandran Nair

Discontinued

The environmental parameters (salinity, temperature, dissolved oxygen (DO), CO_3, HCO_3 and pH) collected from the sea grass beds in the Gulf of Mannar and Palk Bay area in the Mandapam region during January-March 1985 indicated that these parameters in the latter region were stable than in the former. While salinity and temperature of the water over the sea grass bed were comparable, fluctuations were recorded in the DO in one of the stations in the Gulf of Mannar and in CO_3 from station to station in both the areas. The organic carbon value in the mud samples was also higher at Gulf of Mannar. The productivity values determined for 5 species of sea grass around Mandapam area showed increased productivity value in respect of the sea grass Halodule uninerris during January-March 1985.

During the present study 8 species of sea grass were recorded. Among these Cymodocea serrulata is found to be the most abundant sea grass in Mandapam. The survey of the fauna of the sea grass beds revealed that the sea grass beds support many commercially important fishes and fingerlings like mullets, Gerres and the prawn Penaeus indicus.

6.16.71. Studies on the Effect of Steroid Hormones on the Growth and Biochemical Composition of the Mullet Liza parsia (Hamilton).

SRF: Bhaskar Laxman Jadhav
ST: R. Paul Raj

Research work in progress

Steroid hormones have been successfully utilized as anabolic agents as well as to induce maturation, spawning and control of sex in a number of species of fin fishes. The aim of the present investigation is to study the effect of administration of steroids on growth, food utilisation and biochemical composition of Liza parsia. Experiments are conducted using isocaloric and isonitrogenous compounded diets. Graded levels of hormones are used to determine the optimum hormones required in the diet. The androgen 17 α-methyl testosterone, diethyl stilbestrol and estrone have been incorporated in the diets and fed to experimental fish. 17 α-methyl testosterone gives relatively better growth and feed efficiency at lower dosages. Diethyl stilbestrol and estrone hormones also produce positive response, but at very low dosages.

6.16.72. Nutritional Requirements of the Fry and Fingerlings of the Mullet Liza parsia.

SRF: Kiron Viswanath
ST: R. Paul Raj

Research work in progress

This project is undertaken to determine the dietary requirements for macro and micronutrients by the young ones of Liza parsia. Also different natural protein and lipid sources are tested with a view to evolve nutritionally efficient, least-cost diet formulations. All the nutrient requirement studies are conducted in the laboratory, maintaining the fishes in ideal conditions. The protein and lipid requirement studies are conducted for 10 weeks each incorporating graded levels of purified nutrients. The percentage level of the nutrient which produce the best growth is determined. The essentiality of vitamins is determined in a 21 week experiment by adopting deletion technique. Also the optimum level of vitamins to be incorporated in the diet is determined.

The experiments on natural sources of protein and lipid as feed ingredients are conducted for 7 weeks. The protein sources studied include groundnut oil cake, coconut oil cake, soyabean meal, spirulina, fish meal, prawn waste and different combinations of the above ingredients. The different lipid sources tested are gingely oil, soyabean oil, groundnut oil, sunflower oil, sardine oil, beef tallow, shark liver oil, cod liver oil and their combinations. The best sources are identified for practical feed formulations. The nutritional status of the fish are evaluated through morphometric, biochemical, histological and haematological studies.

6.16.73. Biochemical Genetics of Commercially Important Penaeid Prawns.

SRF: P. Philip Samuel
ST: M.J. George

Research work in progress

To measure the content of intraspecies variation among spawning stocks of Penaeus indicus and Parapenaeopsis stylifera electrophoretic studies of gene enzyme variation in natural populations are undertaken. Racial divergence among geographically separated natural population is quantified through analysis for genetic variation in electrophoretically detectable proteins in specimens collected from Waltair, Madras, Tuticorin, Cochin and Bombay. Both sexes are represented in the collections used for the studies. Enzymes and proteins assayed in the different population are acid phosphatase, alcohol dehydrogenase, aldehyde oxidase, aldolase, alkaline phosphatase, esterase, L-glycerophosphate dehydrogenase, lactate dehydrogenase, malic enzyme, malate dehydrogenase, octonol dehydrogenase, proteins, phosphogluconate dehydrogenase, pyroline dehydrogenase and tetrazolium oxidase.

