Department of Master Of Fisheries Science
in
(Aquaculture)

Course Contents & Syllabi

SRI DEV SUMAN UTTARAKHAND University
Badshahithol, Tehri (Grahwal)
Uttarakhand

To,

The Honorable Vice Chancellor,

Sri Dev Suman Uttarakhand University,

Badshahithol,Tehri (Garhwal) Uttarakhand

Sub :- Syllabus of Master Of Fisheries Science Programs in Aquaculture in semester system.

Respected Sir,

Please find enclosed the syllabus of M..FSc. Master Of Fisheries Science Programs in Aquaculture as per the semester system.

Thanking you,

Yours sincerely,

Dr Devendra Singh Rawat,

Department of Zoology (Fisheries Science),

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Curriculum of M.FSc. In Aqaculture

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PREAMBLE

Fisheries has been in limelight during the past three decades as the fastest growing food production system. Capture and Culture Fisheries are vibrant economic activities contributing to agricultural (4.6% GDP) and national economy (1.3% GDP), livelihood and nutritional security, employment generation (11 million people) and foreign exchange earnings (Rs. 8364 crore in 2006-07). Aquaculture sector has witnessed spectacular production increases over the past two decades, driven by technological developments and increased demand for fish. The overriding challenges facing the fisheries sector have been and still are production of adequate and cheap food fish for all and improve the quality of life of fishers and farmers. This could be achieved only by addressing the issues of underutilization and low productivity in inland water bodies, sustainability of capture fisheries, huge post-harvest losses, poor quality and low value addition, unregulated domestic markets and protective global markets, and the low level of domestic fishconsumption. However, the extent and quality of development is largely conditioned by the given policy environment and the quality of available Human Resources. Lack of comprehensive and enabling policy framework at Central and State levels, lack of adequate and professionally skilled human resource resulting in poor implementation of development and welfare programmes, ineffective and redundant services delivery systems, and poor infrastructure development have almost limited the scope of fisheries development in India. Ironically, the importance of policy and HRD has not been given sufficient attention so far. In this context, generating competent professional human resource would be one of the most critical inputs in driving the engine of sustainable fisheries and further development of aquaculture by realising the immense potential for horizontal and vertical expansion.

Globalisation like in other sectors has thrown up opportunities and risks in the fisheries sector also, necessitating changes in policy and governance in order to maximize benefits and minimize risks through sustainable and responsible fisheries management and production. Further, it is having a profound effect on education too, transforming the economies into knowledge based service and innovation economies. Agricultural education in general and fisheries education in particular is no exception. For higher education leaders in India (SAUs/DUs), this new environment holds both threats and opportunities. To benefit from the opportunities as well as address the challenges, fisheries education system should be subjected to constant innovations and reforms, particularly with respect to redesigning of curricula and syllabi, innovative pedagogy, developmental orientation, entrepreneurship, soft skill development, etc. This is a necessary condition to prepare the graduates and equip them to not only effectively respond to the emerging needs and challenges, but also to become creative and proactive partners in piloting this knowledge-led revolution.

Keeping this in view, the ICAR which is vested with responsibilities of guiding and coordinating agricultural education in the country took several steps to ensure quality education to meet the ever changing national and global scenario in fisheries sciences. One of these steps was to set up an Accreditation Board, which among other things is required to periodically assess the curricula of various educational programmes offered by National Agricultural Education System and suggest modifications. Fisheries education in India, since the establishment of the Central

nstitute of Fisheries Education in 1961 for in service training and later the establishment of the first Fisheries College at Mangalore under the SAU system in 1969, has grown manifold and evolved in the last four decades as a professional discipline consisting of Bachelors, Masters and Doctoral programmes in various branches of Fisheries Science. At present, 16 Fisheries Colleges offer four-year degree programme in Bachelor of Fisheries Science (B.F.Sc.), while 10 of them offer Masters and 6 Doctoral programmes. The undergraduate curricula and syllabi were periodically revised and the most recent exercise was undertaken in 2006. All the Fisheries Colleges are in the process of adapting these, bringing in parity of standards between Colleges.
Restructuring of postgraduate curricula and syllabi to upgrade the competence and standard of human resource in fisheries has been felt for quite some time. Only one such exercise was carried out in 2002 to revise the Masters curricula and syllabi, but not that of Doctoral programme. Even the revised Masters syllabi have not been adapted by majority of the Fisheries Colleges. The present exercise of revising and reorienting the postgraduate curricula was initiated by ICAR in 2007 through the constitution of a National Core Group, drawing experts from various fields of Agriculture. Further, in early 2008, eighteen Broad Subject Matter Area (BSMA) Committees were constituted to carry out the massive exercise of restructuring the curricula and syllabi of various Masters and Doctoral programmes. One of the BSMA committees was for Fisheries Science which had its first meeting in March 2008 at CIFE, Mumbai to decide on the nomenclature and number of specializations to be offered at Masters and Doctoral levels and also the broad curricula.
We hope that this document will serve as a guide and help in achieving uniformly high standards in postgraduate education in Fisheries Science across the country as well as uttrakahand.

Career opportunities

MFSc & BFSC graduates can find job in nationalized banks, fisheries department &research etc which functions in the public sector. They can also get placed in organizations involved in seafood exports, feed manufacturing units etc. They can also find self employment in the respective field.

