Doctor of Philosophy (Ph.D.)
in
FISH GENETICS

Courses at a Glance
(Approved by Academic Council on 26.07.2014)

CENTRAL INSTITUTE OF FISHERIES EDUCATION
(A University Established Under Sec3 of UGC Act 1956)
Indian Council of Agricultural Research
Panch Marg, Off Yari Road
Versova, Mumbai – 400 061

Ph.D. (FISH GENETICS)
Course Structure – At a Glance

A	MAJOR COURSES			17 Credits
1	FGB 601	FISH BREEDING PLANS	2+1	
2	FGB 602	GENETIC SELECTION METHODS	2+1	
3	FGB 603	GENETICS IN COMMERCIAL AQUACULTURE	2+1	
4	FGB 604	RESEARCH METHODOLOGY IN FISH GENETICS	1+1	
2	FGB 605	ADVANCES IN CYTOGENETICS	2+1	
3	FGB 606	ADVANCES IN MOLECULAR BREEDING	2+1	
4	FGB 607	TRANSGENICS PRODUCTION AND GMOS	1+1	
5	FGB 608	LINEAR MODELS IN FISH GENETICS	2+1	
B	MINOR COURSES (Courses outside major discipline / from other relevant disciplines)			6 Credits
C	SUPPORTING COURSES (Compulsory)			5 Credits
1	FST 601	ADVANCED STATISTICAL METHODS	2+1	
2	FST 602	SOFTWARE FOR FISHERIES DATA ANALYSIS AND MANAGEMENT	0+2	
		Total Course Work Credits		28 Credits
D	DOCTORAL SEMINAR			2 Credits
1	FGB 691	DOCTORAL SEMINAR I	0+1	
2	FGB 692	DOCTORAL SEMINAR II	0+1	
E	DOCTORAL RESEARCH			45 Credits
	FGB 699	DOCTORAL RESEARCH (Semester III)	0+15	
	FGB 699	DOCTORAL RESEARCH (Semester IV)	0+15	
	FGB 699	DOCTORAL RESEARCH (Semester V)	0+15	
	FGB 699	DOCTORAL RESEARCH (Semester VI)	0+15	
		Total PhD Program Credit Hours		75 Credits

Minimum Credit Requirements

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Genetics and Breeding, the appropriate minor subjects should be Fish Biotechnology, Biochemistry and Physiology, etc)

Supporting subject: The subject not related to the major subject. Need to be identified by the respective BoS from the courses offered by other disciplines and these courses are compulsory to all the students of that discipline.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph.D. students may be exempted from these courses if already studied during Master's degree.

Subject	Master's programme	Doctoral programme
Major	23	17
Minor	06	06
Supporting	05	05
Seminar	01	02
Research	20	45
Field Training	02	
(3 credits from major or minor as required)		
Total Credits	**60**	**75**

Compulsory Non Credit Courses: See relevant section

FISH GENETICS
Course Contents

FGB 601	**FISH BREEDING PLANS**	**2+1**

Objective   To learn the recent advances and development of breeding plans

Theory

Unit I   Genetics in Broodstock management of commercially important fish and shellfish

Unit II   Important reproductive tools for implementation of breeding plan: Endocrine control of reproduction; Captive maturation, Natural and Artificial insemination in shellfish; Synchronisation of spawning; Cryopreservation of gametes.

Unit III   Estimation of heritability and repeatability; Phenotypic, genetic and environmental correlations; Tagging and maintaining breeding records; Growth curves and their components.

Unit IV   Influence of non-genetic factors on growth; Factors influencing production and reproductive traits; Crossbreeding and hybridization; Threshold characters and their selection procedure.

Unit V   Breeding plans to exploit additive and non-additive genetic variation; Maternal influence and its estimation, genetic mechanisms in adaptation, measurement and adaptability indices; G x E interaction.

Unit VI   Consequences of inbreeding and management of genetic variation in fish breeding programme.

Unit VII   Application of pheromone technology in breeding

Practical   Heritability estimation; Correlation between different traits; Selection and genetic gains; Inbreeding; Preservation of gametes; Synchronization of spawning; The focus will be on critical review of contemporary applied breeding programmes and journal articles - students are also expected to prepare a term paper for submission at the end of the semester.

Suggested Readings

1. Doolittle DP. 1987. *Population Genetics: Basic Principles*. Springer-Verlag.
2. Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.
3. Kshirsagar MA & Smith WB. 1995 .*Growth Curves*. CRC Press.
4. Li CC. 1955. *Population Genetics*. University of Chicago Press.
5. Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.
6. Thomas PC, Rath SC & Mohapatra KD. 2003. *Breeding and Seed Production of Finfish and Shellfish*. Daya Publ. House.

