Department of Fisheries
Faculty of Fisheries

Curriculum
for
M. S. in Fisheries Biology and Genetics
Session: 2019-2020

University of Rajshahi
Rajshahi, Bangladesh

UNIVERSITY OF RAJSHAHI
DEPARTMENT OF FISHERIES
FACULTY OF FISHERIES

Curriculum for M. S. in Fisheries Biology and Genetics
Session: 2019-2020

Examinations: Semester-1 Examination: June, 2025
Semester-2 Examination: December, 2025
Semester-3 Examination: June, 2026

Part A

1. **Title of the Academic Program: M. S. in Fisheries Biology and Genetics**
2. **Name of the University:** University of Rajshahi
3. **Vision of the University:**
   To pursue enlightenment and creativity for producing world-class human resources to cater for the needs of changing time.
4. **Mission of the University:**
   M1. To ensure a world-class curriculum with talented academicians and conducive academic and research environment for generation and dissemination of knowledge.
   M2. To maintain international standards in education with focus on both knowledge and skills, and humanitarian and ethical values to meet the needs of the society and state.
   M3. To develop strategic partnerships with leading national and international universities, and organizations for academic as well as research collaborations.
5. **Name of the Program Offering Entity (POE):** Department of Fisheries,
   Faculty of Fisheries, University of Rajshahi, Bangladesh.
6. **Vision of the Program Offering Entity (POE):**
   Vision of the M. S. in Fisheries Biology and Genetics Program
   Academic and need-based research excellence in fisheries biology and genetics for sustainable fisheries management and aquaculture.

7. **Mission of the Program offering Entity (POE):**
   Mission of the M. S. in Fisheries Biology and Genetics Program
   a) To promote advanced teaching-learning and research activities in fisheries biology and genetics for supporting effective fisheries management and aquaculture design and planning.
   b) To share knowledge through national and international collaborative research and training.
8. **Objective of the Program Offering Entity (POE)**
   To offer fisheries education to obtain B. Sc. Fisheries (Hons.), Master of Science (MS in Fisheries Biology and Genetics, MS in Aquaculture, MS in Fisheries Management and MS in Fisheries Technology), MPhil and PhD degree in Fisheries; to conduct teaching and research in various fields of Fisheries to increase the fish production and to meet the nutrient requirement.
9. **Name of the Degree:** M. S. in Fisheries Biology and Genetics
10. **Description of the Program:**

The Department of Fisheries is established in 2000 under the Faculty of Agriculture in the University of Rajshahi. Later on the department is included under newly formed Faculty of Fisheries in 2020. This department was started with three academic and three non-academic staffs with limited infrastructure facilities by enrolling twenty students. At present, the number of seats for student admission in B. Sc. Fisheries (Honours) level is fifty per year. Now, there are twenty academic staff specialized in different aspects of fisheries sector to enrich education and research in this department. In addition, twenty non-academic staffs are currently working for supporting the department. The department has already demonstrated its outreach excellence through establishing linkages with different donors, associations and industries for research, extension and developmental activities in fisheries sector.

The academic curriculum of the department is being offered in English. The department introduced twelve theoretical and four presentation courses in M. S. in Fisheries Biology and Genetics level including biology, breeding, biodiversity, conservation, biotechnology etc.

11. Graduate Attributes (Based on need assessment):

(a) Communicator,
(b) Innovator,
(c) Problem solver,
(d) Leader,
(e) Team builder,
(f) Self- motivated,
(g) Entrepreneur,
(h) Ethically aware,
(i) Digitally skilled,
(j) Multi-tasker and
(k) Adaptable

12. Program Educational Objectives (PEO) of the M. S. in Fisheries Biology and Genetics Program

PEO1: To give post graduate students a comprehensive insight into diversified biology of fish and shellfish.
PEO2: To have basic understanding of the genetics, genetic engineering and biotechnology in fisheries science.
PEO3: To conduct basic and applied research in different aspects of fisheries biology and genetics.
PEO4: To disseminate research findings on fisheries biology and genetics for sustainable aquaculture and fisheries management.

13. Program Learning Outcomes (PLOs)

At the end of the M. S. in Fisheries Biology and Genetics Program, the graduates will be able to-

PLOs	Program Outcomes
PLO1	Explain how aquatic animals function at the level of genome, cell, tissue, organ, organ system and their behaviour, reproduction, development, mode of life cycle and physiological adaptations in relation to the environmental changes for sustainable management and aquaculture.
PLO2	Know the present status, driving factors, and causes of degradation of biodiversity in aquatic systems and plan how to conserve living aquatic resources while securing a sustainable yield.
PLO3	Apply modern genetic engineering and biotechnological approach for successful aquaculture and aquatic resource management.
PLO4	apply appropriate research methods, statistical tests, information technologies in scientific studies in fisheries science and develop skills in oral and written presentations of biological research in population scientific and academic context.

14. Mapping between Mission and PEO

Mission	Program Educational Objectives (PEOs)			
	PEO1	PEO2	PEO3	PEO4
M1	X	X	●	X
M2	X	X	●	X
M3	X	X	X	X

X Strong contribution ● Weak contribution □ No contribution

15. Mapping PLOs with the PEOs

PEOs	Program Outcomes (PLOs)			
	PLO1	PLO2	PLO3	PLO4
PEO1	X	X	X	X
PEO2	X	●	●	●
PEO3	●	X	●	●
PEO4	●	●	X	X

X Strong contribution ● Weak contribution □ No contribution

16. Mapping courses with PLOs

Course Code	Course Title	PLOs			
		PLO1	PLO2	PLO3	PLO4
0831-501	Fish Morphology and Physiology	X	X	X	X
0831-502	Reproductive Biology of Fishes	X	X	X	●
0831-503	Advanced Fish Genetics	X	X	X	●
0831-504	Fish Conservation Genetics	X	X	X	●
0831-505	Research Methodology in Fisheries Biology	X	X	X	X
0831-506	Freshwater Biodiversity	X	X	●	●
0831-507	Captive Breeding of Aquatic Animals	X	X	●	●
0831-508	Climate Change and Fisheries Biology	X	X	●	●
0831-509	Research Defence-1	X	X	X	X
0831-601	Reproductive Biology of Non-piscine Animals	X	X	●	●
0831-602	Developmental Biology of Aquatic Animals	X	X	●	●
0831-603	Fish Genetic Engineering	X	●	X	●
0831-604	Fisheries Biotechnology	X	X	X	X
0831-605	Statistics in Fisheries Biology	X	X	●	X
0831-606	Coastal and Marine Biodiversity	X	X	●	●
0831-607	Endocrinology of Aquatic Animals	X	X	●	●
0831-608	Aquatic Animal Behaviour	X	X	●	●
0831- 609	Research Defence-2	X	X	X	X
0831-701	Thesis	X	X	X	X
0831-702	Thesis Defence	X	X	X	X

Part B

17. Structure of the curriculum

The M. S. in Fisheries Biology and Genetics courses shall consist of compulsory, optional, research defence, thesis and thesis defence. The compulsory courses are of 16 credits, optional courses 8 credits, research defence 4 credits, thesis 8 credits and thesis defence 4 credits with an aggregate credit of 40 credits. The research work of the thesis should be carried out from the beginning of Semester-1.

M. S. in Fisheries Biology and Genetics Semester-1 Examination shall be held at the end of the First Semester having 14 credits, covering six theoretical courses (four compulsory and two optional) including class test and attendance. In addition, a research defence on the problem statement, hypothesis, objectives, expected outcomes and methodology of the proposed research work will be held at the end of the semester having 2 credits.

M. S. in Fisheries Biology and Genetics Semester-2 Examination shall be held at the end of the Second Semester having 14 Credits covering six theoretical courses (four compulsory and two optional) including class test and attendance. In addition, a research defence on findings or progress of proposed research work will be held at the end of the semester having 2 Credits.

M. S. in Fisheries Biology and Genetics Semester-3 Examination shall be held at the end of the Third Semester having 12 Credits, covering thesis and thesis defence performances based on research work.

18. Semester wise distribution of courses

DETAILED BREAKS UP OF COURSES

M.S. in Fisheries Biology and Genetics Semester-1 Examination, June 2025

Course Code	Course Title	Credit
Compulsory		
0831-501	Fish Morphology and Physiology	**2**
0831-502	Reproductive Biology of Fishes	**2**
0831-503	Advanced Fish Genetics	**2**
0831-504	Fish Conservation Genetics	**2**

Optional (any two)		
0831-505	Research Methodology in Fisheries Biology	**2**
0831-506	Freshwater Biodiversity	**2**
0831-507	Captive Breeding of Aquatic Animals	**2**
0831-508	Climate Change and Fisheries Biology	**2**
Research work		
0831-509	Research Defence-1	**2**
	Total	**14**

M. S. in Fisheries Biology and Genetics Semester-2 Examination, December 2025

Course Code	Course Title	Credit
Compulsory		
0831-601	Reproductive Biology of Non-piscine Animals	**2**
0831-602	Developmental Biology of Aquatic Animals	**2**
0831-603	Fish Genetic Engineering	**2**
0831-604	Fisheries Biotechnology	**2**
Optional (any two)		
0831-605	Statistics in Fisheries Biology	**2**
0831-606	Coastal and Marine Biodiversity	**2**
0831-607	Endocrinology of Aquatic Animals	**2**
0831-608	Aquatic Animal Behaviour	**2**
Research work		
0831- 609	Research Defence-2	**2**
	Total	**14**

M.S. in Fisheries Biology and Genetics Semester-3 Examination, June 2026

Research Work	Course Title	Credit
0831-701	Thesis	**8**
0831-702	Thesis Defence	**4**
	Total	**12**
	Grand Total	**40**

Part C

19. Description of the courses

M. S. in Fisheries Biology and Genetics Semester-1 Examination, June 2025

COMPULSORY COURSES

0831-501: Fish Morphology and Physiology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]
Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course to complete 18 months (3 semester) M. S. in Fisheries Biology and Genetics degree. The course is designed to recall students' basic knowledge on morphological and physical aspects of fish body. It basically covers the structural features of major organ system *viz*. digestive, cardiovascular, respiratory, excretory and osmoregulatory, reproductive and urinogenital system in fishes and their physiological processes. The course will enrich students' knowledge to understand the secret of fish body in the research of Fisheries Biology.