Eligibility for Admission:

A) Candidate possessing B.F.Sc. Degree & B.Sc. degree in Life Science, Biotechnology and Zoology,Botany,Chemistry are also eligible:

Department of Master of Fisheries Science (M.FSc) Programs
In Aquaculture

FIRST SEMESTER (Theory & Practicals)				
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	MFSc 401	SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE	60	40
2	MFSc 402	SUSTAINABLE AQUACULTURE	60	40
3	MFSc 403	FISH NUTRITION	60	40
4	MFSc 404	FISH AND SHELLFISH HEALTH MANAGEMENT	60	40
5	MFSc 405	Practical 1 (Based on paper 1 & 2)	60	40
6	MFSc 406	Practical 2 (Based on paper 3 & 4)	60	40

SECOND SEMESTER (Theory & Practicals)				
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	MFSc 407	SEED PRODUCTION OF CULTIVABLE FINFISHES	60	40
2	MFSc 408	PRINCIPLES OF FISH GENETICS AND BREEDING	60	40
3	MFSc 409	ORNAMENTAL FISHES AND AQUARIUM MANAGEMENT	60	40
4	MFSc 410	RIVERINE WATER AQUACULTURE AND FRESHWATER CULTURE	60	40
5	MFSc 411	Practical 1*(Based on paper 1& 2)	60	40
6	MFSc 412	Practical 2 (Based on paper 3 &4)	60	40

THIRD SEMESTER (Theory & Practicals)				
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	MSFT 413	AQUACULTURE BIOTECHNOLOGY	60	40
2	MSFT 414	LARVAL NUTRITION AND CULTURE OF FISH FOOD ORGANISMS	60	40
3	MSFT 415	FISH AND SHELLFISH PHYSIOLOGY AND ENDOCRINOLOGY	60	40
4	MSFT 416	AQUACULTURE AND ENVIRONMENT	60	40
5	MSFT 417	Practical 1 (Based on paper 1 & 2)	60	40
6	MSFT 418	Practical 1 (Based on paper 3 & 4)	60	40

FOURTH SEMESTER (Theory & Practicals)				
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	MSFT 419	APPLICATION OF REMOTE SENSING AND GIS IN HILL STREAM FISHERIES	60	40
	MSFT420	Aquaculture & Fishery Science	60	40
	MSFT 421	Practical (based onPaper 1&2)	60	40
1	MSFT 122	Thesis Research and Presentation	160	40

M.F.Sc. (Aquaculture) Program Structure and Major Courses

Semester-I

M.FSc 401-SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE (2+1)

Objectives: To learn effective soil and water quality management practices

Theory:

Unit-1

Soil and water interaction: Physical and chemical properties of soil and water,Productivity Vs nutrient quality and quantity of soil and water; aquatic microorganisms and their role in carbon, nitrogen, phosphorus and sulphur cycles and impact on aquatic habitats & Species.

Unit-2

Soil and water quality monitoring: soil and water quality standards; soil and water quality monitoring and management.Fertilizers and manures: Different kinds of fertilizers and manures, fertilizer grade, source, rate and frequency of application,

Unit-3

Biofertilizers, Use of treated sewage for pond fertilization, Ecological changes taking place after fertilizing,Primary production, degradation of molecules in aquatic environment, Utilization of bioactive compounds by microorganisms.

Unit-4

Soil and water quality management: Cat clay/pyrite soil, seepage, water treatment, water filtration devices ,aeration, chlorination, ozonization and UV radiation, Algal bloom control, eutrophication, Aquatic weed management,

Unit-5

Waste water treatment practices, Water quality management in hatcheries,Waste discharge standards, Role of microorganisms in fish production, fish health and fish safety; Microbial load and algal blooms.

Practical

Soil and water quality parameters,
Application of fertilizers and assessment of primary productivity,
Analysis of toxic elements,
Microbial techniques,
Visit to effluent treatment plant
Design and operation of biological filters,
Equipment used in soil and water analysis.

Suggested Readings

Boyd. C.E. 1979. Water quality in warm water fish ponds, Agric. Exper. Stn.
Bxper. Stn. Auburn. University, 359 pp.
APHA
AOAC

List of journals

Toxic Environmental Chemistry
Journal of Applied Aquaculture
Journal of Environmental Research
Asian Journal of Microbiology Biotechnology Environmental Science
Hydrobiologia,
Limnology and oceanography

Research area

Carbon-nitrogen ratio in pond productivity
Adverse effects of chemical fertilizer application
Biofertilizers in pond productivity
Quantification of phosphorus as a limiting factor in different types of soils
Control of Cyanobacteria through nutrient manipulation.

M.FSc 402: SUSTAINABLE AQUACULTURE (2+1)

Objective

To gain knowledge on sustainable aquaculture practices

Theory

Unit-1

Present scenario and problems: Trends in global and Indian aquaculture; different farming systems; intensive systems and constraints- environmental degradation and disease outbreaks.

Unit-2

Environmental issues: Exotic species introduction; escapement; contamination of indigenous gene pool; salinization of soil and water; environmental impact; over exploitation of wild stocks; mangrove deforestation.

Unit-3

Socio-economic issues: Conflicts over water and land use; conflicts of interest between aqua farmers and fishermen; resistance from local public; anti-dumping duties.

Unit-4

Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture;

Unit-5

bioremediation; role of biotechnology, traceability.Economic viability: export vs. domestic marketing, value addition.

Practicals:

Visit to conventional aquafarm to see the management of used water.
Survey on environmental impact nearby aquaculture farms.
Setting model for sustainable aquaculture (organic farm, integrated farm).
Remote sensing and GIS (geographical information system) in Environment impact assessment (EIA).
Economic evaluation of aquaculture practices.

Suggested Readings:

James P. Mc Vey. 1983: Handbook of Mariculture Vol. I. Crustacean Aquaculture. CRC Press. Inc. Florida; 442 pp.
Pillay, T.V.R. & Dill, W.M.A. 1988. Advances in Aquaculture.
Pillay. T.V.R. & M.N. Kutty, 2005: Aquaculture – Principles and Practices , Black Well Sciences, U.K.
Takeo Imai, 1978: Aquaculture in shallow seas. Progress in shallow . Sea culture Amerind Publishing Co. Pvt. Ltd. New Delhi. 613 pp.
Bardach, E.J. Rhyther, J.H. & W.O. Mc. Larney. 1972: Aquaculture. The Farming and Husbandry of freshwater and Marine Organisms. John Wiley and Sons. New York: 868 p.

List of journals:

Applied Fisheries and Aquaculture.
Aquaculture Research.
Aquaculture.

