CURRICULUM

MS Programme in Zoology

under the One Year Grading System
Sessions 2020-2021 and 2021-2022

Department of Zoology
University of Dhaka

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Curriculum Committee 2021

Professor Dr. Rowshan Ara Begum - Head, Self-Assessment and Curriculum Committee
Department of Zoology, University of Dhaka

Professor Dr. Md. Sagir Ahmed - Member, Self-Assessment and Curriculum Committee
Department of Zoology, University of Dhaka

Professor Dr. Md. Shamimul Alam - Member, Self-Assessment and Curriculum Committee
Department of Zoology, University of Dhaka

Professor Dr. Md. Aminul Islam Bhuiyan - Member, Curriculum Committee
Department of Zoology, University of Dhaka

Preparation and Authentication of the Curriculum

After long deliberations in a series of meetings and Workshops the Academic Committee of the Department of Zoology, University of Dhaka approved the structure and draft of the curriculum prepared by the Curriculum Committee and the course content developed by the concerned faculties. This curriculum will be effective from the session 2020-2021.

Contents

Rules and Guidelines for MS Programme in Zoology
for the session 2020-2021 and 2021-2022

1. Introduction to the Department of Zoology

The Department of Zoology, University of Dhaka is one of the oldest departments of the university and the pioneer institute to introduce teaching and research in animal sciences in the country, and therefore, played a commendable role in promoting zoological study in Bangladesh. Since its inception in 1954, the department has been the best learning seat for zoology in the country and producing graduates of global competence, successfully serving the nation in various capacities. As a research hub, the department undertakes enormous researches to generate knowledge for the improvement of zoological sciences, food security, biodiversity conservation and management, biotechnology, epidemiology, pest control, etc. The department also provides advisory and community services to government and private sectors, related to biodiversity conservation and environmental protection.

The department is housed in a large three-storied beautifully designed building located at a scenic place within the Curzon Hall Campus and has required infrastructural facilities for delivery of lectures, practical demonstrations and undertaking research activities. The department has adequate number of lecture rooms, equipped with modern logistics, for each individual cohort of students. The department has also adequate number of undergraduate practical laboratories.

Faculty members and non-academic staffs: The Department of Zoology has 27 faculty members (December, 2020). Almost all of the faculty members are highly qualified with brilliant results in the undergraduate and graduate levels. Most of the members achieved PhD degrees from countries like Australia, Canada, Japan, UK and USA. At the moment, three female and two male faculty members are on 'study leave' to pursue PhD (from the UK and Japan). The department has 12 Professors (six female and six male), 02 female Associate Professors, 07 Assistant Professors (four female and three male) and 06 Lecturers (two female four male). The department has supernumerary (2 posts) and honorary professors. Few retired professors are also involved with the department. The department have 18 non-academic staff (two female and sixteen male).

Research Facilities: Research is also a major focus of the department and carried out in all disciplines of zoology, particularly in specialized branches of the department, viz. Entomology Fisheries, Wildlife Biology, Parasitology and Genetics & Molecular Biology with focus on demand led areas. The department has moderately equipped specialized research laboratories, representing all specialized branches. The departmental faculties and students publish a good number of research articles every year. Collaborative researches are carried out with different research institutions home and abroad.

Outdoor facilities and collaborative research opportunity: A pond of 0.99 hectare, located within Curzon Hall Campus is available for aquatic research. In addition, an animal garden of 0.5 hectare is maintained for animal breeding and rearing. The University of Dhaka has been developing marine research facilities at Cox's Bazaar and would be available for zoology students for carrying research on marine ecosystem and biodiversity.

Apart from these, the Department undertakes research in collaboration with other research institutions of the country such as, Bangladesh Atomic Energy Commission, Bangladesh Council for Scientific and Industrial Research, National Institute of Biotechnology, Bangladesh Jute Research Institute, Bangladesh Rice Research Institute, Bangladesh Agricultural Research Institute, National Institute for Preventive and Social Medicine, Space Research and Remote Sensing Organization, Fisheries Research Institute, ICDDR,B, BIRDEM, BSMMU, etc. Funds are sought from a number of national and international organizations. The national institutions include University Grants Commission, Ministry of Science and Technology and ICT, Bangladesh Agricultural Research Council, Ministry of Environment and Forests, Ministry of Fisheries and Livestock, Ministry of Agriculture, Ministry of Education, etc.

Departmental library: Department of Zoology has a seminar library: Professor Yousuf Zai Seminar Library, named after the first Head of the Department. The library contains more than seven thousand books and a huge number of reading materials, including journals, thesis papers, project reports, etc.

Departmental museum: The department harbours a museum which is the largest of its kind in the country and holds a large number of animal specimens (representing all major phyla), embryological and histological preparations, animal skeletons, models, etc. and is used for practical demonstration classes.

Stipends and awards available at the department: The department offers a few stipends and awards to the outstanding students. The department announces such stipends/awards on a yearly basis and invites applications from those who fulfill the criteria set for the stipends/awards.