Expected Outcomes:

At the end of the course, the students will be able to- i) obtain proper knowledge on structure and function major organ systems of fish; ii) obtain proper knowledge on the physiology major organ systems of fish iii) apply acquired knowledge in all aspects of studying fishery science.

At the end of the course, the students will able to-

CLOs	Course Outcomes	Lectures
CLO1	Explain the background of studying fish morphology and physiology.	1
CLO2	Differentiate structural variation in major organ systems in different fish groups.	3
CLO3	Understand structure, variation and mode of action of special organs and receptors in adaptive radiation in fishes.	5
CLO4	Explain physiology of major organ system in fishes and apply acquired knowledge both in lab and field based work.	4

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	●	●	X
CLO2	X	●	●	●
CLO3	X	X	●	●
CLO4	X	X	●	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	-Lecture -Power point presentation	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20)
CLO2	Morphology of the organ systems: Digestive system, Cardiovascular system, Respiratory system, Excretory and osmoregulatory system,	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

	Reproductive and urinogenital system.		Final Examination(70)
CLO3	Morphology and Physiology of special organs: Light organs, electric organs, poison glands and receptors.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO4	Physiology of digestion, blood circulation, respiration, excretion and osmoregulation, reproduction.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	

Recommended books/literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Helfman GS, Collette BB and Facey DE (1997),The Diversity of Fishes. Blackwell Science, UK.
- Kotpal RL (1999) Modern Textbook of Zoology Vertebrates, second edition. Rastogi Publications, India.
- Kumar S and Tembhre M (1996) Anatomy and Physiology of Fishes. Vikas Publishing House Pvt Ltd, India.
- Lagler KF, Bardach JE, Miller RR and Passino (1977) Ichthyology, second edition. John Wiley & Sons. New York, USA.
- Munshi JSD and Hughes GM (1992) Air Breathing Fishes of India Their Structure, Function and Life History. Oxford & IBH Publishing Co Pvt Ltd, India.
- Shammi QJ and Bhatnagar S (2002) Applied Fisheries. Agrobios, India.
- Yadav BN (1997) Fish and Fisheries. Daya Publishing House, India

0831-502: Reproductive Biology of Fishes

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course to complete 18 months (3 Semester) M S in Fisheries Biology and Genetics degree. The course is designed to expand students' basic knowledge on reproductive aspects of commercially important fish species of Bangladesh. It basically covers the reproductive biology of carps, catfishes, hilsa, snakeheads, ornamental fishes, eel, shark, marine finfish and other fishes. The course will enrich students' knowledge to understand the secret of reproductive biology while studying the reproductive periodicity, fecundity, maturation stages of gonad, gonadal length index and gonado-somatic index in fishes which will helpful in the research of Fisheries Biology.

Expected Outcomes:

At the end of the course, the students will be able to- i) obtain proper knowledge on reproductive biology fresh and marine water fish; ii) obtain proper knowledge on reproductive periodicity of fish iii) estimate and relate fecundity, gonadal measures with various body parameters iv) apply acquired knowledge in management and conservation of farm and wild fish population.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Explainthe background of studying reproductive biology of fishes.	1
CLO2	Understand and apply the knowledge of reproductive biology in management and conservation of fresh and marine water fish species.	3
CLO3	Understand the reproductive periodicity and apply knowledge in management of farm and wild fish population.	2
CLO4	Understand the methods of fecundity estimation and apply knowledge in management of wild fish population.	2
CLO5	Differentiate the maturation stages of fish and apply knowledge in management fish farm.	2

CLO6	Relate gonadal length and weight among body length and weight and apply knowledge in management and conservation of fish population.	2

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	X	●	●
CLO2	X	X	●	●
CLO3	X	X	X	●
CLO4	X	X	X	●
CLO5	X	X	X	●
CLO6	X	X	X	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	-Lecture -Power point presentation	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Reproductive biology of some important fishes: carps, catfishes, hilsa, snakeheads, ornamental fishes, eel, shark, marine finfish and other fishes.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO3	Reproductive periodicity in fishes.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO4	Estimation of the fecundity of fishes.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO5	Maturation stages of ova and gonad.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO6	Gonadal length index and gonado-somatic index.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

Recommended books/literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Kumar S and Tembhre M (1996) Anatomy and Physiology of Fishes. Vikas Publishing House Pvt Ltd, India.
- Lagler KF, Bardach JE, Miller RR and Passino (1977) Ichthyology, second edition. John Wiley & Sons. New York, USA.
- Shammi QJ and Bhatnagar S (2002) Applied Fisheries. Agrobios, India.
- Yadav BN (1997) Fish and Fisheries. Daya Publishing House, India.

0831-503: Advanced Fish Genetics

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

The course provides the understanding of basic knowledge of chromosomes, DNA, genomes, genes, transcription, RNA, translation, gene expression and gene regulation. The principle and application of molecular tools will be discussed for the detection of kin, the identification of populations, the reconstruction

of phylogenetic relationships, and to the understanding of local adaptation and evolution for the field of ecology, conservation, breeding and natural resource management. The aim of the course is to provide an understanding of the genetic principles underpinning these applications, thus allowing an assessment of the potential and limitations of molecular approaches to specific questions in ecology, evolution and resource management.

Expected Outcomes:

At the end of the course, the students will be able to obtain knowledge on basic concepts of molecular biology and the methods and techniques used in studying molecular biology in fisheries and aquaculture.
At the end of the course, the students will able to-

CLOs	Content Learning Outcomes	Lectures
CLO1	Describe structure of genes in prokaryotes and eukaryotes.	3
CLO2	Explain molecular organization and structure of chromosomes.	2
CLO3	Explain structure, replication, proofreading and repairing of nucleic acids.	4
CLO4	Describe mechanism and estimation of level of gene expression; Describe properties, chain initiation and termination codons.	2
CLO5	Explain principles, techniques and applications of gel electrophoresis.	2
CLO6	Explain regulation at different level of gene expression.	2
CLO7	Describe types, biochemical basis, process and importance of mutation.	2
CLO8	Describe history, required components, techniques and applications of Polymerase Chain Reaction.	2
CLO9	Explain genetics of fish immune system, specially Major histocompatibility Complexes (MHCs).	3

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	●	X	●
CLO2	X	●	X	●
CLO3	X	●	X	●
CLO4	X	●	X	●
CLO5	X	●	●	●
CLO6	X	●	X	●
CLO7	X	●	●	●
CLO8	X	●	X	X
CLO9	X	●	X	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction: Rationale; expected outcomes; Structure of genes in prokaryotes and eukaryotes; Operon.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Chromosomes: Molecular organization of chromosomes; Nucleosome; Chromosomal proteins.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Structure and synthesis of nucleic acids: structure of DNA and RNA; Replication of nucleic acids; Proofreading and DNA repairing.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	Gene expression (Structure and synthesis of RNA and Protein): Mechanism of transcription, RNA splicing, Translation; Over expression; Estimation of level of gene expression; RNA polymerase-	- Lectures followed by discussion - Participatory question-answer - Online resources	

	structure and function; Genetic code- Properties, chain initiation and termination codons; overlapping genes and split genes.		
CLO5	Gel electrophoresis and molecular markers: Principles, techniques and applications.	- Lectures followed by discussion - Participatory question-answer - Video demonstration	
CLO6	Control of Gene expression: Pre-transcriptional, transcriptional, post-transcriptional, translational gene regulation.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Mutation and mutants: types, biochemical basis, mutagenesis, mutation and genetic code; importance; mutation hot-spots.	- Lectures followed by discussion - Participatory question-answer	
CLO8	PCR: History, required components, techniques and applications.	- Lectures followed by discussion - Participatory question-answer	
CLO9	Genetics of fish immune system: Immunoglobulins- Fish antibodies and immunoglobin genes; T-cell receptors; Microglobulin- Fish endogenous and exogenous antigens; Major histocompatibility Complexes (MHCs) in fishes- Use of MHC polymorphisms; MHC and disease resistance.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., and Watson, J.D., 1994. Molecular Biology of the Cell. (3rd Edition). Garland Publishing Inc. New York and London.
- Freifelder, D., 1987. Molecular Biology (2nd Edition). Jones and Bartlett Publishers, Inc. Boston.Portola Valley.
- Lewin, B., 1997. GENES VI. Oxford University Press. Oxford, England.
- Carvalho, G.R. and Pitcher, T.J. (Editors), 1995. Molecular Genetics in Fisheries. Chapman and Hall, London.
- Darnell Jr, J., Lodish, H. and Baltimore, D., 1995. Molecular Cell Biology. W.H. Freeman and Co., New York.
- Kumar, H.D., 1998. Molecular Biology. Vikas Publishing House Pvt Ltd., New Delhi, India.
- Stryer, L., 1988. Biochemistry (3rd Edition) W.H. Freeman and Co., New York.
- Turner, B.J. (Editor), 1984. Evolutionary Genetics of Fishes. Plenum, New York.
- Watson, J.D., Hopkins, N.H., Roberts, J.N., Steitz, J.A. and Weiner, A.M., 1987. Molecular Biology of the Gene Vol. 1 and 2. Benjamin Cummings.
- Gupta PK (1998) Cytology Genetics and Molecular Biology. Rastagi Publications, India.
- Shah MS (2010) Genetics of Aquaculture and Fisheries Management, first edition. Published by MrsZinnatunAra Shah, Khulna, Bangladesh.
- Tave D (1993) Genetics for Fish Hatchery Manager, second edition. AVI Book. New York, USA.