Research area:

Development of value added products
Strategies for domestic marketing of fresh farmed fish and shrimp
Organic farming of fish and shrimp
Model for traceability

M.FSc 403 FISH NUTRITION (2+1)

Objective: To create basic understanding of the nutritional requirements of fish/shellfish.

Theory:

Unit-1

Fish nutrition: Principles of fish nutrition and terminologies.Nutritional requirements of cultivable finfish and shellfish: larvae, juveniles and adults; role of natural food in fish nutrition.

Unit-2

Role of nutrients: amino acids, fatty acids, proteins, lipids, carbohydrates,vitamins and minerals.Nutritional biochemistry: Classification, nutrient quality and evaluation of proteins, lipids and amino acids; intermediary metabolism.

Unit-3

Nutritional bioenergetics: Energy requirement of fishes, Protein to energy ratio,digestible energy, nitrogen balance index, Protein sparing effect, high energy feeds, isocaloric diets.

Unit-4

Nutritional physiology: Digestion, accretions and nutrient flow, Factors affecting digestibility.
Feed technology: Feed ingredients and their composition, feed formulation,preparation and evaluation; digestibility of feeds, feed additives (attractants, growth stimulants and probiotics) and binders, stability and storage properties of feed

Unit 5

Nutritional pathology: Antinutritional factors and antimetabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms.Feeding management: methods of feeding, ration size and frequency, feed performance and economics.

Practical

Formulation and preparation of a balanced fish feed Feeding trials
Proximate analysis- moisture, crude protein, crude lipid ,ash , acid insoluble ash content of feed.
Estimation of crude fibre, nitrogen free extract, calcium and phosphorus content of feed
Estimation of protein and lipid quality
Determination of gross energy content of feed and feed ingredients
Determination of the digestibility of feed using markers
Estimation of FCR from feeding trials and preparation of feeding table
Estimation of growth parameters from feeding trials.
Analysis of mycotoxins from feed ingredients/feed.
Gut content analysis to study artificial and natural food intake

Suggested readings

ADCP (Aquaculture Development and Co-ordination Programme) 1980.
Fish Feed Technology, ADCP/REP/80/11.FAO, Rome.
D' Abramo, LR., Conklin, D.E and Aklyama. D.M, 1977, Crustacean Nutrition:
Advances in Aquaculture Vol. 6. World Aquaculture Society, Baton Roughe, L.A..
Guillame, J., Kaushik, S., Berqot P., and Metallier, R., 2001. Nutrition and feeding
of fish and crustaceans, Springer Praxis Publishing, Chichester, UK.
Halver J.E. 1989. Fish Nutrition, Academic Press, San Diego, CA.
Halver, J.E, and Tlews, K.T. 1979. Finfish nutrition and fishfeed technology Vol. I
and II Heenemann, Berlin.
Hepher, B. 1988. Nutrition of pond fishes.
Lavens, P. and Sorgeloos, P. 1996. Manual on the production and use of live food
for aquaculture FAO Fisheries Technical Paper 361, FAO, Rome.
Lovell, T., 1988. Nutrition and Feeding of Fish. Kluwer Academic Publishers.
Muir J.F., and Robert Donald (Eds.) 1968. Recent Advances in Aquaculture Vol.II. Blackwell Science.
NRC (National Research Council), 1993. Nutrient requirements of fish. National Academy Press, Washington.
New, M.B. 1987. Feed and feeding of fish and shrimp. A manual on the preparation and preservation of compound feeds for shrimp and fish in aquaculture. F.A.O. Rome – ADCP/REP/87/26.
Halver, J and Hardy, R.W. 2002. Fish nutrition. Academic press, London. 824 p
Sena S.De Silva, Trevor A.Anderson. 1995. Fish Nutrition in Aquaculture,
Chapman & Hall Aquaculture Series, London.
Lovell, R.T. 1998. Nutrition and Feeding of Fishes, Chapman & Hall, New York
NRC. Nutrient Requirements of Warm Water Fishes. National Academy of
Sciences, Washington.
Houlihan, D., Boujard, T and Jobling, M. 2001. Food intake in fish. Blackwell
science Ltd, London.
Joachim W. Hertrampf and Felicitas Piedad-Pascual. 2000. Handbook on ingredients for aquaculture feeds. Kluwer Academic Publishers, London.

List of Journals
Aquaculture nutrition.
Annual review of nutrition.
Annals of nutrition and metabolism.
Animal nutrition and feed technology.
Animal feed sciences and technology.
Indian journal of animal nutrition.
Annual review of physiology.

Research area
Specific requirement of amino and fatty acids.
To develop fish and shrimp maturation diets
Energy requirement of different cultivable species
Alternative protein sources
Nutraceuticals for aquaculture feed.

M.FSc 404 FISH AND SHELLFISH HEALTH MANAGEMENT (2+1)

Objectives:To provide the holistic knowledge on fish and shellfish pathogens, and its control measures.

Theory

Unit-1
Basics of fish and shellfish health management: Host-pathogen-environment relationship, Management of culture systems, Environmental stress.

Unit-2
Diseases in aquaculture: parasitic, bacterial, viral and fungal pathogens of fish and shellfish. Water, soil, environmental parameters and their effects on fish health. Disease in hatcheries and grow out systems. Epidemiology of diseases,

Unit-3
nutritional pathology:Techniques in health management: Microbiological, haematological, histopathological, immunological and molecular techniques. Disease surveillance and reporting.

Unit-4
Defence system in fish and shellfish: Defence systems in fish, innate and acquired immunity, inflammation response to diseases. Antibody and cell mediated immunity in fish and shellfish.

Unit-5
Methods for disease control and management. Environment management, chemotherapeutic agents, host management, prophylaxis- vaccines, adjuvants, immunostimulants and probiotics. Use and abuse of antibiotics and chemicals in health management. Fish health and quarantine systems. Seed certification, SPFand SPR.

Practical
Microbiological Techniques.
Histopathology.
Molecular and immunological techniques.