General protein patterns of closely related species like Penaeus pencillatus and P. merguiensis from Puri; P. canaliculatus, P. latisulcatus and P. japonicus from Madras; Parapenaeopsis hardwickii and P. sculptilis and Metapenaeus monoceros, M. affinis, M. brevicornis and M. kutchensis from Bombay are also analysed.

6.16.74. Role of Trace Elements on the Growth and Physiology of Selected Microalgae.

SRF: S. Srisudha
ST: P.V. Ramachandran Nair

Research work in progress

Trace elements, an important group of micronutrients are incorporated into essential organic molecules in photosynthetic reaction. Determination of the best combination of optimum concentration of trace elements namely Cu, Mn and Zn in the culture medium for growth of microalgae - Isochrysis galbana (flagellate) and Synechocystis salina (blue green alga) used as feed in the hatcheries of aquaculture system, is the objective of this investigation.

The uptake of Cu, Mn and Zn by I. galbana and S. salina under different induced environmental conditions - salinity, temperature and pH are studied in terms of cell counts, amount of chlorophyll and carotenoid pigments and rate of carbon fixation by C^{14} technique. All the experiments are of one month duration to monitor the growth variation in different phases of the life cycle. Studies on biochemical composition of the two microalgae are conducted at an interval of 5 days for a month with different concentrations of Cu, Mn and Zn for determination of the variation in contents of protein, carbohydrate and lipid. Metal speciation studies by anodic stripping voltametry are conducted in cultures of I. galbana and S. salina exposed to different periods of light for intercomparison of copper uptake. Synergestic and antagonistic effects of the three metals on the two species are also studied. Existence of copper is in the complex state in both the species.

Also interspecies differences are noticed. Quantitative estimation of algal pigments by thin layer chromatography is conducted with cultures of exponential phase. The concentrations of chlorophyll a, c, carotenoids and xanthophylls are determined to understand the variation under different metal concentrations.

Electron microscopic studies for understanding the toxicological response of algae to a higher level of copper show certain intracellular structural changes and disorganisation of photosynthetic lamellae in S. salina but appreciable disruption in cellular structure not observed in I. galbana.

Optimum concentrations of three metals accelarate the growth of algae by increasing the cell counts, chlorophyll a, c, carotenoids and the rate of carbon fixation. Higher salinity favours the growth of flagellates and lowers the growth of blue green algae. Higher pH inhibits growth in them. Biochemical composition - protein, lipid, carbohydrate show considerable variation in the different phases of the life cycle.

6.16.75. Ecology of Some Economically Important Marine Algae from Mandapam Region (South India).

SRF: G. Pandian
ST: P.V. Ramachandran Nair

Research work in progress

Ecological studies are made at Krusadi Island and Pudumadam from the intertidal areas and data on algal frequency, coverage, frequency-cover ratio and biomass are collected. In addition to these, data on algal biomass are also collected randomly through skin diving from subtidal areas of 0.5 m to 4.0 m depth at both places. Observations on environmental parameters such as pH, salinity, dissolved oxygen and nutrients are made from the 2 collection sites. Relative water movement is estimated using clod card method. Selected edible seaweeds from both places are chemically analysed for protein, carbohydrate and lipid contents. Physiological studies and investigation on calorific values are also carried out on them. Seasonal changes in growth and fruiting behaviours are investigated. Culture studies on Hydroclathrus clathratus, Colpomenia sinuosa, Gracilaria edulis, Gracilaria crassa, Ulva lactuca and Ulva fasciata in the laboratory with running seawater aquaria and also on controlled conditions are carried out.

A total of 12 species and 16 species of edible seaweeds are found to grow at Krusadi Island and Pudumadam respectively.

6.16.76. Studies on Pearl Sac Formation in the Indian Pearl Oyster Pinctada fucata (Gould).

SRF: Mini Thomas
ST: K. Alagarswami

Research work in progress

Quality of pearl sac derived from the transplanted mantle plays a vital role in producing better cultured pearls. Studies on pearl sac formation would be very valuable in standardising pearl oyster surgery techniques for achieving improved pearl production in terms of quality and quantity. Investigations are based on experimental surgery and post-operative rearing of pearl oysters in the farm using standard histological and histochemical techniques.