FGB 602	**GENETIC SELECTION METHODS**	2+1

Objective   To impart knowledge on the efficiency of different selection methods.

Theory

Unit I   Introduction: Past and present status of fish breeding.

Unit II   Strain comparison; Factors affecting the rate of genetic improvement; Performance testing.

Unit III   Correction and standardization of animal breeding data; Simultaneous prediction of breeding values for several traits; Recurrent and Reciprocal Recurrent Selection.

Unit IV   Prediction of breeding values and environmental effects; LS, BLUP methods, Multivariate Breeding Value Prediction.

Unit V   QTL and MAS; Breeding values for binary traits; Selection and breeding for disease resistance and survival analysis; Diallel analysis; Selection for single trait and multiple traits.

Unit VI   Estimation of genetic gain under different selection program

Practical   Diallele crossing; Estimation of breeding values; Construction of selection index; Least squares and BLUP methods for estimation of genetic and non genetic parameters; Application of various computer software for genetic analyses: SAS, AsREML, PEST, and SelAction; Estimation of genetic parameter, heritability, building of pedigree information, genetic gain.

Suggested Readings

1. Cameron ND. 1997. *Selection Indices and Prediction of Genetic Merit in Animal Breeding*. CABI.
2. Doolittle DP.1987. *Population Genetics: Basic Principles*. Springer-Verlag.
3. Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.
4. Li CC. 1955. *Population Genetics*. University of Chicago Press.
5. Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
6. Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.
7. Turner HN & Young SSY. 1969. *Quantitative Genetics in Sheep Breeding*. Cornell University Press.

FGB 603   **GENETICS IN COMMERCIAL AQUACULTURE**   **2+1**

Objective   To provide knowledge on genetic improvement programmes to study the impact on commercial aquaculture.

Theory

   Unit I   Case study of national and international genetic improvement programs like Jayanti Rohu, Common Carp, Tiger Shrimp *P. monodon*, GIFT Tilapia, Norwegian Salmon, Hungarian carp, Pacific White Shrimp *L. vannamei*, etc.

   Unit II   Socio-economic impact, technological adoption, increased production. Impact of climate change on fish germplasm

   Unit III   Environmental impact of improved varieties/strains

   Unit IV   Application of Hybridization, ploidy manipulation, monosex culture, genetic engineering, transgenesis for commercial purpose

   Unit V   Application of nanotechnology in Aquaculture

Practical   Developing the protocols for evaluating the various genetic improvement programs and their impacts; Preparation of questionnaire to survey; Survey on impact of the programme on farmers; Survey on impact of the programme on the consumers. Review of literature on the recent development of aquaculture, on nanotechnology.

Suggested Readings
   1. Kirpichnikov VS. 1981. *Genetic Basis of Fish Selection*. Springer Verlag.
   2. Lutz CG. 2003. *Practical Genetics for Aquaculture*. Wiley-Blackwell.
   3. Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
   4. Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall

FGB 604	**RESEARCH METHODOLOGY IN FISH GENETICS**	1+1

Objective To understand integration of the methodologies under various genetic approaches.

Theory

Unit I Probability, binomial distribution, multinomial distribution, normal distribution, chi square distribution, student's t distribution, and F distribution.

Unit II Basic matrix algebra, least square procedure, multiple, regression and correlation.

Unit III Testing of genetic hypothesis, test of hypothesis, test for significance, test for significance ratio, detection and estimation of linkage.

Unit IV Path coefficient and calculation of inbreeding coefficient and relationship, analysis of variance, one way estimation of mean and variance, multiple comparison among means designed contrast, all pair with comparison, comparison with control partition of variance.

Unit V Hierarchical classification Component of variance, Multivariate models, factorial experiment mixed classification single covariate in experimental design; Analysis of multivariate data and non orthogonal data. AMOVA

Practical Problems in probability, use of chi square, t distribution and F distribution in test statistics, problems in path coefficient and calculation of inbreeding coefficient, ANOVA, single and multiple ways.

Suggested Readings
1. Biradar RS. 2002. *Course Manual on Fisheries Statistics*. 2nd Ed. CIFE, Mumbai.
2. Keller G. 2001. *Applied Statistics with Microsoft Excel*. Duxbury.
3. Kothari CR. 1998. *Research Methodology*. 2nd Ed. Vishwa Prakashan.
4. Levin RL & Rubin DS. 1983. *Statistics for Management*. Prentice-Hall of India.
5. Panse VG & Sukhatme PV. 1978. *Statistical Methods for Agricultural Workers*. ICAR.
6. Siegel, S & Castellan NJ Jr. 1988. *Non Parametric Statistical Methods*. John Wiley & Sons.

| **FGB 605** | **ADVANCES IN CYTOGENETICS** | **2+1** |

Objective   To understand the advances in cytogenetics and their applications in genetic programmes.