Biochemical tests.
PCR.
ELISA.
Agglutination test.
Challenge tests of seed.
Isolation of bacteria from sample and biochemical tests.
Purification of virus.
Stress related study of fish and shellfish.

Suggested Readings

Aline, W. 1980. Fish diseases, Spranger – Verlay, Berlin Heidelberg, New York.
Schaperclaus, W. 1986. Fish diseases (Vol. I & II)., Oxonian Press Pvt. Ltd.
Wedmeyer, G. Meyer, F.P. and Smith, L., 1999. Environmental Stress and Fish Diseases, Narendra Publishing House, Delhi. P. 192.
Ronald J. Roberts Ed. 1989. Fish Pathology. 2nd Edition, Baillere Tindall, London.
Carl, J. Sindermann 1990. Principal diseases of Marine Fish and Shelfish. Vol. I &
II, Second Edition. Academic Press.
Woo, P.T.K.and Bruno, D.W. (Eds.) 1999. Fish Diseases and Disorders. Vol. 3.
Viral, Bacterial and Fungal Infection. LAB International Publishing.
Geroge Iwama and Teruyuki Nakanishi (Eds.) 1996. The Fish Immune system –Organism, Pathogen and Environment. Academic Press Publication.
Austin, B. and Austin, D.A. 1987. Bacterial Fish Pathogens (Diseases in Farm and Wild). Ellis Horward Ud.
Valerie Inglis, Ronald J. Roberts and Niall R. Bromage 1993. Bacterial Diseases of Fish. Blackwell Scientific Publication, London.
Chris Andrews, Adrian Excell and Neville Carrington 1988. The Manual of Fish Health. Publ. By Salamander Books Ltd., London.
Felix, S. Riji John, K, Prince Jeyaseelan, M.J. and Sundararaj V. 2001.Fish Disease
Diagnosis and Health Management. Publication by Fisheries College and Research, Institute, T.N. Veterinary and Animal Sciences University.
Thoothukkudi Shankar. K.M. and Mohan. C.V. 2002. Fish and Shellfish Health Management,UNESCO Publication.
Andrews, C, Excell A and Carrington, N. 1988. The manual of fish health.
Salamander Book Ltd. Londaon. pp.209.

List of journals

Applied Fisheries and Aquaculture.
Aquaculture Research.
Aquaculture.
Journal of Fish Diseases.
Diseases of Aquatic Organisms.
Fish & Shellfish Immunology.

Research area

Control of bioluminescent bacteria (LB) in aquaculture systems Standardization of chemicals used in controlling diseases Antibiotic residues in the culture systems

Semester II

M.F.Sc. 407: SEED PRODUCTION OF CULTIVABLE FINFISHES (2+1)

Objectives:To learn seed production and hatchery management of commercially important cultivable fishes.

Theory:

Unit-1

Introduction: History, constraints and current status of natural seed collection and hatchery seed production.

Unit 2

Reproductive biology: Development, maturation and maintenance of gonads,anatomy of gonads, reproductive mechanisms, parental care, developmental stages, endocrine control of reproduction.

Unit-3

Induced spawning: hypophysation, evaluation of carp milt and egg, cryopreservation technique, use of different synthetic hormones and analogues for induced spawning.

Unit-4

Seed production and hatchery: criteria for site selection of hatchery and nursery,hatchery technology for different species, carps; mahseer; trout; catfishes;Jar hatchery, Chinese hatchery and other hatchery systems- design and operation, hatchery protocols, larval rearing stages, rearing technology, packaging and transport of larvae.

Unit -5

murrels; freshwater prawn; seabass; mullet; grouper; shrimp; edible oysters ;
abalone; clam; cockles; sea cucumbers.Hatchery management: SPF and SPR; Larval health and nutrition; Anaesthetics, antistressors in handling and seed transport; vaccines for larvae; biosecurity

Practicals

Study of gonadal development in carps and other cultivable finfishes Identification of carp and catfish seed Collection and identification of cultivable brackish water finfish seseed
Packing and transportation of cultivable finfish seed.
Induced breeding of fishes through various inducing agents.
Evaluation of carp milt and egg.
Design and operation of Chinese hatchery.
Preparation of brood and larval feed for different cultivable finfish.
Rearing of carp spawn and fry.
Visit to different finfish hatcheries.

Suggested Readings

Thomas.P.C et al, 2003. Breeding and seed production of finfish and shellfish,Daya publishing house, New delhi.
Mathew Landau, 1992. Introduction to Aquaculture, John Wiley and sons, INC,New york

James P Mcvey, 1983: Handbook of Mariculture, CRC press, Florida
Jhingran. V G, 1991, Fish and Fisheries of India, Hindustan Publishers
Pillay.T V R and M N Kutty, 2005, Aquaculture- principles and practices, Blackwell sciences, UK
Rath, P K, 2000, Freshwater Aquaculture, Scientific Publishers, Jodhpur
FAO, 1992, Manual of seed production of carps
Jhingran VG and Pullin R S V , 1985, Hatchery Manual for the Common, Chinese and Indian major carps, ICLARM.

List of journals

Applied Fisheries and Aquaculture
Aquaculture Research
Aquaculture

Research area

Fecundity in fish
Spawn survival
Techniques for high density packing and transport
Production and evaluation of stunted fingerlings
Evaluation of ITKs in seed transport

M.F.Sc. 408: PRINCIPLES OF FISH GENETICS AND BREEDING (2+1)

Objective: To impart knowledge on genetic basis of inheritance and breeding plans for Commercially Hill stream important fishes.

Theory

Unit-1

Introduction: Origin and advancement in genetics; physical basis of heredity;genetic correlation; multiple alleles. Cytogenetics: Importance and karyotyping.Fish breeding: History and advancement of fish breeding, mode of reproduction ,basic breeding methods and breeding programmes.

Unit-2

Population genetics: sympatric and allopatric distribution, Individual vs population, gene and genotype frequencies, Hardy-Weinberg equation.