Mission and Vision of the Department: Zoology is the aspect of science that deals with the study of the animals' morphology, physiology, habitat, behavior, evolution and genetics. Zoology department has 25-Year Academic Plan (2011-2035) where vision and mission are clearly mentioned and are given below:

Mission: To develop human resources and knowledge base through teaching and research to contribute to national development.
Vision: An ecologically / environmentally sound Bangladesh.

Academic Programme of the department
The department offers four academic degree programmes. These are:

i. Bachelor of Science (Honours) in Zoology- BS (Honours) is a four year integrated degree programme comprising of theory and practical works.
ii. Master of Science (MS) in Zoology- a one year programme based either on course work and practicals (Group A: Non-thesis Group) or research and course works (Group B: Thesis Group). MS degree courses are offered in 5 specialized branches of zoology, *viz.* Entomology, Fisheries, Wildlife Biology, Parasitology and Genetics & Molecular Biology. An MS student may choose any one of these branches for her/his study.
iii. MPhil in Zoology- is a two year degree, based on course work and research. Courses are offered in the above mentioned specialized branches. Registered students need to successfully complete 8-credit course to be promoted from 1st year to 2nd year of the programme.
iv. PhD in Zoology- is normally a four year degree based on research, however, need to take 8-credit course to be promoted from 1st year to 2nd year of the programme, except for the students completed their 4 years BS and 1 year MS in Dhaka University.

2. Introduction to the MS Programme

Programme name: Master of Science in Zoology MS in Zoology

2.1 General Objectives of the Programme

The MS in Zoology is a comprehensive programme and intended to produce professionals of global competence capable of contributing to national development in each of the five different branches of zoology, viz. Entomology, Fisheries, Wildlife Biology, Parasitology and Genetics and Molecular Biology. The MS program in Zoology is aligned to meet the expectations of country's policy for tertiary education.

2.2 Eligibility for Admission to the MS in Zoology Programme

All the successful students of the BS (Hons) programme of the department are eligible to get admission into the MS Program of the Department without having any screening or admission test. A student may seek admission to the immediate next batch of MS Programme following publication of BS (Hons) results. However, in a special circumstance, a student may seek admission within two years of the publication of his/her BS (Hons) results upon approval of the departmental Academic Committee and the Vice Chancellor of the University. A student having four year BS Honours in Zoology from any recognized university is eligible to apply for admission into MS course with the approval of the Academic Committee.

2.3 Options in MS in Zoology Programme

(a) Choice for specialization

The MS degree in Zoology is offered in the following five specialized areas of Zoology:

(i) Zoology in Fisheries; (ii) Zoology in Entomology; (iii) Zoology in Wildlife Biology; (iv) Zoology in Parasitology; and (v) Zoology in Genetics & Molecular Biology.

A student may take up only one of these specialized programmes. After admission in to the MS course, the students will be asked to apply for his/her choice for a specialized branch with priority preferences. The department will then allocate the specialized branch of MS study to the students on a merit basis. There is an equal number of seats in each specialized branch.

(b) Options for Thesis and Practical Groups

The department offers the MS degree by course and practical work (Non-thesis Group) or by course and thesis work (Thesis Group). Students having a CGPA 3.5 and above in BS level may opt for thesis work as a partial fulfilment of his/her MS degree. However, the department may refix the CGPA points time to time. A thesis student requires to perform his/ her research work under the supervision of a teacher of her/his specialized branch of study. The student needs to contact the teacher under whom he/she is willing do thesis work and once the teacher agrees to supervise the work, only then the student may embark on his/her thesis work. The students are also required to fill out a proforma mentioning the thesis title and the name of the supervisor.

3. Duration of the Programme

The MS Programme will be of 1 (one) academic year duration as distributed below:

Classes	28 weeks
Preparation time for course final examination	4 weeks
Course final examination (theory)	4 weeks
Time for submission of seminar/projects/practical report after completion of last theoretical examination	2 weeks
Time for submission of thesis after completion of last theoretical examination	12 weeks
Results	4 weeks
Total	52 weeks

Results would be published within 4 weeks from the date of last final examination (theory/ practical/viva-voce/thesis presentation, whichever is the latest).

4. Assignment of credits

The entire Master's programme in Zoology will be covered by a set of theoretical classes, thesis work, practical (laboratory/field) and seminar courses.

(a) **A total of 30 credits,** either under 5 or 10 individual courses is assigned for the MS course without having any provision for options for courses.

(b) The distribution of credits is as follows:

Theory	Practical (including a short project assessment)/Thesis	Seminar other than thesis work	Viva-voce	**Total credit**
20	6	2	2	**30**

(c) **Theoretical courses:** A minimum of 15 class-hours will constitute 1 (one) credit and there will be 30 lecture-hours for a 2-credit course and 60 lecture-hours for a 4-credit course.

(d) **Practical courses:** Practical courses are only for the students of non-thesis group. There will be 30 practical classes under 6 credit courses, a project work for 1 credit course and a number of field/laboratory visits will be organized as decided by each of specialized branches of the MS Programme.