Theory

Unit I   Introduction to molecular cytogenetics; FISH, CGH.

Unit II   Chromosome banding: Advanced chromosome banding including Restriction Enzyme banding, fluorescent banding, CMAS3 staining, replication banding; *In-vitro* techniques for chromosome handling;

Unit III   Genotoxicity: Chromosomal aberrations: inherited and induced, structural and numerical; Sister chromatid exchanges, MNT, comet assay.

Unit IV   Cytogenetics and fish evolution; Cytoplasmic inheritance; Cytogenetic application in fish breeding programmes.

Unit V   Chromosome and gene manipulation; Cross breeding and hybridization; Maintenance of variation; Radiation hazards.

Unit VI   Application of nanotechnology in genome mapping. Stock Identification methods. Identification of Farm escapees; Application of Nanobiosensor for tracking of Fish. Genomics in Conservation: DNA Bar coding, FishBol

Practical   Preparation of chromosome spreads using *in-vivo* and *in-vitro* methods;, Restriction Enzyme banding; Fluorescent banding, CMAS3 staining, replication banding; Screening the brooders for cytogenetic defects. Discussion on papers related to recent developments in Cytogenetics

Suggested Readings
1. Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.
2. McGregor HC & Varley JM. 1983.*Working with Animal Chromosomes*. John Wiley & Sons.
3. Pisano E. 2007. *Fish Cytogenetics*. Science Publ.
4. Sharma AK & Sharma A. 1980. *Chromosome Techniques: Theory and Practice*. Butterworths.
5. Sumner AT. 1990. *Chromosome Banding*. Unwin Hyman.

| FGB 606 | ADVANCES IN MOLECULAR BREEDING | 2+1 |

Objective   To learn the advances in molecular breeding and their incorporation in genetic improvement programmes.

Theory

Unit I   Exploitation of non additive genetic variance; Breeding for disease resistance; Survival analysis.

Unit II   Application of markers in fish breeding; Identification of QTLs and MAS. whole genome selection, SNP

Unit III   Cryopreservation of gametes and its applications.

Unit IV   Risk assessment of exotics and hybrids; quarantine procedures.

UNIT VI   Patenting methods, IPR issues related to fish genetic innovations.

UNIT VII   Techniques in genome analysis, genome mapping and functional genomics; Repetitive DNA-sequences; Interspersed repeated DNA sequences, Transposable Elements: Long interspersed elements (LINEs), Short interspersed elements (SINEs), Alu family, genome evolution;

Practical   Identification of QTLs; Gene mapping; molecular identification of stock; Pedigree assigning using molecular data, estimation of genetic parameters using molecular data.

Suggested Readings

1. Fuller BJ, Benson EE & Lane N. 2004. *Life in the Frozen State*. CRC Press.
2. Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
3. Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.
4. Weller JI. 2001. *Quantitative Trait Loci Analysis in Animals*. CABI.

FGB 607   **TRANSGENICS PRODUCTION AND GMOs**   **1+1**

Objective   To acquaint with the current status in development of transgenics and their potential commercialization.

Theory

Unit I   Principles of transgenic technology and transgenic production, Its application to fisheries; Risk assessment; GMOs and biosafety regulations, gene therapy, designer ornamental fish strains; Biotechnological interventions in fish breeding.

Unit II   Ethical Issues in GMOs: Cartagena protocol, National regulations on GMOs, Impact assessment of GMOs, transgenic containment.

Unit III   Critical analysis of the regulations related to introduction of GMOs

Unit IV   IPR issues related to GMOs

Practical   Gene transfer experiments; Northern blotting, Southern blotting for integration and expression of transgene; Demonstration of the electroporation, microinjection, expression of the marker genes.

Suggested   1. Celis JE. 1998. *Cell Biology: A Laboratory Handbook*. Academic Press.
Readings   2. Pinkert CA. 1994. *Transgenic Animal Technology: A LaboratoryHandbook*. Academic Press.
3. Stickney RR. 2005. *Aquaculture: An Introductory Text*. CABI.

FGB 608	LINEAR MODELS IN FISH GENETICS	2+1

Objective To learn the application of different statistical models in breeding data.

Theory

Unit I Matrix operations: Determinants, inverse of matrix, linear equations, the matrix algebra of regression analysis.

Unit II Linear models: Fixed effects, random effects; Mixed models: their application in estimation of genetic variance components and parameters;

Unit III Model building and simulations.

Unit IV Analysis of non-orthogonal and multivariate data.

Practical Matrix operation, matrix inversion, matrix algebra of regression analysis; Least Square analysis in the one way classification; One way classification with regression and covariance; Two way classification with and without interactions; Multiple and nested classification; Maximum likelihood estimation of genetic parameters, Analysis of non orthogonal and multivariate data; Use of various statistical packages for genetic parameter estimations: SAS, REML, PEST, SelAction.