Unit-3

Chromosome manipulation: ploidy induction methods-triplody and tetraploidy,advantages and disadvantages of polyploids, androgenesis and gynogenesis.

Unit-4

Sex determination: sex differentiation and sex reversal in fishes, sex control and its role in aquaculture.Selection: scope, applications and methods of selection, marker assisted selectionbiochemical and molecular markers.Hybridization: heterosis, hybrid vigour,

Unit-5

introgression.Inbreeding: methods of estimation, inbreeding depression and consequences,measures to reduce inbreeding in hatcheries.Conservation genetics: Genetic resources of India and conservation, endangered species, cryopreservation of fish gametes.

Practicals

Exercises on multiple alleles.
Estimation of gene and genotype frequencies.
Exercises on Hardy-Weinberg equation.
Estimation of inbreeding coefficient.
Protocol of androgenesis and gynogenesis.
Protocol of cryopreservation of milt.
Karyotypic studies.
Isolation of DNA from fish blood.

Suggested readings

Genetics for Fish Hatchery Managers-Douglas Tave
Aquaculture and fisheries biotechnology genetic approaches –R.A Dunham; CABI publishers.
An introduction to quantitative genetics-D.S Falconer Principles of genetics -Eldon John Gardner.
Principles of genetics- D. Peter Snustad, Michael J. Simmons, John B. Jenkins.
Practical Genetics for Aquaculture - Charles Gregory Lutz.
Fish genetics and biotechnology.-W.S Lakra.
Text book of fish genetics and biotechnology- P.V.G.K. Reddy, S. Ayyappan, D.M. Thampy and Gopal Krishna. New Delhi, Indian Council of Agricultural research publication.
Applied Fish Genetics- B.J. Padhi, R.K. Mandal. Fishing Chimes.

List of journals

Applied Fisheries and Aquaculture
Fisheries Research
Fisheries Science
Aquaculture Research
Aquaculture

Research

Hybridization of cultivable species
Karyotypic studies
Breeding performance of different stocks of brood
Conservation of endangered species

M.F.Sc. 409: ORNAMENTAL FISHES AND AQUARIUM MANAGEMENT (2+1)

Objectives:

To impart knowledge on ornamental fish production and aquarium keeping.

Theory

Unit-1

Aquarium fish trade: Present status; potential; major exporting and importing countries; species-wise contribution of Hill stream freshwater and marine fishes; contribution of culture and capture; marketing strategies; anaesthetics, packing and transportation.

Unit-2

Breeding techniques: Reproductive biology, captive breeding and rearing of Hill stream freshwater, brackishwater, marine ornamental fishes and invertebrates.

Unit-3

Setting of aquarium: Design and construction of tanks; species-wise tank size requirement; heating, lighting, aeration and filtration arrangements; decorations used; common aquarium plants and their propagation.

Unit-4

Aquarium management: Feed, health and water quality management; prophylaxis;quarantine.Value addition: Colour enhancement; genetic manipulation and production of new strains; hybrids; acclimatization strategies for Hill stream ornamental fish to freshwater.

Unit-5

Major freshwater ornamental fishes.Reproductive biology, sexual dimorphism, breeding habits and induced breeding of ornamental fishes.Food requirement of larval and adult fishes Health management of ornamental fishes. Specific diseases and their cure. Precautions and water quality monitoring Marine ornamental fishes, their health management and food requirements.Setting and maintenance of aquaria.

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Practical

Identification of common freshwater aquarium fishes and breeding trials of selected freshwater fishes.

Identification of common brackish water and marine aquarium fishes.

Aquarium fabrication, setting and maintenance.

Management of water quality parameters in aquarium tank.

Study of different filters, aerators and other accessories used in aquarium.

Preparation of powdered and pelleted feed for ornamental fishes.

Visit to ornamental fish farms.

Identification of common parasites infecting ornamental fishes.

Study of bacterial, viral, fungal diseases of ornamental fishes and their control Prophylactic and quarantine measures.

Suggested Readings

Axelrod, H.R., 1967. Breeding aquarium fishes. TFH publications Inc. England. Pp. 288.

Axelrod, H.R. and vorderwinkler, W. 1978. Encyclopaedia of tropical Fishes, TFH publications Inc. England pp.631.

Axelrod, H.R. and Sweenen, M.E., 1992. The fascination of breeding aquarium fishes. TFH publication Inc. pp.448.
Andrews, C, Excell A and Carrington, N. 1988. The manual of fish health.Salamander Book Ltd. Londaon. pp.209.
Dick Mills, 1981. Aquarium fishes, Kingfisher Books Ltd. London. Pp. 197.
Sanford, G. and Crow, R. 1991. The manual of tank busters. Salamander books Ltd, London, UK. Pp.159.
Sinha, V.R.P. 1981, Integrated synergic approach to aquaculture. Resour. Manage,Optim., 1 (4). 331-41.
Spotte, S. 1979. Fish and invertebrate culture, John Wiley and sons, New York,USA.
Thabrow De, W.V. 1981. Popular aquarium plants. Thornbill Press. UK. Pp. 200.

List of journals:

Aquaculture Research
Aquaculture

Research area:

Pigment enhancement of selected ornamental fishes
Breeding and rearing of indigenous brackish water and marine ornamental fishes
Culture of live feed for larval rearing
Disease control in ornamental fishes:

M.F.Sc.410: RIVERINE WATER AQUACULTURE AND FRESHWATER CULTURE (2+1)

Objectives: To gain knowledge in Riverrine water aquaculture and Fresh water culture.

Theory:

Unit-1

Introduction: An overview of status of water aquaculture and Riverrine of finfishes of the world; Present trend and scope of Riverrine and freshwater culture in Garhwal & kumaun Uttrakhand.

Unit-2

Different farming systems: Extensive, Semi-intensive and Intensive; Cage and Penculture; Re circulatory and running water systems.Important cultivable finfishes: distribution, biology, seed collection, hatchery technology, culture techniques, problems and prospects (Hillstream fish, Snow trout culture,mahseer Culture,Grass culture, Silver culture of fresh water.