0831-504: Fish Conservation Genetics

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

The aim of the course is to provide an understanding of the advanced genetic concepts, principles and methods related to species' conservation and natural resource management for the long-term survivability of a species in a changing environment. The course will cover basic population genetic and evolutionary principles that determine genetic variation in both natural and artificial environments (captivity/hatcheries).

This course covers methods of measuring genetic diversity in populations; identification of the conservation and evolutionary units; genetics and consequences of population fragmentation; reintroductions of organisms into the wild; inbreeding and genetic drift; genetics of small populations; genetic management of wild and captive populations and the role of molecular tools in enforcement and development of recovery plans.

Expected Outcomes:

At the end of the course, the students will be able to explain concepts of populations and its structure for fisheries management and conservation.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Define population and conservation genetics and describe their application. Describe importance, estimation, causes of loss and influencing factors of genetic diversity.	1
CLO2	Explain population genetic theories and principles with their applications and deviations.	2
CLO3	Explain genetic drift with their causes and the factors affecting it.	2
CLO4	Describe types, methods of estimation and consequences of inbreeding in fish populations.	2
CLO5	Explain basic concept of population connectivity and structure with measure ofcoefficient of genetic differentiation.	2
CLO6	Explain genome mapping, DNA fingerprinting and sequencing with their applications.	2
CLO7	Explain general principles and applications of taxonomic, biochemical and molecular tools in stock composition analyses.	2
CLO8	Describe mitochondrial DNA with its inheritance and applications for determining fish population structure.	2
CLO9	Explain genetic aspects of endangered populations as per guidelines of IUCN.	2
CLO10	Describe present status and causes of loss fish genetic diversity in Bangladesh	2
CLO11	Describe methods and techniques of conservation and preservation of aquatic species.	2

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	X	X	●
CLO2	X	X	X	●
CLO3	X	X	X	●
CLO4	X	X	●	●
CLO5	X	X	X	●
CLO6	X	X	X	●
CLO7	●	●	X	X
CLO8	X	●	X	●
CLO9	X	X	●	●
CLO10	X	X	●	●
CLO11	X	X	●	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction: Population and Conservation Genetics; application; causes of loss of genetic diversity; cause of extinction. Genetic diversity: importance, estimation and influencing factors.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/

CLO2	Population Genetic theories and principles: Gene and genotype frequencies; Causes of changes in gene and genotype frequencies; Hardy-Weinberg Equilibrium; Deviation of Hardy-Weinberg Equilibrium; Application.	- Lectures followed by discussion - Participatory question-answer - Online resources	Class Test (20) Final Examination(70)
CLO3	Genetic drift: Finite population size and genetic drift; effect of genetic drift, effective population size, separating sexes, variations in number gametes, inbreeding, variation in time, age; structure, neighbourhood size	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	Inbreeding: types, methods of estimation and consequences.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Population connectivity and structure: Dispersal; Gene flow; Limitation of freshwater aquatic organisms; genetic structure of random mating populations; Genetics of population structure and fragmentation; Coefficient of genetic differentiation – F_{ST}, R_{ST}, Q_{ST}, G_{ST} - their relative merits & demerits; Genetic similarity & distance.	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	
CLO6	Genome mapping and DNA fingerprinting: Cytogenetics and physical mapping; DNA based technology; Linkage mapping; Multilocus DNA fingerprinting, applications and genome mapping; DNA sequencing.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Taxonomic, biochemical and molecular tools in stock composition analyses: General principles and applications.	- Lectures followed by discussion	
CLO8	Mitochondrial DNA: The mitochondrial genome; analysis of fish population structure.	- Lectures followed by discussion	
CLO9	Threatened species: Threatened species as per guidelines of IUCN. Genetic aspects of endangered population.	- Lectures followed by discussion	
CLO10	Fish Genetic diversity of Bangladesh: Endemic species; Exotic species; Causes of loss of genetic diversity; Genetic evaluation of exotics and quarantine procedures.	- Lectures followed by discussion - Participatory question-answer	
CLO11	Conservation and preservation of aquatic species:issues and strategies, In-situ and Ex-situ conservations; Institutes and Societies associated with conservation.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- R. Frankham, J. D. Ballou and D. A. Briscoe. Introduction to Conservation Genetics. Cambridge University Press.
- Allendorf and G. H. Luikart. Conservation and the Genetics of Population. F. W. Blackwell Publishing.
- M. B. Hamilton. Population Genetics. Blackwell-Willey.
- Ryman, N. and Utter, F (editors) 1987. Population Genetics and Fishery Management. Washington Sea Grant Program, University of Washington Press, Seattle and London.
- Falconer, D.S. and Mackay, T.F.C., 1996. Introduction to Quantitative Genetics (4rd Edition) Longman, UK.
- Crow, J.F. and Kimura, M., 1970. An Introduction to Population Genetics Theory. Harper and Row Publishers, New York.
- Chapman, B. (Editor), 1985. General and Quantitative Genetics. Elsevier Science Publishers, B.V.

Amsterdam-Oxford-New York-Tokyo.
- Hartl, D.L. and Clark, A.G., 1989. Principles of Population Genetics (2nd edition). Sinauer Associates, Sunderland, MA.
- Hedrick, P.W., 1985. Genetics of Populations. Jones and Bartlett Publishers, Inc. Boston.
- Kirby, L.T., 1990. DNA Fingerprinting: An Introduction. W.H. Freeman and Co. Saltlake City, UT. Mayden, R.L. (Editor), 1993.
- Mustafa, G. 1999. Genetics in Sustainable Fisheries Management. Blackwell Science Ltd.
- Roberts, D.F. and De Stefano, G.F. (Editor), 1986. Genetic Variation and its Maintenance. Cambridge University Press.
- Soule, M.E. (Editor), 1987. Viable Populations for Conservation. Cambridge University Press.
- Turner, B.J. (Editor), 1984. Evolutionary Genetics of Fishes. Plenum Press.
- Whitemore D.H. (Editor) 1990. Electrophoretic and Isoelectric Focussing Techniques in Fisheries Management. CRC Press.
- Gupta PK (1998) Cytology Genetics and Molecular Biology. Rastagi Publications, India.
- Shah MS (2010) Genetics of Aquaculture and Fisheries Management, first edition. Published by MrsZinnatunAra Shah, Khulna, Bangladesh.
- Tave D (1993) Genetics for Fish Hatchery Manager, second edition. AVI Book. New York, USA.

OPTIONAL COURSES

0831-505: Research Methodology in Fisheries Biology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course has been designed to guide students to gain knowledge of basic theories and methods involved in scientific research in the discipline of fisheries biology and genetics. Students develop the skills to recognize and reflect on the strengths and limitations of different research methodologies, understand the links between theory and practice, critically assess research, and address ethical and practical issues.Once equipped with this knowledge, students would be skilled to review and conduct methodologically sound research under supervision in an area of their choosing. How to manage and analyze data (including computer assisted), and how to write up and present findings in thesis and manuscript are core components of this course. Students will be equipped with the knowledge and ability to undertake original research projects and develop a set of transferable workplace skills.