Suggested Readings
1. Dutkowski G & Gilmour A. 2005. *AsReml Cook Book*. Statistical Software Package.
2. Littell RC, Milliken GA, Stroup WW & Wolfinger RD**.** 1996. *SAS Systemfor Mixed Models*. SAS Institute.
3. Lynch M & Walsh B. 1997. Genetics and Analysis of Quantitative Traits. Sinauer, Sunderland.
4. Saxton AM. 2004. *Genetic Analysis of Complex Traits Using SAS*. SASPubl.

List of Journals
1. Acta Cytologica
2. Advances in Genetics Incorporating Molecular Genetic Medicine
3. Animal Genetic Resource Information
4. Animal Genetics
5. Annual Review of Genetics
6. Bioinformatics
7. Biological Conservation
8. BMC Bioinformatics
9. BMC Molecular Biology
10. Breeding Science
11. Briefings in Bioinformatics
12. Briefings in Functional Genomics and Proteomics
13. Cancer Genetics and Cytogenetics
14. Conservation Biology
15. Conservation Genetics
16. Cytogenetics
17. In Silico Biology
18. Indian Journal of Agricultural Statistics
19. Indian Journal of Cytology and Genetics

20. Indian Journal of Genetics and Plant Breeding
21. Indian Journal of Statistics
22. Journal of Animal Breed and Genetics
23. Journal of Animal Science
24. Journal of Applied Statistics
25. Journal of Bio-Chemistry and Molecular Biology
26. Journal of Computational and Graphical Statistics
27. Journal of Genetics
28. Journal of Heredity
29. Journal of Molecular Biology
30. Journal of Official Statistics
31. Journal of Statistical Software
32. Journal of Statistics Education
33. Journal of Tissue Culture Methods
34. Molecular Cytogenetics
35. Molecular and Cellular Biology

Broad Research Areas

1. Cryopreservation of gametes of species of commercial importance
2. Estimation of gene and genotype frequencies using various population genetic tools (markers)
3. Estimation of effective population size, inbreeding accumulation rate in a breeding population
4. Genetic stock structure analysis; genetic variability studies of species of commercial importance
5. Estimation of genetic parameters in species of commercial importance
6. Developing breeding plans for different commercial fish and prawn species
7. Estimation of genetic parameters in species of commercial importance
8. Estimation of heterosis and Inbreeding depression in breeding population
9. Construction of growth curves for different commercial fish and prawn species
10. Developing breeding plans for different commercial fish and prawn species
11. Cryopreservation of gametes of species of commercial importance
12. Application of molecular genetic markers for estimation of effective population size, rate of inbreeding
13. Estimation of genetic diversity and relatedness using molecular information
14. Morphometric analysis of stocks
15. Milt quality analysis and cryopreservation of milt
16. Estimation of linkage disequilibrium using molecular genetic data
17. Application of molecular genetic markers for estimation of effective population size, rate of inbreeding
18. Estimation of genetic diversity and relatedness using molecular information
19. QTL Analysis and application in selective breeding
20. Estimation of linkage disequilibrium using molecular genetic data
21. Application of molecular genetic markers for estimation of effective population

size, rate of inbreeding

22. Estimation of genetic diversity and relatedness using molecular information
23. QTL Analysis and application in selective breeding
24. Chromosome mapping for different commercial fish and prawn species
25. Karyotyping and chromosome spread preparation for different commercial fish and prawn species
26. Application of Nanotechnology for fish Breeding
27. Development of Nano-delivery system
28. Nano-toxicity study
29. Estimation of genetic parameters using various statistical packages like SAS, AsREML, PEST
30. Molecular data analysis using softwares like GENEPOP
31. Establishing cell lines
32. Construction of growth curves for different commercial fish and prawn species
33. Estimation of genetic and non-genetic parameters
34. Developing breeding plans for different commercial fish and prawn species
35. Cryopreservation of gametes of species of commercial importance
36. Developing breeding plans for different commercial fish and prawn species
37. Estimation of genetic parameters in species of commercial importance
38. Estimation of genotype-environment Interaction
39. Estimation of heterosis and Inbreeding depression in breeding population
40. Socio-economic impact studies for genetically improved varieties
41. Evaluation of International genetic improvement programmes
42. Chromosome mapping for different commercial fish and prawn species
43. Karyotyping and chromosome spread preparation for different commercial fish and prawn species
44. Pedigree assigning using molecular data
45. Estimation of genetic parameters using molecular data
46. Estimation of genetic and non-genetic parameters using various statistical packages like SAS, AsREML, PEST