Unit-3

Hill stream crustaceans: Important cultivable species of shrimps, crabs and lobsters; distribution, biology, brood stock collection, different systems of culture.

Unit-4

Culture of hill stream molluscs: Present status and scope in India, Species cultured (mussels, oysters, pearl oysters, scallops, clams, sea cucumber) distribution, biology, practices followed in India, farming methods, problems and prospects.

Unit-5

Seaweed culture: Major seaweed species of commercial importance; methods of culture; farming of agar, algin, carrageenan yielding species; emerging trends in their farming in open seas; Integration with other farming systems.

Practicals

Identification of cultivable brackishwater finfish
Identification of cultivable brackishwater shellfish
Identification of cultivable marine finfish
Identification of cultivable marine shellfish
Identification of cultivable seaweeds
Designing of cages and pens
Visit to brackish water shrimp farm
Visit to mariculture sites

Suggested Readings:

Barnabe Gilbert 1990: Aquaculture – Vol. II. Ellis Horwood; 1097 pp.
Dilip Kumar, K. 1992: Fish Culture in undrainable ponds. F.A.O. Tech. Paper: 325p. 240.
Pillay, T.V.R., 1990: Aquaculture, Principles and Practices. Fishing News books Ltd: p. 575.
Shepherd, J. and Brommage N. 1990: Intensive Fish Farming. B.S.P. Professional Books: p.404.
Bardach, E.J. Rhyther, J.H. & W.O. Mc. Larney. 1972: Aquaculture. The Farming and Husbandry of freshwater and Marine organisms. John Wiley and Sons. New York: p 868.
Barnabe Gilbert 1990: Aquaculture – Vol II,: Ellis Horwood: pp. 1097.

List of journals:

Applied Fisheries and Aquaculture
Marine Biotechnology
Journal of Animal Nutrition
Aquaculture Research
Aquaculture

Research area:

Cage and pen culture for brackish water finfish
Cage and pen culture for hill streamfinfish.

Semester III

M.F.Sc. 413 AQUACULTURE BIOTECHNOLOGY (2+1)

Objectives: To give knowledge of different biotechnological tools for enhanced fish production.

Theory

Unit-1

Introduction: definition and historical aspects of biotechnology,Genetic engeneering: cloning, restriction/modification enzymes, splicing of DNA,plasmid vectors.

Unit-2

Chromosome manipulation and sex manipulation: gynogenesis, androgenesis,polyploidy, production of monosex population and super males.Transgenesis: definition, transgenic fish, detection of transgenes, applications,regulatory aspects of transgenesis.

Unit-3

Tissue culture: tissue culture, cell lines, primary and secondary culture, culture media.Molecular markers used in fisheries and aquaculture: allozymes, mitochondrial DNA, multiple arbitary primer markers- RAPD, AFLP, nuclear DNA markers-RFLP, microsatellites.

Unit-4

Fish genomics, proteomics and comparative genomics.Biotechnology in fish conservation Biotechnology in health management:

Unit-5

Molecular (nucleic acid and antibody based) diagnostics, vaccines, GMOs.Cryopreservation of gametes and embryos.

Practicals

Agarose and Polyacrylamide gel electrophoresis
Plasmid DNA isolation
Isolation of DNA from fish blood
Restriction digestion of DNA
Ligation reaction
Bacterial transformation by calcium chloride method
Polymerase chain reaction
Cryopreservation of milt
Cytogenetic techniques- ploidy evaluation using erythrocyte measurements and chromosome numbers
Production of monosex population by sex reversal
Demonstration of chromosome manipulation techniques- gynogenesis, androgenesis, triploidy, tetraploidy, hybridization

Suggested Readings

Fingerman,M.,NagabhushanamR.and Thompson M.F.1997 Recent advances in marine biotechnology (vol1-3) Oxford and IBH publishing co.PvtLtd. New Delhi
Glick ,B.R. and Pasternak, J.J. 1999. Molecular biotechnology:principles and

applications of Recombinant DNA Technology,ASM Press,Washington,DC.
Hoar,W.S.and Randal,D.J.19 Fish Physiology.Academy Press,New York.
Lehninger,A.L.1984.Principles of Biochemistry,CBS Publishing,New Delhi.
Primrose,S.B.1989.Modern Biotechnology,Blackwell Scientific,Oxford.
Rodney .B.1998.Concepts in Biochemistry.Cole Publishing Company,London.

List of journals

Marine Biotechnology
Aquaculture Research
Aquaculture

Research area:

Genomics and proteomics
Production of GMOs and their evaluation
Production of cell lines

M.F.Sc.414: LARVAL NUTRITION AND CULTURE OF FISH FOOD ORGANISMS(2+1)

Objective

To create basic understanding of the nutritional requirements of fish/shellfish larvae and to impart knowledge on mass culture and enrichment of live food organisms.

Theory

Unit-1

Larval nutrition: larval stages, nutritional requirements of fish and shellfish larvae,quality requirements of larval feeds (particle size, digestability), natural food and its importance in aquaculture,

Unit-2

nutritional quality of commonly used fish food organisms, bioenrichment, biofilm/periphyton and its use, culture of single cell proteins and their nutritional quality, formulation and preparation of artificial feeds for larval rearing, microparticulate diets.

Unit-3

Fish food organisms: bacterioplankton, phytoplankton and zooplankton and their role in larval nutrition.Mass culture techniques: Methods of collection, maintenance and rearing of fish.

Unit-4

food organisms, Different media used in culture, Mass culture of fish foodorganisms and their application in hatcheries, culture of important microalgae,rotifers, artemia, cladocerans, copepods, oligochaetes, nematodes and insect larvae.

Unit-5

Pathogens in aquatic environment, Safety of aquaculture products, Role of microbes in aquatic environment; assessment of probiotic impact in aquaculture.