Basic studies on the histology of different layers of mantle in selected area, histochemistry of these areas with particular reference to marginal zone, inorganic chemicals present and studies of the periostracal groove are carried out. Studies on the growth of pearl sac under different environmental conditions such as temperature, O_2 availability and salinity; and physiological conditions like physical conditioning, induced spawning, different maturity stages and total starvation; and investigation on pearl sac formation in December, April and August representing winter, summer and windy seasons respectively are carried out. Pearl sacs under histological and histochemical studies are grown from different regions of mantle, implanted at different sites, and

oriented in different ways. The mantle material used are pre-treated in different ways. Graded concentrations of eosin, commercial physiological saline and sterilised double filtered seawater are used in the treatments. Exposing the mantle to ultraviolet light rays, giving cold treatments, preparing the graft before definite time intervals, transplanting the old pearl sacs and reusing the old and good pearl sacs are also done.

It is found from the studies made so far, that good quality pearls can be produced by selection of tissue for implantation.

6.16.77. Studies on the Digestive Enzymes of the Cultivable Grey Mullet Liza parsia (Hamilton & Buchanan 1822).

SRF: K. Palanisamy
ST: P.P. Pillai

Research work in progress

Information on changes in digestive secretions and enzyme activities will be necessary to understand digestive mechanisms, feeding habits and nutritional requirements. Crude digestive enzyme extracts of L. parsia are prepared from oesophagus, cardiac stomach, pyloric stomach, pyloric caeca, anterior intestine, posterior intestine, liver, spleen and gall bladder. Different carbohydrate substrates were tested with the crude enzyme extract of each region for their ability to hydrolyse them. Amylase activity is found to be distributed throughout the alimentary canal. All the substrates tested are hydrolysed except salicin and cellulose. Maximum activity of the enzymes are found in pyloric caeca and anterior intestine. The amylase activity is characterised in terms of optimum pH, temperature, substrate concentration, effect of different metallic chlorides, and stability of the enzyme.

The distribution profile of trypsin, chymotrypsin, carboxypeptidase A, carboxyopeptidase B, aminopeptidase, lipase, esterase, alkaline phosphatase and acid phosphatase are studied. The total protease activity has been characterised in terms of parameters like pH, temperature, substrate concentration, effect of inhibitors, stability of the enzyme with respect to pH, temperature and storage. Variations in enzyme activity with respect to season, age and size group, maturity stages and sexes are carried out. Changes in digestive enzyme activity after hatching has been studied for 30 days. Changes in digestive enzyme activity after feeding and effect of dietary change on the activities of digestive enzymes in juvenile stage of mullets have been studied. Since the mullets mainly feed on detritus in nature, studies on the role of micro organisms in digestion are also attempted.

6.16.78. Population Biology and Ecology of Artemia from the Salt Marshes of South-east Coast of India.

SRF: Joslet Mathew
ST: S. Kulasekhara Pandian

Research work in progress

Artemia is the best known live-feed for aquaculture. Information on population biology and ecology of Artemia in natural habitats from India is extremely poor and hence this study from salt marshes of south-east coast of India is being made. Survey on the relative abundance, distribution, size, age composition and reproductive biology of Artemia population in the high saline habitats form the major part of the study. Studies on the production of Artemia in controlled systems and identification of strains are also being made.

The development of Artemia population in the habitats of Tuticorin salt pans mainly depends on environmental parameters. Cysts hatch out during periods of low salinity. The nauplii feed voraciously on algae. In very high salinity nauplii production stops, giving way to cyst production. Propagation of Artemia population is through parthenogenesis, as only the females are encountered in this region.

6.16.79. Nature and Ecological Significance of Nutrient Regeneration in Different Prawn Culture Fields.

SRF: K.K. Joshi
ST: P.P. Pillai

Research work in progress

The area of particular interest for increasing our understanding of the function of culture ecosystem are chiefly the nature of housed and supplied nutrients, their spatial and temporal distribution, seasonal availability and regeneration and energy relationships at the water-sediment interface. The present investigation has been taken up to study the nature and significance of nutrients and their regeneration in different prawn culture fields.