Expected Outcomes:

At the end of the course, the students will be able to- i) obtain proper knowledge on research methodology; ii) obtain proper knowledge on research and/or project proposal writing iii) apply acquired knowledge in thesis, scientific articles, reference writings etc.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Understand and describe the introduction, rationale and expected outcome of studying of research methodology in Fisheries Biology.	1
CLO2	Understand and explain fisheries biological research and terminologies, research advisor, problems on research etc.	2
CLO3	Know, explain and apply Principle, field layout, Sampling design, Measurement and Scaling technique, Methods of Data collection etc.	3
CLO4	Understand and explain the access to the field, site visit, data/sample collection, data records and sample preservation etc..	3
CLO5	Discuss and explain sample maintenance, marking/tagging, dissecting, different measurements etc.	3
CLO6	Know, explain and apply to write the research background including importance, problem statement and objective, Methodology including a time frame, Expected findings, citation.	2

CLO7	Know, explain and apply to the project proposal writing, project progress report and final report writing..	2
CLO8	Understand, explain and apply to write abstract, introduction, methodology, review of literature, results, discussion, recommendation and citation	2
CLO9	Understand, explain and apply to write reference for journal papers, books, proceedings, conference paper, electronic documents, unpublished documents, etc.	2
CLO10	Understand, explain and apply to write the scientific article including abstract, introduction, methodology, results and discussion, recommendation and citation.	2

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	X	X	X
CLO2	X	X	X	X
CLO3	X	X	X	X
CLO4	X	X	X	X
CLO5	●	●	●	X
CLO6	●	●	●	X
CLO7	●	●	●	X
CLO8	●	●	●	X
CLO9	X	X	●	X
CLO10	X	X	●	X

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	-Lecture -Power point presentation	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Fisheries biological research and terminologies, Research advisor, Problems on research.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO3	Principle, field layout, Sampling design, Measurement and Scaling technique, Methods of Data collection etc.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO4	Fieldworks: Access to the field, Site visit, Data/Sample collection, Data records and Sample preservation etc.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO5	Lab works: Sample maintenance, Marking/Tagging, Dissecting, Different measurements etc.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO6	Research proposal writing / Synopsis writhing: Research background including importance, problem statement and objective, Methodology including a time frame, Expected findings, citation.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO7	Project proposal writing, Project progress report and final report writing.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO8	Thesis writing: Abstract, introduction, methodology, review of literature, results, discussion, Recommendation and citation	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO9	Reference writing: journal papers, books, proceedings, conference paper, electronic documents, unpublished documents, etc.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

CLO10	Scientific article writing: Abstract, introduction, methodology, results and discussion, Recommendation and citation.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

Recommended books/literature:

- Kothari CR (2004) Research Methodology - Methods and Techniques (2nd Edition). New Age International Publishers.
- Kumar R (2010) Research Methodology: A Step-by-Step Guide for Beginners (Third Edition). SAGE Publications Ltd
- Berg BL (2001) Qualitative research methods for social sciences. 4th ed. USA: Allyn & Bacon.
- Booth WC, Colomb GG and Williams JM (2003) The craft of research. 2nd ed. Chicago: The University of Chicago Press.
- Burrows T (2011) Writing research articles for publication. Thailand: The Asian
- Burton S and Steane P (eds) (2004) Surviving your thesis. London: Routledge
- Dawson C (2002) Practical research methods: a user-friendly guide to mastering research techniques and projects. Oxford: How To Books Ltd.
- Given LM (ed) (2008) The Sage encyclopedia of qualitative research methods, volumes 1 & 2. California, Thousand Oaks: Sage Publications.
- De Leeuw ED, Hox JJ and Dillman DA (eds) (2008) International handbook of survey methodology. EAM.
- Yin RK (2011) Qualitative research from start to finish. New York: The Guilford Press.
- Walliman N (2011) Research methods: the basics. Oxon: Routledge.
- SeltmanHj (2014) Experimental design and analysis. Carnegie Mellon University.
- Neergaard H and Ulhoi JP (eds) (2007) Handbook of qualitative research methods in entrepreneurship. UK. Edward Elgar Publishing Ltd.
- Modern Language Association of America (2009) MLA handbook for writers of research papers. 7th ed. New York: Modern Language Association of America.

0831-506: Freshwater Biodiversity

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a theoretical course on freshwater biodiversity of Bangladesh and prerequisite to complete the MS in Fisheries Biology and Genetics degree. The course covers the concept and categories of freshwater biodiversity, Genetic, Species, habitat biodiversity of freshwater fishes and other fisheries items, biodiversity indices, IUCN red list and research trend of freshwater biodiversity in Bangladesh.

Expected Outcomes:

At the end of the course, the students will be able to describefreshwater biodiversity, their status, causes of degradation for their sustainable management and conservation.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Know and understand introduction, rationale and expected outcomes of the course.	1
CLO2	Define and, explain the concept of freshwater biodiversity; past and present status; rationale, and scope of freshwater biodiversity study.	2
CLO3	Describe freshwater habitats such as : Ponds, rivers, beels, haors, baors, streams, Kaptai and other lakes, and other freshwater habitats of Bangladesh. Fisheries hotspots in Bangladesh.	3
CLO4	Define and describe the species diversity of fishes: Major groups of fishes in Bangladesh, habitat-wise fish biodiversity in Bangladesh.	3
CLO5	Describe the species diversity of shellfishes and other organisms: Important groups of shellfishes and other fisheries organisms in Bangladesh, habitat-wise biodiversity in Bangladesh.	3

CLO6	Describe the biodiversity of freshwater vegetation: Common aquatic vegetation in freshwater bodies of Bangladesh, their ecological roles, relation to fisheries, and economic importance.	2
CLO7	Know and understand the threatened freshwater biodiversity of Bangladesh: Threatened freshwater fish and other aquatic species of Bangladesh, criteria of IUCN Redlist categories.	3
CLO8	Define, explain and apply the biodiversity indices: Shannon-Weiver Index, Simpson Index, Margalef Index, Poulie's Index and other indices of measuring biodiversity.	3
CLO9	Know and describe research on freshwater biodiversity: Past and current researches on freshwater biodiversity in Bangladesh and outside Bangladesh.	2

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	X	X	X
CLO2	●	X	●	●
CLO3	●	X	●	●
CLO4	●	X	●	●
CLO5	●	X	●	●
CLO6	●	X	●	●
CLO7	●	X	●	●
CLO8	●	X	●	X
CLO9	●	X	●	X

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CO1	Introduction, rationale and expected outcomes.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Concept and definition of freshwater biodiversity; past and present status; rationale, and scope of freshwater biodiversity study.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Freshwater habitats: Ponds, rivers, beels, haors, baors, streams, Kaptai and other lakes, and other freshwater habitats of Bangladesh. Fisheries hotspots in Bangladesh.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	Species diversity of fishes: Major groups of fishes in Bangladesh, habitat-wise fish biodiversity in Bangladesh.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Species diversity of shellfishes and other organisms: Important groups of shellfishes and other fisheries organisms in Bangladesh, habitat-wise biodiversity in Bangladesh.	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	
CLO6	Biodiversity of freshwater vegetation: Common aquatic vegetation in freshwater bodies of Bangladesh, their ecological roles, relation to fisheries, and economic importance.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Threatened freshwater biodiversity of Bangladesh: Threatened freshwater fish and other aquatic species of Bangladesh, criteria	- Lectures followed by discussion - Participatory question-answer	

	of IUCN Redlist categories.	Online resources	
CLO8	Biodiversity indices: Shannon-Weiver Index, Simpson Index, Margalef Index, Poulie's Index and other indices of measuring biodiversity.	- Lectures followed by discussion - Participatory question-answer Online resources	
CLO9	Research on freshwater biodiversity: Past and current researches on freshwater biodiversity in Bangladesh and outside Bangladesh.	- Lectures followed by discussion - Participatory question-answer Online resources	

Recommended books/literature:

- Bhuiyan AL (1964) Fishes of Dacca. Asiatic Society of Pakistan, Dacca, Bangladesh.
- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Galib SM and Mohsin ABM (2011) Cultured and Ornamental Exotic Fishes of Bangladesh Past and Present. Lambert Academic Publishing, Germany.
- Helfman GS, Collette BB and Facey DE (1997) The Diversity of Fishes. Blackwell Science, UK.
- Hosetti BB and Kumar A (2002) A Textbook of Applied Aquatic Biology. Daya Publishing House, India.
- IUCN Bangladesh (2000) Red Book of Threatened Fishes of Bangladesh. IUCN-The World Conservation Union, Bangladesh.
- Talwar PK and Jhingran AK (1991) Inland Fishes of India and Adjacent Countries, volume 1 and 2. Oxford & IBH Publishing Co Pvt Ltd, India.
- Rahman AKA (1989 and 2005) Freshwater Fishes of Bangladesh, first and second editions. Zoological Society of Bangladesh, Dhaka, Bangladesh.
- Shafi M and Quddus MMA (2001) Fisheries of Bangladesh (in Bangla). Kabir Publications, Dhaka, Bangladesh.

0831-507: Captive Breeding of Aquatic Animals

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a theoretical course on captive breeding of aquatic animals of Bangladesh and prerequisite to complete the MS in Fisheries Biology and Genetics degree. The course covers essential components and breeding environments, breeding technique of native and non-native cultivable and ornamental fish and other fisheries items.

Expected Outcomes:

At the end of the course, the students will be able to perform breeding programs for native, exotic and ornamental aquatic organisms.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Describe history and importance of Captive Breeding of Aquatic animals.	1
CLO2	Describe essential components and environments for breeding programs of aquatic animals.	2
CLO3	Perform breeding of native ornamental and other fishes.	4
CLO4	Perform breeding of exotic ornamental fishes.	3
CLO5	Perform breeding of non-fish aquatic organisms.	2
CLO6	Describe past and recent research trends on aquatic animals breeding in and outside Bangladesh.	2

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	●	●	●
CLO2	X	●	●	●
CLO3	X	●	●	●
CLO4	X	●	●	●
CLO5	X	●	●	●
CLO6	X	●	●	X

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Essential components and breeding environments.	- Lectures followed by discussion - Participatory question-answer	
CLO3	Breeding of native ornamental and other fishes.	- Lectures followed by discussion - Participatory question-answer	
CLO4	Breeding of exotic ornamental fishes.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Breeding of non-fish aquatic organisms.	- Lectures followed by discussion - Participatory question-answer	
CLO6	Past and recent research trends on aquatic animals breeding in and outside Bangladesh.	- Lectures followed by discussion - Participatory question-answer - Online resources	

Recommended books/literature:

- Galib SM and Mohsin ABM (2011): Cultured and Ornamental Exotic Fishes of Bangladesh Past and Present. Lambert Academic Publishing, Germany.
- Hosetti BB and Kumar A (2002): A Textbook of Applied Aquatic Biology. Daya Publishing House, India.
- Shammi QJ and Bhatnagar S (2002) Applied Fisheries. Agrobios, India.
- Yadav BN (1997) Fish and Fisheries. Daya Publishing House, India.