Practical

Collection, identification and isolation of live food organisms using various techniques
Preparation of various culture media
Preparation and maintenance of stock microalgal culture

Preparation of artificial feed for rearing finfish and shellfish larvae
Mass culture of microalgae
Mass culture of cladocerans, copepods and rotifers.
Culture of Artemia nauplii, infusoria – freshwater and marine
Culture of earthworms and chironomid larvae

Suggested readings

CIFE Publn. 1993. Training manual on culture of live food organisms for Aqua hatcheries, Central Institute of Fisheries Eduction Versova, Mumbai, 400061.
Dwivedi, S.N. et.al. (1982). Live feed culture. Proc. Seminar on prospects of aquarium fish export from India, Bombay . MPEDA Philippe Dhert and Patrick Sorgelovs (1995).
MPEDA Publn. 1993. – Hand book on Aqua farming – Live feed. Micro algal culture
Muthu, M.S. (1983). Culture of live feed organisms. Tech. Paper 14. Summer Institute in Hatchery production of prawns seeds. CMFRI, Cochin.
Santhanam, R., Ramnathan, M., Venkataramanujum (1997) – A manual of Methods in plankton. Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences Uty. Tuticorin, 628 008.
Sorgelos, P. & Kulasekhara Pandian, S. 1984 – Culture of live food organisms with – special reference to Artemia culture – CMFRI spl. Pub (15)
Sasi Nayar, Shripad. Hegde, Srinivas Sudha, P., 1998. Live food organisms as feed in Aquaculture. INFOFISH. International 2/95.
Tonapi, G.T. (1980). Freshwater animals of India, OXFORD & IBH Publication.
Hagiwara, A., Snell, T. W., Lubzens, E and Tamaru, C.S.1997. Live food in aquaculture. Proceedings of the live food and marine larviculture symposium. Kluwer Academic Publishers, London

List of Journal

Aquaculture nutrition
Annual review of nutrition
Annals of nutrition and metabolism
Animal nutrition and feed technology
Animal feed sciences and technology
`Indian journal of animal nutrition
Annual review of physiology

Research area

Bioenrichment of live food
Automated live food production systems
Ontogeny of digestive system in fish larvae
Development of inert feeds for larvae

M.F.Sc. 415: FISH AND SHELLFISH PHYSIOLOGY AND ENDOCRINOLOGY (2+1)

Objective: To learn functional physiology of fish and shellfish

Theory

Unit-1

General physiology and endocrinology: Physiology of migration and behaviour,chemical nature of hormones, storage, release and control of hormones,serochemistry, structure and function of neuro-endocrine system, biotic and abiotic factors influencing homeostasis, ecophysiology, endocrine control of growth.

Unit-2

Nutritional and digestive physiology: Mechanism of chemo, electro and mechanorecption, gustation, digestive enzymes and isozymes, nutrient tansporters, gut microbial digestion, excretion.

Unit-3

Neurophysiology: Neurosecretory system in fishes, crustaceans and molluscs, neurotransmitters, ecdysis.

Unit-4

Reproductive physiology: maturation and spawning, spermatogenesis, oogenesis,yolk formation, mechanism of sex reversal.

Unit-5

Respiratory physiology: structure and chemical composition of respiratory pigments, gas exchange concept, osmoregulation.Stress physiology: stress response, stress hormones, stress adaptation.

Practical

Hormone assay –RIA (Radio Immuno Assay), ELISA.
Dissection of fin and shellfish to study endocrine glands
Histological techniques to study endocrine cells
Identification of moult stages
Serological analysis
Application of Electrocardiogram and respirometer

Suggested Readings

Bell, T.A and lightner, T.A (1988) A hand book of normal penaeid shrimp
histology, world aquaculture society
Adiodi, K.G and Adiodi, R.G(1971) endocrine control of reproduction in decapods
crustacean, biology reviews
Hoar, W.S., Randall, D.J. and Donaldson – Fish Physiology.
Matty, A.J. 1985 Fish endocrinology (Croom Helm, Ltd. U.S.A. 267 p
Nikolsky, G.V. the ecology of fishes, Academic press. London
Lagler, K.P berdach, J.C. Miller, R.R and may passion, D.R. 1977. Ichthyology.
John wiley and sons inc. Newyork.

List of journals

Applied Fisheries and Aquaculture
Fisheries Research
Fisheries Science

Comparative Biochemistry & Physiology

Research area

Maturation in broodfish
Physiology of stress
Endocrine control of respiration and osmoregulation
Extra hypothalamo-hypophysial control of reproduction

M.F.Sc. 416: AQUACULTURE AND ENVIRONMENT (2+1)

Objective: To impart knowledge on interactions between aquaculture and the environment

Theory

Unit-1

Aquaculture and ecosystem relationship: Ecosystems and productivity, biotic interaction within ecosystems and ecological homeostasis.

Unit-2

Climate: weather elements of concern in aquaculture, Green house gases, global warming and their impact.Impact of environment on aquaculture: Raw water source,

Unit-3

physical and chemical characteristics, contaminants and pollutants (algae, pathogens, heavy metals,pesticides) and their effect on productivity.

Unit-4

Impact of aquaculture on environment: waste water discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.

Unit-5

Environment monitoring: Problems and preventive measures of antibiotic and drug residues, salination of soil and water, Eutrophication, Environment impact assessment and environmental audit, Biosensors in aquatic environment, toxicity assessment, Ecolabelling and traceability Environment management: Introduction of exotics and escape of farmed fish,

Practicals

Waste water analysis
Environment impact assessment
Environmental audit
Toxicity assessment studies
Ecolabelling and traceability
Isolation, enumeration and Identification of bacterial population
Physical and chemical characteristics of soil
Design and construction of effluent treatment plant

Suggested Readings

Nikolsky, G.VThe Ecology of fishes, Academic Press. London 325 p
Lagler, K.P, Bardach, J.E, Miller, R.R. and May Passino, D.R. 1977. Ichthyology,
John Wiley & Sons, Inc. New York. 506.
Norman J.R. 1977 A history of fishes (Ernest Benn Ltd., London 467 p.)
Adiyodi, K.G. and Adiyodi, R.G. 1970 & 1971 – Endocrine control of reproduction
in Decapod Crustacea, Biol. Rev. 121 – 165 pp

List of journals

Applied Fisheries and Aquaculture
Tropical Science
Toxic Environmental Chemistry
Pesticides Research
Journal of Aquaculture and Aquatic Science
Journal of Environmental Research
Asian Journal of Microbiology Biotechnology Environmental Science
Indian journal of environmental health

Research area

Impact of probiotics on environment
Impact of extreme climate on aquaculture
Role of disruptors in aquaculture

Semester IV

M.FSc 421-APPLICATION OF REMOTE SENSING AND GIS IN HILL STREAM FISHERIES,2+1

Objective

To impart theoretical knowledge and practical skill on application of remote sensing and GIS in oceanographic studies and aquatic environment management planning.