Measurement of hydrographical parameters such as temperature, pH, Eh, dissolved oxygen, calcium content in the sediment and overlying water are investigated from seasonal fields, perennial fields and coconutgrove-cum-prawn farming fields. The water samples are also analysed for nutrients like phosphate, nitrate, nitrite and silicate. Besides, studies are also being made on the primary productivity, and chemical composition of particulate organic matter and dissolved organic matter.

Fluctuations in water temperature during different seasons are very low, ranging from $27^{o}C$ to $33^{o}C$. The temperature is at its maximum during premonsoon months extending up to June after which with the onset of monsoon it declines. Salinity fluctuates widely in prawn culture fields because of the influence of monsoon and consequent

run off from land. During the premonsoon period, the salinity of all stations exhibits considerable increase. During monsoon months large quantities of freshwater enter and lowering of salinity occurs. The dissolved oxygen content of the water does not show much fluctuations though relatively higner values are found during monsoon period. The nitrite value is maximum during monsoon and postmonsoon seasons. Nitrate value shows wide fluctuations in different seasons. The inorganic phosphates are maximum during pre and postmonsoon periods. The silicate values are high during monsoon months.

6.16.80. Studies on Some Aspects of the Reproductive Physiology of the Female Grey Mullet Mugil Cephalus L.

SRF: A. Gopalakrishnan
ST: P.P. Pillai

Research work in progress

Induced breeding of Mugil cephalus in India is not yet successful. Information on biochemical changes occurring in different tissues during the maturation process and histochemical changes occurring in the ovary of M. cephalus are lacking. Work on the reproductive physiology of female fish of the species is, therefore undertaken. Breeding season, fecundity, gonadosomatic index of the species; histology of oogenesis and vitellogenesis, histochemistry of oogenesis, and developmental stages in the ovary are investigated. Biochemical analyses of total protein, carbohydrates, lipids, cholesterol, DNA, RNA, etc. to know the mobilisation of these components during the maturation of ovary in different tissues like liver, ovary, muscle and blood, are undertaken. Histochemical studies on the localization of steroidogenic tissues of the ovary, identification of the female specific vitellogenic protein bands in the electrophorograms of ovary and blood during the maturation of ovary, and ultrastructure studies on the oocytes and follicle cells during ovarian development also form part of the investigations.

6.16.81. Studies on the Pathology of Penaeid Larvae and Post-Larvae.

SRF: A. Sait Sahul Hameed
ST: P. Vedavyasa Rao

Research work in progress

Diseases contribute significantly to mortalities ranging from 1 to 100% of larvae and post-larvae of prawns in hatcheries. Investigations are therefore being carried out on the pathological conditions of larvae and post-larvae of Penaeus indicus at Narakkal Prawn Culture Laboratory, Cochin and Kovalam Prawn Culture Laboratory, Madras. Side by side studies on the wild stock are also being undertaken.

Abnormality in the eye in post-larvae, deformity probably due to bacterium V. algiolyticus, infestation of mysis stage by Vorticella sp., infestation by amoeboflagellate in nauplii, protozoea and mysis stage, infestation of mysis stage by Nitzschia closterim, whirling disease of post-larvae, appendage rot in mysis due to bacteria and soft prawn are some reasons that cause mortality in the larval stages. Bacteria from diseased specimens are isolated and identified. Comparative pathogenicity of different marine species of Vibrio, and histopathological studies on larval stages are being made. Remedial measures also become part of the investigations.

6.16.82. Studies on the Ecology and Production of Algae in Prawn Culture Systems.

SRF: R. Devapiriyan
ST: P.P. Pillai

Research work in progress

There is a close relationship between plankton abundance and fish and prawn production, because plankton is at the base of the food web. The fish/prawn culturist can obtain information on the continuing condition of the plankton community and on the supply of food organisms in the culture systems. In prawn and fish culture systems, different algal forms exhibit seasonal variations and varying succession patterns. These algal forms belong mainly to Bacillariophyceae, Dinophyceae, Cyanophyceae and flagellates. The actual triggering factors vary with the ecosystem. Very often, it is the relative proportion of the macro and micronutrients that determine the succession pattern. Nutrient analysis of water and sediment, studies on the seasonal variation of algae, succession pattern, measurement of primary production and chlorophylls, measurement of hydrological conditions and gut analysis of prawn and fish are, therefore carried out and the work is in progress.