0831-508: Climate Change and Fisheries Biology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]
Time: 3 hours (Seven questions to be set and five to be answered)

Course Descriptions:

Anthropogenic climate change presents a wide range of impacts and challenges for both the planet and the organisms that exist upon it. This course provides a basic introduction the biological consequences ofclimate change on aquatic organisms, with regard to physiology, behaviour, population dynamics, and community effects. The course focuses on what is known, and what is not known, about the ways in which the suite of changing climate variables influence biological systems.Students will also explore the challenges, conversations and uncertainties climate change present to scientists in terms of its potential impacts on freshwater and marine species' distributions including infectious pathogens and their arthropod vectors.

Expected Outcomes:

At the end of the course, the students will be able to explain concept of climate change and their effects on ecosystem, biology and reproduction for sustainable fisheries management and aquaculture.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Explain the basic concepts of climate change and its importance in fisheries.	3
CLO2	Explain physical and ecological impacts of climate change on marine and inland ecosystems.	3
CLO3	Explain climate change impacts on reproduction of fish and other fisheries organisms.	3
CLO4	Explain climate change impacts on the feeding of fish and other fisheries organisms.	3
CLO5	Describe types, sources and effects of aquatic pollution on fisheries.	3
CLO6	Explain climate change mitigation measures.	3
CLO7	Describe past and recent researches on climate change and fisheries in and outside Bangladesh.	3

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	●	X	●	●
CLO2	●	X	●	●
CLO3	●	X	●	●
CLO4	X	●	●	●
CLO5	X	X	●	●
CLO6	●	●	●	X
CLO7	●	●	●	X

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Physical and ecological impacts of climate change on marine and inland ecosystems.	- Lectures followed by discussion - Participatory question-answe	
CLO3	Climate change impacts on reproduction of fish and other fisheries organisms.	- Lectures followed by discussion - Online resources	
CLO4	Climate change impacts on the feeding of fish and other fisheries organisms.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Aquatic pollution: Types, sources and effects on fisheries.	- Lectures followed by discussion - Participatory question-answer	
CLO6	Climate change mitigation measures.	- Lectures followed by discussion - Participatory question-answer	
CLO7	Past and recent researches on climate change and fisheries in and outside Bangladesh.	- Lectures followed by discussion	

Recommended books/ literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Hosetti BB and Kumar A (2002) A Textbook of Applied Aquatic Biology. Daya Publishing House, India.
- Shammi QJ and Bhatnagar S (2002) Applied Fisheries. Agrobios, India.

Research Work

0831-509: Research Defence-1

Credit: 2

Full Marks: 100

Course Description:

This course provides students to design and execute a meaningful research project that demonstrates critical thinking and uses the knowledge and skills learned while in undergraduate and the M. S. in Fisheries Biology & Genetics program.The course aims to give students skills for critical reading of research literature, articulate research objectives clearly and for developing a research proposal for a master's thesis project. Finally students can describe their proposed research project clearly in oral forms to faculty, mentors, and lab-mates.

Expected Outcomes:

At the end of the research defence, intensive and constructive discussions of proposed research projects from definition of problem statement, hypothesis and research objectives through different scientific approaches, research design and expected data analysis will enable student to develop critical thinking and scholarly skills in developing research proposal.

At the beginning of Semester-1, all students will be attached to the academic staff as a supervisor. Students/They will face a research defence based on the problem statement, hypothesis, objective, expected outputs and limitations, review of literature and methodology of the proposed research.

M.S. in Fisheries Biology and Genetics Semester-2Examination, December2025

COMPULSORY COURSES

0831-601: Reproductive Biology of Non-piscine Aquatic Animals

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and /or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course to complete 18 months (3 semester) M S in Fisheries Biology and Genetics degree. The course firstly focuses an overview of shellfish fisheries of Bangladesh along with their importance and economic significance of non-piscine aquatic animals of Bangladesh. The course is basically designed to increase students' basic knowledge on the biological aspects *viz.* life history, food and feeding, digestion, reproduction and its control mechanisms of shrimps, lobsters, crabs and crayfish, oysters, squid, mussels etc. The course will enrich students' knowledge to understand the secret of important biological features of non-piscine aquatic animals that will be helpful in the research of Fisheries Biology.

Expected Outcomes:

At the end of the course, the students will be able to- i) obtain proper knowledge on the status of shell fishery in Bangladesh; ii) obtain proper knowledge on reproductive biology of crustaceans and mussels iii) apply acquired knowledge in managing farm and wild population of crustaceans and mussels.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Explain the background of studying reproductive biology of non-piscine aquatic animals.	1
CLO2	Understand the importance and significance of shell fishery in Bangladesh.	3
CLO3	Understand the reproductive biology of important crustaceans and apply knowledge in management of wild population.	8
CLO4	Understand the reproductive biology of important mussels and apply knowledge in management of wild population.	8

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	X	X	●
CLO2	●	X	X	●
CLO3	X	X	●	●
CLO4	X	X	●	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	-Lecture -Power point presentation	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Shellfishes: Types and their importance and economic significance. An overview of shellfish fisheries in Bangladesh and in the world.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO3	Biology of shrimps, lobsters, crabs and crayfish with particular emphasis on life history, food and feeding, digestion,	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

	reproduction and its control mechanisms.	-Online resources	
CLO4	Biology of oysters, squid and mussels with particular emphasis on life history, food and feeding, digestion, reproduction and its control mechanisms.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	

Recommended books/literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Kumar S and Tembhre M (1996) Anatomy and Physiology of Fishes. Vikas Publishing House Pvt Ltd, India.
- Lagler KF, Bardach JE, Miller RR and Passino (1977) Ichthyology, second edition. John Wiley & Sons. New York, USA.
- Paul SK (2001) Shrimp and Lobster: Biology, first edition (in Bangla). Published by Monika Paul, Natore, Bangladesh.
- Shammi QJ and Bhatnagar S (2002) Applied Fisheries. Agrobios, India.
- Yadav BN (1997) Fish and Fisheries. Daya Publishing House, India

0831-602: Developmental Biology of Aquatic Animals

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course to complete 18 months (3 semester) M S in Fisheries Biology and Genetics degree. The course firstly focuses on basic component of animal development *viz.* gametogenesis and fertilization. Then the course describes the developmental biology of some important fishes, crustaceans and mollusks. The course also describes maturation stages, factors influencing breeding, breeding behavior, colouration, courtship, size at recruitment and first maturity of important fisheries of Bangladesh. The course will enrich students' knowledge to understand developmental biology that will be helpful in the research of Fisheries Biology.

Expected Outcomes:

At the end of the course, the students will be able to- i) obtain proper knowledge on gametogenesis; ii) obtain proper knowledge on embryonic and larval development of aquatic animals iii) apply acquired knowledge in managing breeding performance of aquatic animals.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Explainthe background of developmental biology of aquatic animals.	1
CLO2	Understand the process of gametogenesis and demonstrate spermatogenesis and oogenesis.	3
CLO3	Understand and explain the basic concept of developmental stages of life.	3
CLO4	Understand and explain the concept on embryonic and larval development of finfish and shellfish.	4
CLO5	Understand and explain the concept on embryonic and larval development of crustaceans and molluscs.	3
CLO6	Understand and explain the concept on maturation stages of fish along with breeding behaviour.	4

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	X	●	●
CLO2	●	X	●	●
CLO3	X	X	●	●
CLO4	X	X	●	●
CLO5	X	X	●	●
CLO6	X	X	●	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	-Lecture -Power point presentation	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Gametogenesis: Spermatogenesis and oogenesis, the structure of sperm and ovum, egg types.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO3	Fertilization: Zygote, cleavage patterns, blastulation, gastrulation, organogenesis and coelom in finfishes and shellfishes.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO4	Developmental biology of some important fishes: embryonic development, fry, juveniles, adults, sexual dimorphism, maturation stages, factors affecting the development of finfishes and shellfishes.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO5	Developmental biology of commercially important crustacean species (shrimps, lobsters, crabs) and molluscs (mussels and snails).	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO6	Maturation stages, factors (internal and external) influencing breeding, breeding behaviour- colouration, courtship, size at recruitment and first maturity.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	

Recommended books/literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Kumar S and Tembhre M (1996) Anatomy and Physiology of Fishes. Vikas Publishing House Pvt Ltd, India.
- Lagler KF, Bardach JE, Miller RR and Passino (1977) Ichthyology, second edition. John Wiley & Sons. New York, USA.
- Paul SK (2001) Shrimp and Lobster: Biology, first edition (in Bangla). Published by Monika Paul, Natore, Bangladesh.
- Yadav BN (1997) Fish and Fisheries. Daya Publishing House, India

0831-603: Fish Genetic Engineering

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]
Time: 3 hours (Seven questions to be set and five to be answered)

Course description:

This course is aimed to provide knowledge and understanding genetic engineering, the basic principles of

recombinant DNA technology, gene manipulation and genetic transformation and their application to plant, animal and microbes improvement and their conservation.This course presents an overview of the research and commercial applications, and issues/challenges in the area of Genetic Engineering. They will be able to know biosafety and risk management related to genetically modified fish and shellfish. Moreover, they will gather the knowledge to produce mutational aquatic animals for aquarium culture.