Theory

UNIT I

General consideration, Survey planning, Position fixing; Sampling frequency and duration, Data storage and transmission;

UNIT II

Sensors for temperature and salinity (Via conductivity); The measurement of depth (via pressure); CTD units for estuarine and open ocean work;Sensor calibration techniques; Sensors for measuring flow; Tracking of drogue buoys. Acoustic Doppler current measurements; Optical measurements; transmittance and subsurface reflectance;

UNIT III

In situ fluorescence for the determination of pigment concentration;Remote sensing optical methods; Satellite measurements of temperature (via thermal I.R.), the interpretation of Microwave (geotropic currents,waves, surface winds).

UNIT IV

Geographical Information System (GIS): Definition, Concepts, Spatial data management. Data base management system. Data Capture, Digitization, Data integration, Projection and Registration, Data Structure, Data Modeling.

UNIT V

Visual Image Interpretation; Applications of GIS in aquatic Resource identification; Digital Image Processing (DIP): Different Methods and Approaches

Practical

Position fixing techniques. Operation of C.T.D. units and their calibrations. Various types of current meters and measurement of currents. Wave recorders and measurements. Determination of pigment concentrations. Remote sensors – interpretation of data. Practical on visual interpretation of data from map, Practical on Digital Image Processing (DIP). Field practical on the Application of GPS. Mapping of aquatic environment resources through GIS softwares (ARCVIEW, MAPINFO etc.).

Suggested Readings

Elangovan K. 2005. *GIS: Fundamentals, Applications and Implementations*. New India Publ. Agency.

ESRI. 2007. *Understanding GIS, The ARC/INFO Method*. Environmental System Research Org, USA.

Lillesand TM, Kiefer RW, Chipman JW. 2004. *Remote Sensing and Image Interpretation*. John Wiley & Sons.

Meaden GJ & Do Chi T. 1996. *Geographical Information System: Applications to Marine Fisheries*. FAO Tech. Paper No. 356.

Meaden GJ & Kapetsky JM. 1991. *Geographical Information System and Remote Sensing in Inland Fisheries and Aquaculture*. FAO Tech.

MFSc 422:Aquaculture & Fishery Science

Object:To gain in depth knowledge and field exposure on sustainable aquaculture practices
Theory:

UNIT I

Scope, importance and present status.Concept of Different culture systems: Extensive and intensive fish culture, Fish culture in ponds and reservoirs. Culture in rice fields, bheries, Concept of Monoculture and polyculture.

UNIT II

Cultivable fish species: Characters and classification, culture practice.Preparation and maintenance of fish farm: Site selection, Soil characteristics, Fertility and pH maintenance. Role of fertilizers, required water quality and its maintenance.Development of natural food and supplementary feeding Control of Aquatic weeds, insects and predatory fishes.

UNIT III

Concept of composite fish farming: History, Species suitability for poly-culture, Importance. Food requirement and maintenance, Importance of live food culture for fishes Culture of Common carp and Exotic Trouts.Mahseer and Schizothoracid fishery. Current status, problems and perspectives.

UNIT IV

Inland Capture fisheries of India: Riverine fishery with special reference to Ganga and its tributaries.Lakes, Dams / Reservoir fishery- Problems and perspectives.Estuarine fishery. Characteristics and species dynamics.Marine fishery: Coastal, Off shore and deep sea fishery.Recreational fishery and Cooperative movements. Fish Farmers Development Agencies (FFDA).

UNIT V

Fish fauna and their adaptive features. Current status of hill-stream fishery and future perspectives. Hill-stream fish fauna and hill-stream adaptation Fish fauna of river Ganga. Ecology of freshwater lentic and lotic bodies. (Physico- chemical and biological characteristics) Ecology of Hillstream Fishes (Physico- chemical and biological characteristics)

Practical

Visit to conventional aquafarm to see the management of used water;
Survey on environmental impact nearby aquaculture farms; Setting model for sustainable aquaculture (organic farm, integrated farm); Applications of remote sensing and GIS (geographical information system); Economic evaluation of aquaculture practices.

Suggested Readings

Bardach JE. 1997. *Sustainable Aquaculture*. John Willey & Sons.
Bardach JE, Rhyther JH & Mc. Larney WO. 1972. *Aquaculture Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.14
Beets WC. 1990. *Raising and Sustaining Productivity of Small-HolderFarming Systems in the Tropics*. Agbe Publ.
Edwards P, Little DC & Demaine H. (Eds.). 2002. *Rural Aquaculture* CABI.
FAO 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO.
Imai T. 1978. *Aquaculture in Shallow Seas. Progress in Shallow Sea Culture*. Amerind Publ.
James PM. 1983. *Handbook of Mariculture*. Vol. I. *Crustacean Aquaculture*. CRC Press.
Leung P, Lee CS & O'Bryen JP. (Eds.). 2007. *Species and System Selection for Sustainable Aquaculture*. Blackwell Publ.Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*.
Chapman & Hall.Selvamani BR & Mahadevan RK. 2008. *Aquaculture, Trends and Issues*. Campus Books International.

Y. Sreekrishna & Latha Shenoy: Fishing gear and craft Technology, ICAR Publication, New Delhi