6.16.83. Ecological Characteristics of Prawn Culture Fields in Cochin Area.

SRF: P.G. Joseph Gilbert
ST: P.S.B.R. James

Undergoing 2nd semester of course work and research work also commenced at Cochin.

6.16.84. Studies on Reproductive Physiology of Lates calcarifer.

SRF: Kuldeep Kumar Lal
ST: P.S.B.R. James

Undergoing 2nd semester of course work and research work also commenced at Tuticorin.

6.16.85. Studies on Microbiological Decomposition and Recycling of Organic Matter in Brackishwater Culture Ponds of Cochin.

SRF: K. Sureshkumar
ST: V. Chandrika

Undergoing 2nd semester of course work and research work also commenced at Cochin.

6.16.86. Studies on Haemolymph of the Prawn Penaeus indicus. H. Milne Edwards.

SRF: P. Laxmi Latha
ST. A. Laxminarayana

Undergoing 2nd semester of course work and research work also commenced at Cochin.

6.16.87. Studies on Selected Isozymes in Crassostrea madrasensis

SRF: Annie Mathew
ST: A.G. Ponniah

Undergoing 2nd semester of course work and research work also commenced at Cochin.

6.16.88. Studies on Penaeid Prawn Seed in Selected Centres in the Cochin Backwater.

SRF: Mary Mathews
ST: K.J. Mathew

Undergoing 2nd semester of course work and research work also commenced at Cochin.

6.16.89. Studies on the Reproductive Physiology of Liza parsia in Relation to Hormonal Application.

SRF: Sally Anne Thomas
ST: L. Krishnan

Undergoing 2nd semester of course work and research work also commenced at Cochin.

6.16.90. Studies on the Effect of Pollution on Distribution and Physiology of Selected Seaweeds.

SRF: Gulshad Mohammed
ST: V.S.K. Chennubhotla

Undergoing 2nd semester of course work and research work also commenced at Tuticorin.

6.16.91. Electrophoretic Studies on the Grey Mullet Mugil cephalus (L).

SRF: S. Vijayakumar
ST: M.K. George

Undergoing 2nd semester of course work and research work also commenced at Cochin.

6.17. LIST OF PUBLICATIONS - MANUALS

1. Manual of research methods for crustacean biochemistry and physiology. CMFRI Special Publication No. 7, 1981, 172 pp.

2. Manual of research methods for fish and shellfish nutrition. CMFRI Special Publication No. 8, 1981, 125 pp.

3. Manual of research methods for marine invertebrate reproduction. CMFRI Special Publication No. 9, 1982, 214 pp.

4. Approaches to finfish and shellfish pathology investigations. CMFRI Special Publication No. 11, 1983, 43 pp.

5. Application of genetics in aquaculture. CMFRI Special Publication No. 13, 1983, 90 pp.

6. Manual of research methods for invertebrate endocrinology. CMFRI Special Publication No. 14, 1983, 114 pp.

7. Production and use of Artemia in aquaculture. CMFRI Special Publication No. 15, 1984, 74 pp.

8. Manual on marine toxins in bivalve molluscs and general consideration of shellfish sanitation. CMFRI Special Publication No. 16, 1984, 100 pp.

9. Handbook on diagnosis and control of bacterial diseases in finfish and shellfish culture. CMFRI Special Publication No. 17, 1984, 50 pp.

10. Mariculture research under the Centre of Advanced Studies in Mariculture. CMFRI Special Publication No. 19, 1984, 109 pp.

11. Water quality management in aquaculture. CMFRI Special Publication No. 22, 1985, 96 pp.

12. A practical manual for studies of environmental physiology and biochemistry of culturable marine organisms. CMFRI Special Publication No. 25, 1986, 45 pp.