Expected Outcomes:

At the end of the course, the students will be able to describe recombinant DNA techniques, DNA cloning, transgenic technology in fisheries and aquaculture and biosafety of these techniques.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Describe basic concept and prospect of genetic engineering technology in fisheries and aquaculture.	2
CLO2	Describe recombinant DNA techniques usedin aquatic animals focusing on selection ofgene of interest, enzymes commonly used in these technology andformation of DNA constructs.	3
CLO3	Describe DNA extraction and purification techniques from fish tissue and nucleic acid hybridization processes used in fisheries and aquaculture.	3
CLO4	Describe DNA cloning techniques used in fisheries and aquaculture.	3
CLO5	Describe Gene expression, isolation and cloning for different purpose in fisheries and aquaculture.	2
CLO6	Describe transgene transfer techniques and theirintegration, transmission and expression in fishes;Describe reporter genes with their properties and application.	5
CLO7	Describe effects of transgene in fish and shellfish and environment.	2
CLO8	Describe risk assessment of transgenic with emphasis on biosafety regulations, food safety and ethical issues.	1
CLO9	Describe biotechnology in fish health management.	1

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	X	X	●
CLO2	X	X	X	●
CLO3	X	X	X	●
CLO4	X	●	X	●
CLO5	X	●	X	●
CLO6	X	●	X	●
CLO7	X	●	X	●
CLO8	X	●	X	●
CLO9	●	●	X	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction: Prospects for genetic engineering in fishes. Fish as model animals for genetic engineering and biotechnology. An overview of genes cloned from fishes.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Recombinant DNA techniques: Selection of a gene of interest; Enzymes commonly used in DNA technology; Restriction endonucleases- Major classes and	- Lectures followed by discussion - Participatory question-answer - Online resources	

	nomenclature; Ligase enzyme; Reverse transcriptase; kinase enzyme, DNA polymerase, maring of DNA constructs.		
CLO3	DNA extraction and purification: Isolation of total cellular DNA; Nucleic acid hybridization- Northern blotting; southern blotting; Western blotting; molecular hybridization; Labelling of nucleic acids.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	DNA cloning: Selection of suitable vector (plasmids); cutting DNA at precise location; joining two prices of DNA. Transformation, amplification of DNA, selection of the hosts expressing recombinant DNA. Isolation of target DNA for the host cells.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO5	Gene expression, isolation and cloning: Gene expression and expressed sequence tags (ESTs); growth, ovulation and reproduction, diseases, brain, cold tolerance, osmoregulation, genetic imprinting and parental predominance, transposable elements, ribosomes and proteomics.	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	
CLO6	Gene transfer technology: Selection of fish species; Transgene; mitochondrial DNA in gene transfer; Promoters; Collection of germ cells or embryos; Gene transfer techniques; Manipulating embryonic stem cells; Transgene Integration; transmission of transgenes; transgene expression; Reporter genes- properties and application.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Transgenic fish and shellfish: Gene transfer for growth-hormone and AFP genes; performance of transgenic fish; transgenic production of pharmaceuticals; gene knockout technology, and potential role.	- Lectures followed by discussion - Participatory question-answer	
CLO8	Bio-safety: Risk assessment for transgenic; GMOs and biosafety regulations, food safety of transgenic aquatic organisms; ethical issues of GMOs; National regulation of GMOs.	- Lectures followed by discussion - Participatory question-answer	
CLO9	Biotechnology in health management: Monoclonal antibodies; Immunotoxin; Vaccines; Nucleic acid probes;	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Dunham RA (2004) Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI Publishing UK.
- Gupta PK (1998) Cytology Genetics and Molecular Biology. Rastagi Publications, India.
- Ranga MM and Shammi QJ (2005) Fish Biotechnology. Agrobios, India.
- Shah MS (2010) Genetics of Aquaculture and Fisheries Management, first edition. Published by

MrsZinnatunAra Shah, Khulna, Bangladesh.
- Tave D (1993) Genetics for Fish Hatchery Manager, second edition. AVI Book. New York, USA.
- A. R. Beaumont and K. Hoare (2003). Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell Publishing.
- Carl A. Pinkert. Transgenic Animal Technology: A Laboratory Handbook.
- V.S.Kirpichnikov. Genetic bases of fish selection.
- W. S. Lakra and Gopakrishnan. Genetics, genetic engineering and Biotechnology in fisheries.
- Genetics and Fish Breeding: C.E.Purdom.
- Practical Genetics for Aquaculture: C. Greglutz.

0831-604: Fisheries Biotechnology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

The course will introduce the students to the historical development, scope and features of old and modern biotechnology. The course provides students with the background knowledge and practical methodologies for the current technologies used for genetic improvement of fish and shellfish aquaculture and wild fishery resource management. The course is designed to familiarize the students with practical use of genetic markers in selection and hybridization of fishes. This course is also aimed to know different biotechnological approaches; to produce different value added products and bi-products, to know different diseases of fish and shellfish and health management in farmed fishes and wild fisheries management.

Expected Outcomes:

At the end of the course, the students will be able to describe monosex, inbred, gynogen, androgen, marine products using modern biotechnology with their application and limitations.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Describe definition, history and application of biotechnology and fisheries biotechnology.	2
CLO2	Describe and design genetic improvement program for commercial aquaculture fishes using different selective breeding.	2
CLO3	Explain and design inbreeding program for inbred and clonal lines production; Describe and design crossbreeding and hybridization program for Indian and Chinese carps.	4
CLO4	Explain and produce gynogens and androgens for aquaculture and fisheries management.	2
CLO5	Explain and produce sex reversed and monosex fish population using different techniques.	2
CLO6	Describe polyploidy production and their performance in fisheries and aquaculture.	2
CLO7	Describe commercial application of fish biotechnology, genetic engineering and other technology.	1
CLO8	Describe environmental biotechnology with emphasis on risks of aquatic organisms from genetic biotechnology and engineering.	2
CLO9	Describe constrains and limitations of genetic biotechnology, especially of research; development, biodiversity, political and economic issues.	1
CLO10	Describe marine Biotechnology: Marine natural products; physiology of marine organisms; source of metabolites; seeweeds; sponges;	4

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	●	X	●

CLO2	X	●	X	●
CLO3	X	X	●	●
CLO4	X	X	●	●
CLO5	X	X	●	●
CLO6	X	●	●	●
CLO7	X	X	X	●
CLO8	X	X	X	●
CLO9	●	●	X	X
CLO10	X	●	X	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction: Definition; Branch of biotechnology; History of animal biotechnology;Old vs new Biotechnology; Biotechnology in Fisheries and aquaculture-history and application.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Selective breeding: Selection based on gene of known large effect: QTL and MAS; Breeding values for binary traits; Selection and breeding for disease resistance and survivalanalysis; Partial diallele analysis; Selection for single trait and multiple traits; Genetic improvement program for tilapia (GIFT), common carp, atlantic salmon and thaipangus, sharpunti; correlations;	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Inbreeding and hybridization: Production of clonal lines; genetics of hybridization; Natural and artificial hybridization; Hybridization in Indian and Chinese carps;	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	Gynogenesis and androgenesis: induction and performances of gynogens and androgens, reproduction; inbred productions.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO5	Sex reversal and breeding: Sexual dichromatism; chemical and mechanical sex reversal and breeding in all-female XX systems, all-male ZZ systems, and all male YY systems; Social induction;	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	
CLO6	Polyploidy: Polyploid induction in fish and shellfish, triploid cells, ploidy determination; performances of triploid fish and invertebrates, tetraploid fish and shellfish, and hexaploid fish	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Commercial application of fish biotechnology: polyploidy, sex reversal and breeding and genetic engineering; surrogation technology; probiotics in aquaculture; cryopreservation technology	- Lectures followed by discussion - Participatory question-answer	
CLO8	Environmental biotechnology:	- Lectures followed by discussion	

	Environmental risks of aquatic organisms from genetic biotechnology-Theoretical risks, environmental risk data on transgenic fish and genetic sterilization.	- Participatory question-answer	
CLO9	Constrains and limitations of genetic biotechnology: Research issues; general recommendations; development issues; biodiversity issues; political issues; and economic issues.	- Lectures followed by discussion - Participatory question-answer	
CLO9	Marine Biotechnology: Marine natural products; physiology of marine organisms; source of metabolites; Seeweeds; sponges;	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Dunham RA (2004) Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI Publishing UK.
- Gupta PK (1998) Cytology Genetics and Molecular Biology. Rastagi Publications, India.
- Ranga MM and Shammi QJ (2005) Fish Biotechnology. Agrobios, India.
- Shah MS (2010) Genetics of Aquaculture and Fisheries Management, first edition. Published by MrsZinnatunAra Shah, Khulna, Bangladesh.
- Tave D (1993) Genetics for Fish Hatchery Manager, second edition. AVI Book. New York, USA.
- A. R. Beaumont and K. Hoare (2003). Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell Publishing.
- Carl A. Pinkert. Transgenic Animal Technology: A Laboratory Handbook.
- V.S.Kirpichnikov. Genetic bases of fish selection.
- W. S. Lakra and Gopakrishnan. Genetics, genetic engineering and Biotechnology in fisheries.
- Genetics and Fish Breeding: C.E.Purdom.
- Practical Genetics for Aquaculture: C. Greglutz.
- Kirby, L.T., 1990. DNA Fingerprinting: An Introduction. W.H. Freeman and Co. Saltlake City, UT. Mayden, R.L. (Editor), 1993.
- Roberts, D.F. and De Stefano, G.F. (Editor), 1986. Genetic Variation and its Maintenance. Cambridge University Press.