13. Theorems of environmental adaptation. CMFRI Special Publication No. 26, 1986, 50 pp.

14. Nutritive value of live feed organisms and their enrichment. (Accepted for publication)

15. Neuroendocrine research and techniques. (Accepted for publication)

16. Techniques for estimation of bilateral growth rates and productivity in aquaculture pond system. (Accepted for publication)

17. Approaches to physiological studies on moult cycle in crustacea. (Final manuscript awaited)

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1.	Asha Narayan, George, K.C. and Diwan, A.D.	1984	Morpho-histology of the pituitary gland of the estuarine teleost fish Valmugil cunnesius (Valenciennes). Proc. Indian Acad. Sci. (Anim. Sci.)., 93 (6): 565-571.
2.	Asha Narayan, George, K.C. and Diwan, A.D.	1985	Histology of the pituitary gland of the grey mullet, Mugil cephalus L. J. Fish. Biol., 26: 381-390.
3.	Ajitha Kumar, B.S. and Alagarswami, K.	1986	Effect of pollution due to coconut husk retting on reproductive potential of green mussel, Perna viridis. National Seminar on Mussel Watch, Cochin Univ. of Sci. & Technology, 1986.
4.	Anuradha Krishnan and Alagarswami, K.	1987	Influence of larval density on rearing of Pinctada fucata larvae. Abstract submitted to the National Seminar on Shellfish Resources and Farming at Tuticorin, 1987.
5.	Chandge, M.S. and Paul Raj, R.	1987	Nutritive value of a few dietary lipid sources for juveniles of prawn Penaeus indicus. National Symposium of Physiology of Crustacea, Aurangabad University, 1987.
6.	Charles John Bhaskar and Syed Ahamed Ali.	1984	Protein requirement of post-larvae of Penaeus indivus using purified diets. Indian J. Fish., 31 (1): 74-81.
7.	Diwan, A.D.	1984	Neurological endocrinology: The co-ordinating mechanism. Science Reporter, 442 p.

8. Diwan, A.D. 1985 " Waste Not Want Not ". Science Today, 28.

9. Diwan, A.D. and Usha, T. 1985 Characterisation of moult stages of Penaeus indicus based on developing uropod setae and some closely allied structures. Indian J. Fish., 32 (2): 275-279.

10. Gopal, C. and Paul Raj, R. 1987 The effects of dietary protein levels and protein sources on the protein conversion and ammonia excretion in juvenile Penaeus indicus. National Symposium of Physiology of Crustacea, Aurangabad University, 1987.

11. Jayasankar, P. and Muthu, M.S. 1983 Toxicity of ammonia to the larvae of Penaeus indicus H. Milne Edwards. Indian J. Fish., 30 (1): 1-12.

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13. Joseph Gilbert P.G. and Pillai, V.K. 1987 Lime requirement of pond soils for aquaculture around Cochin backwaters. Mar. Fish. Infor. Ser. T & E Ser.71.

14. Joseph Gilbert, P.G. and Pillai, V.K. Physico-chemical characteristics of soils in the aquaculture systems of Cochin estuarine area. (Journal of Tropical Aquaculture, Oxford University Press, Calcutta - Communicated).

15. Kalyanaraman, M. and Paul Raj, R. 1985 Effect of salinity on the food intake, growth, conversion efficiency and proximate composition of post- larval Penaeus indicus. 2nd Indo-Pacific and 4th All India Symposium of Invertebrate Reproduction, Madras.

16. Kiron, V. 1986 Tilapia: The Aqua-Chicken. Fishing Chimes. 6 (8): 9-15.

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6.19. STATEMENT OF EXPENDITURE IN RUPEES

Head	1980-'81	1981-'82	1982-'83	1983-'84	1984-'85	1985-'86	Total
Pay and Allowances	50,238	115,006	150,433	181,390	225,685	242,165	964,917
TA/DA	950	6,277	5,342	2,206	3,687	1,560	20,022
Fellowship/Scholarship	37,160	113,922	194,983	285,562	330,901	548,700	1,511,228
Seminar/Workshops	15,650	8,000	10,000	5,080	-	-	38,730
Recurring Expenditure	70,328	154,632	221,030	189,562	143,890	117,435	896,877
Non-recurring Expenditure	41,340	72,913	100,000	65,584	62,721	23,740	366,298
Total	215,666	470,750	681,788	729,384	766,884	933,600	3,798,072

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