OPTIONAL COURSES

0831-605: Statistics in Fisheries Biology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite for understanding the courses related to statistics The course is designed to strengthen the student's existing knowledge of biostatistics and its classification and application to fisheries and aquaculture research. Additionally, this course covers basic understanding the goodness of fit and independence of two attributes in a contingency table, lest of significance of correlation coefficient and regression coefficient and its uses in fisheries biology and genetics research.

Expected Outcomes:

At the end of the course, the students will be able to obtain proper knowledge on basic statistics and apply these in Fisheries Biology.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Recall basic concepts of statistics.	2
CLO2	Understand and explain basic concepts of Statistics in Fisheries Biology.	2

CLO3	Construct frequency distribution and do graphical representations of data	2
CLO4	Measure and apply LLR, LWR, GLI, GSI, condition factor, and fecundity counting methods.	2
CLO5	Measure and apply central tendency in fisheries biology.	1
CLO6	Measureand apply variability in fisheries biology.	1
CLO7	Measure and apply Normal distribution and standard errors.	2
CLO8	Measure and apply Correlation and regression in fisheries biology.	2
CLO9	Compute and apply t-test: t-test in Fisheries Biology.	2
CLO10	Compute and apply Analysis of variance (ANOVA) in fisheries biology.	2
CLO11	Measure and apply Chi-Square test in fisheries biology.	1
CLO12	Compute statistical analyses using computer software.	1
CLO13	Prepare Assignment: Presentation on thesis findings.	1

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	●	●	●	X
CLO2	●	●	●	X
CLO3	●	●	●	X
CLO4	●	X	●	X
CLO5	●	●	●	X
CLO6	●	●	●	X
CLO7	●	●	●	X
CLO8	●	●	●	X
CLO9	●	●	●	X
CLO10	●	●	●	X
CLO11	●	●	●	X
CLO12	●	●	●	X
CLO13	●	●	●	X

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Concepts of Statistics in Fisheries Biology: Populations and samples, statistics and parameters, types of variables and scale of measurement and others.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Construction of frequency distribution and graphical representations of data	- Lectures followed by discussion - Participatory question-answer	
CLO4	LLR, LWR, GLI, GSI, condition factor, and fecundity counting methods.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Measures of central tendency: Basic terminologies. The mean, median, mode and other measurements of central tendency. Applications in fisheries biology.	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	
CLO6	Measures of variability: Basic terminologies. Range, variance, standard deviation and other variability measurements. Applications in fisheries biology.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Normal distribution and standard errors:	- Lectures followed by discussion	

	Normal distribution and standard errors in depth. Applying normal distribution probabilities to a nonnormal distribution. Sample size and standard deviation effects on standard errors.	- Participatory question-answer	
CLO8	Correlation and regression: Correlation and co-efficient of correlation. Simple regression analysis, Multiple regression analysis. Applications in fisheries biology.	- Lectures followed by discussion - Participatory question-answer	
CLO9	t-test: t-test in details.	- Lectures followed by discussion - Participatory question-answer	
CLO10	Analysis of variance (ANOVA): One-way, factorial and repeated-measures ANOVA. Applications in fisheries biology.	- Lectures followed by discussion - Participatory question-answer	
CLO11	Chi-Square test: Chi-Square test of in-depth. Applications in fisheries biology.	- Lectures followed by discussion - Participatory question-answer	
CLO12	Computation of statistical analyses using computer software.	- Lectures followed by discussion - Participatory question-answer	
CLO13	Assignment: Presentation on thesis findings.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Spigel MR and Steohens LJ (2000) Theory and Problems of Statistics, third edition. TATA McGraw-Hill Publishing Company Limited, New Delhi, India.
- Kothari CR (2004) Research Methodology - Methods and Techniques (2nd Edition). New Age International Publishers.
- Kumar R (2010) Research Methodology: A Step-by-Step Guide for Beginners (Third Edition). SAGE Publications Ltd.
- Burrows T (2011) Writing research articles for publication. Thailand: The Asian
- Burton S and Steane P (eds) (2004) Surviving your thesis. London: Routledge
- Dawson C (2002) Practical research methods: a user-friendly guide to mastering research techniques and projects. Oxford: How to Books Ltd.
- Given LM (ed) (2008) The Sage encyclopedia of qualitative research methods, volumes 1 & 2. California, Thousand Oaks: Sage Publications.
- De Leeuw ED, Hox JJ and Dillman DA (eds) (2008) International handbook of survey methodology. EAM.

0831-606: Coastal and Marine Biodiversity

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]
Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a theoretical course on coastal and marine biodiversity of Bangladesh and prerequisite to complete the MS in Fisheries Biology and Genetics degree. The course covers concept and categories of Coastal and Marine fish biodiversity, Genetic, Species, Habitat biodiversity of Coastal and Marine fishes and other fisheries items with special reference to mangrove ecosystem, coral reef, In situ and Ex situ conservation and research trend of coastal and marine biodiversity in Bangladesh.

Expected Outcomes:

At the end of the course, the students will be able to describe coastal and marine biodiversity, their status, causes of degradation for their sustainable management and conservation.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Describe the conservation biodiversity, and rational and scope of conservation	2

	biodiversity study.	
CLO2	Know and describe the coastal and estuarine biodiversity	3
CLO3	Know and describe the marine biodiversity.	4
CLO4	Describe the aquatic biodiversity in the mangrove ecosystem.	3
CLO5	Know and compare the threatened and non- threatened aquatic biodiversity in coastal and marine waters.	3
CLO6	Explain and apply the conservation techniques such as *In situ* and *Ex-situ* conservation of aquatic animals.	4
CLO7	Know and describe the research trend on coastal and marine biodiversity in Bangladesh.	3

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	●	X	●	●
CLO2	●	X	●	●
CLO3	●	X	●	●
CLO4	●	X	●	●
CLO5	●	X	●	●
CLO6	●	X	●	●
CLO7	●	X	●	X

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Concept of conservation biodiversity, and rational and scope of conservation biodiversity study.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Coastal and estuarine biodiversity	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Marine biodiversity.	- Lectures followed by discussion - Participatory question-answer	
CLO4	Aquatic biodiversity in the mangrove ecosystem.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Threatened aquatic biodiversity in coastal and marine waters.	- Lectures followed by discussion - Participatory question-answer - Video demonstration	
CLO6	Conservation techniques: In situ and Ex-situ conservation of aquatic animals.	- Lectures followed by discussion - Participatory question-answer	
CLO7	Research on coastal and marine biodiversity in Bangladesh.	- Lectures followed by discussion	

Recommended books/literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Castro P and Huber ME (1997) Marine Biology, second edition. WCB McGraw-Hill, USA.
- Helfman GS, Collette BB and Facey DE (1997) The Diversity of Fishes. Blackwell Science, UK.
- Hosetti BB and Kumar A (2002) A Textbook of Applied Aquatic Biology. Daya Publishing House, India.
- IUCN Bangladesh (2000) Red Book of Threatened Fishes of Bangladesh. IUCN-The World Conservation Union, Bangladesh.
- Rahman AKA (1989 and 2005) Freshwater Fishes of Bangladesh, first and second editions. Zoological Society of Bangladesh, Dhaka, Bangladesh.
- Shammi QJ and Bhatnagar S (2002) Applied Fisheries. Agrobios, India.
- Shafi M and Quddus MMA (2003) Fisheries of the Bay of Bengal. Kabir Publications, Dhaka, Bangladesh.

0831-607: Endocrinology of Aquatic Animals

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]
Time: 3 hours (Seven questions to be set and five to be answered)

Course Descriptions:

This course offers the students the general aspects of sexual and metabolic endocrinology in reared aquatic animals, with particular reference to the control methods of productive and reproductive functions. This course provides students the ability to understand how the endocrine system of aquatic animals allows them to make adaptive changes towards environmental changes, particularly with interest applied to the areas of reproduction and growth, animal physiology. The students can able to understand how endocrinology can be applied to practical problems in aquaculture and others such as migrations and relationships between species. The student will acquire knowledge concerning main contaminants in aquatic environment (bio-monitoring) with a special reference to endocrine disruptors.

Expected Outcomes:

At the end of the course, the students will be able to obtain proper knowledge on hormones in aquatic animals including types, scope, role on the life process and breeding process of fish.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Know and understand general concept, history, scope of endocrinology with special emphasis on fish.	1
CLO2	Understand the methods of study and assay of hormones from synthesis to action mechanism of hormones.	4
CLO3	Know about concept and action of Neurohormones.	4
CLO4	Describe anatomy and histophysiology, secretions, functions and mechanisms of Pituitary gland.	4
CLO5	Describe Endocrinology of testis.	4
CLO6	Describe Endocrinology of the ovary.	3
CLO7	Know the roles of hormones on the life processes and breeding processes of fish and use them for aquaculture.	2

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	●	●	●
CLO2	X	●	●	●
CLO3	X	●	●	●
CLO4	X	●	●	●
CLO5	X	●	●	●
CLO6	X	●	●	●
CLO7	X	●	●	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	General concept of endocrinology: Scope and position of endocrinology, historical background with special emphasis on fish.	-Lecture -Power point presentation	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final
CLO2	Organization of the endocrine system. Methods of study, the assay of hormones, hormone synthesis, release	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

	and transport, receptor mechanisms, hormone action mechanisms, hormonal interrelations.		Examination(70)
CLO3	Neuroendocrinology: Concept of neurosecretion, control of the endocrine system, hormonal actions on the brain.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO4	Pituitary gland: Anatomy and histophysiology, secretions, functions and mechanisms.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO5	Endocrinology of testis: Histology of testes, the chemistry of androgens, regulation of testicular functions, biology of spermatozoa, environment and sexual periodicity.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO6	Endocrinology of the ovary: Histology of the fish ovary, the biochemistry of the ovarian hormones, endocrine control of ovary. Vitellogenesis of the eggs. Hormonal profiles of the egg maturation process.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO7	Hormones: The modern concept of the hormone, roles of hormones on the life processes and breeding processes of fish and its impact on aquaculture.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

Recommended books/literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Kumar S and Tembhre M (1996) Anatomy and Physiology of Fishes. Vikas Publishing House Pvt Ltd, India.
- Lagler KF, Bardach JE, Miller RR and Passino (1977) Ichthyology, second edition. John Wiley & Sons. New York, USA.
- Yadav (1995) Fish Endocrinology. Daya Publishing House, India.
- Yadav BN (1997) Fish and Fisheries. Daya Publishing House, India.

0831-608: Aquatic Animal Behaviour

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Seven questions to be set and five to be answered)

Course Description:

This course is a theoretical course on aquatic animal behaviour and prerequisite to complete the MS in Fisheries Biology and Genetics degree. The course covers concept, terminologies, mechanism and importance of Aquatic Animal Behaviour, Instinctive and learned behaviour, feeding and breeding behaviour, parental care, migration and social interactions.

Expected Outcomes:

At the end of the course, the students will be able to- i) obtain proper knowledge on types, theories and mechanism of behaviour; ii) obtain proper knowledge on feeding, breeding and migratory behaviour and parental care of aquatic animals iii) apply acquired knowledge in take-caring specifically breeding performance of aquatic animals.

At the end of the course, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Understand and describe the introduction, rationale and expected outcome of studying of behaviour of aquatic animals.	1
CLO2	Understand and explain different terminologies, types, theories and mechanism of behaviour of aquatic animals.	4
CLO3	Know, explain and apply the feeding behaviour of shellfishes, amphibians, reptiles and aquatic aves and mammals in aquaculture.	4
CLO4	Understand, explain and apply the reproductive behaviour of fishes and other aquatic animals in captive breeding management.	4
CLO5	Discuss, explain and apply the parental care of fishes, shellfishes, amphibians, reptiles, aquatic aves and mammals in breeding management.	4
CLO6	Know, explain and apply the migratory behaviour of fishes and other aquatic animals in aquatic animal harvesting and conservation activities.	3
CLO7	Understand and explain the social interaction, aggregation, aggression and cooperation of different groups of aquatic animals.	2

Mapping CLOs with PLOs

CLOs	PLOs			
	PLO1	PLO2	PLO3	PLO4
CLO1	X	●	●	●
CLO2	X	●	●	●
CLO3	X	●	●	●
CLO4	X	X	●	●
CLO5	X	X	●	●
CLO6	X	X	●	●
CLO7	X	X	●	●

X Strong contribution ● Weak contribution □ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale and expected outcome.	-Lectures followed by discussion -Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Terminologies, Types, theories and mechanism of behaviour	-Lectures followed by discussion -Participatory question-answer	
CLO3	Feeding behaviour: Fishes as predator, Fishes as prey and their interaction; grazers, strainers, suckers, parasites and cannibalism. Feeding behaviour of shellfishes, amphibians, reptiles and aquatic aves and mammals.	-Lectures followed by discussion -Participatory question-answer -Power point presentation -Online resources	
CLO4	Reproductive behaviour of fishes and other aquatic animals.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO5	Parental care of fishes, shellfishes, amphibians, reptiles, aquatic aves and mammals.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO6	Migratory behaviour of fishes and other aquatic animals.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	
CLO7	Social interaction, Aggregation, Aggression and Cooperation.	-Lectures followed by discussion -Participatory question-answer -Power point presentation	

Recommended books/ literature:

- Bone Q and Moore RH (2008) Biology of Fishes, third edition. Taylor & Francis, USA and UK.
- Kumar S and Tembhre M (1996) Anatomy and Physiology of Fishes. Vikas Publishing House Pvt Ltd, India.
- Lagler KF, Bardach JE, Miller RR and Passino (1977) Ichthyology, second edition. John Wiley & Sons. New York, USA.
- Yadav BN (1997) Fish and Fisheries. Daya Publishing House, India

Research Work

0831-609: Research Defence-2

Credit: 2

Full Marks: 100

Course Description:

This course provides students to design and execute a meaningful research project that demonstrates critical thinking and uses the knowledge and skills learned while in the M. S. in Fisheries Biology & Genetics Semester-1& 2. Students are able to articulate research or project objectives clearly, state claims and evidence, results clearly. Finally students can describe their proposed research project with their findings clearly in oral forms to faculty, mentors, and lab-mates.

Expected Outcomes:

At the end of the research progress presentation, the students will be able to respond comments and questions from the peers and faculties about their research efforts and can identify strength and weakness in ongoing research and presentations. Students will face defence based on their research progress or findings of the research work.

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0831-701: Thesis

Credit: 8

Full Marks: 100 (Abstract-10, Introduction-25, Methodology-20, Results and Discussion-20, Conclusion and Recommendation-5 and References cited-20 Marks).

Course Description:

This course provides students to design and execute a meaningful research project that demonstrates critical thinking and uses the knowledge and skills learned while in the M. S. in Fisheries Biology & Genetics. Students are able to articulate research or project objectives clearly, situate research within an academic or scholarly context, state claims and evidence clearly, assess validity of claims, evidence, outcomes, and results. Finally students can describe their proposed research project with their findings clearly in written forms to supervisor and examiners.

Expected Outcomes:

At the end of the writing thesis, the student will demonstrate their ability to conduct own research project, select relevant literature, apply methodologies, process and analysis of data, make critical interpretation and answer to questions raised in the problem statement.

Thesis may be consisting of Abstract, introduction (including problem statement, hypothesis, importance, objectives, limitations, and review of literature), methodology, results & discussion, conclusion & recommendation, and reference cited.

0831-702: Thesis Defence

Credit: 4

Full Marks: 100

Course Description:

This course provides students to design and execute a meaningful research project that demonstrates critical thinking and uses the knowledge and skills learned while in the M. S. in Fisheries Biology & Genetics. Students are able to articulate research or project objectives clearly, situate research within an academic or scholarly context, state claims and evidence clearly, assess validity of claims, evidence, outcomes, and results. Finally students can describe their proposed research project with their findings clearly in oral forms to faculty, mentors, and lab-mates.

Expected Outcomes:

At the end of the writing thesis, the student will be able to i) present research findings in brief ii) develop their presentation skills iii) develop skills to accept and response to relevant and constructive feedback in a meaningful way.

Students will face defence based on research findings including problem statement, hypothesis, importance, objectives, limitations, methodology, results & discussion and recommendation.

Part D

20. Grading/Evaluation:

Eligibility for the semester final examination:

Candidates having less than 60% attendance will not be allowed to fill up the examination form. Candidates having less than 75% to 60% attendance will be allowed to fill up the examination form on special grounds on such documentary evidence and the approval of special permission of Academic Committee but students will have to pay in addition to the examination fees, the requisite fee prescribed by the syndicate for the purpose. Attendance marks will be allotted based on the following Table –

Earned Percentage*	90 and above	85 to less than 90	80 to less than 85	75 to less than 80	70 to less than 75	65 to less than 70	60 to less than 65	less than 60
Marks	10	9	8	7	6	5	4	0

* Earned percentage should be calculated in the round figure according to the regular statistical method.

Semester final results will be published in GPA out of 4 on the basis of all courses and final result for the MS in Aquaculture degree will be published in CGPA out of 4 on the basis of all semester final examinations.

Grades will be awarded in accordance with provisions shown in the table as –

Numerical grade*	Letter Grade	Grade Point
80% or its above	A^+ (A plus)	4.00
75% to less than 80%	A (A regular)	3.75
70% to less than 75%	A^- (A minus)	3.50
65% to less than 70%	B^+ (B plus)	3.25
60% to less than 65%	B (B regular)	3.00
55% to less than 60%	B^- (B minus)	2.75
50% to less than 55%	C^+ (C plus)	2.50
45% to less than 50%	C (C regular)	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00
Incomplete**	I	-

* Earned numerical grade should be calculated in round figure (once in a course) according to roundup statistical method.

** Absence from the final examination will be considered as incomplete with the letter grade "I".