(e) **Thesis:** The student will embark on his/her thesis research from the beginning of MS study and must submit thesis within 12 weeks after completion of the theoretical examination. Of the allocated 6 credits for thesis, 60 marks (40%) will be dedicated to thesis presentation/defence on the research work.

(f) Seminar: Each given student (from thesis and non-thesis groups) of each specialized branch requires to give a seminar on a specific topic, assigned by the respective specialized branch. Seminar will be organized after the completion of the theoretical examinations and will carry 2 credits. Students are required to prepare a paper on his/her topic and make a power-point presentation for evaluation.

5. Evaluation of students' performance

The total performance of a student in a given course will be evaluated on the basis of a scheme of continuous assessment, in-course and final examinations.

(a) In-courses assessment (theory courses) will be made through a set of in-course examinations and class participation. In-course examination of one hour duration shall be conducted and evaluated by the course teacher. There will be a minimum of 2 (two) written examinations for 3 or 4 credit courses and a minimum of 1 (one) written examinations for 2 credit courses. Questions for in-course examination should preferably be of objective type. Additional assessment examinations may be made by the course teacher. In such cases the marks of all the examinations will be used to calculate average marks for the course. The course teacher will show the assessed in-course scripts to the students.

(b) Continuous assessment of practical (laboratory/field) courses will be made through observations of the students at work, and also through viva-voce, homework assignments, evaluation of practical reports, in-course practical examinations and project report as preferred by the department.

(c) The scheme and pattern of continuous assessment will be announced by the course teacher on the first day of classes.

(d) Distribution of marks for a theory course:

Class attendance	5%
In-course assessment	35%
Course final examination	60%

(e) Distribution of marks for a practical course(6 credit):

i) In-course	40% (60 marks)
Class attendance for practical (7.5 marks)	5%
In-course assessment & project (In-course assessment 27.5 marks + Project 25 marks)	35%
ii) Course final examination	60% (90 marks)

(f) The distribution of marks for thesis (6 credit):

Thesis presentation/defense	40% (60 marks)
Thesis evaluation by external examiners	60% (90 marks)

(g) The distribution of marks for seminar (2 credit)

Presentation	50%
Review paper	50%

(h) Basis for awarding marks for class attendance:

Attendance (%)	Marks (%)
95 and above	5
90 to less than 95	4
85 to less than 90	3
80 to less than 85	2
75 to less than 80	1
Less than 75	0

(i) Make-up examination (theory courses):

A student failing to appear in an in-course examination will not be allowed to sit for any make-up examination. Absence in any in-course examination will be counted as zero for calculating the average in in-course examination for that course. However, a student can apply to the chairman of the department for make-up test provided he/she satisfies certain conditions. The Chairman will only place the application before the academic committee if the particular student had met an accident or his/her parent(s) had expired or he/she had gone through a surgical procedure one/two days before assessment examination date or any other such situation which the Academic Committee feels can be considered. The make-up examination must be held before the start date of the final examination.

(j) The course final examination (theory courses):

i. The course final examination will be conducted centrally by the Controller of Examinations as per existing system.

ii. Pattern of theory questions will be decided by the academic committee of the department. However, there will be no objective questions/part in the course final examination. There would be combination of broad and short questions.

iii. The course final examinations will be of three (3) hours duration for 4-credit courses, 2½ hours for 3-credit courses, and two (2) hours for 2-credit courses.

iv. For the evaluation of course final examination there will be two examiners: the first examiner- course teacher and the second examiner- anyone other than the course teacher, preferably form the department.

v. Under double-examiner system if the difference of first and second examiners marks of a course is more than 20% of total marks, there will be a 3rd examiner. Marks of the nearest two examiners will be averaged out as final marks.

(k) Assessment of seminar: Seminar (other than thesis) will be evaluated by internal members of the examination committee. Fifty percent marks will be allocated for the presentation, and the rest 50% marks for the report.

(l) Assessment of final laboratory work for non-thesis students: The final examination on practical work will be evaluated by the course teacher along with the external examiner.

(m) Assessment of project: For the students of non-thesis group a short project be assigned for the individuals or to a group of students by the concerned class teachers. The project will be evaluated by the class teachers.

(n) Assessment of thesis: Oral presentation/thesis defence will be evaluated by all members of the committee and the concerned supervisor. Thesis will be evaluated by two external examiners from outside of the department. If difference of marks of the internal and external examiners is more than 20%, there will be a third examiner to examine the thesis. Marks of the nearest two examiners will be used to get average marks as final marks.

(o) Viva-voce/oral examination: Viva-voce/oral examination will be conducted by the Examination Committee.

(p) The Grading System: Marks obtained for each course will be converted to grades. A basic four point (4.00) grading scale will be followed. The following letter grades and corresponding grade-points will be used to determine the grade point average (GPA):

Marks obtained	Corresponding Letter Grade	Grade Point
80% or above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00

6. Grading description

The explanations of letter grades are described as follows:

A: Exceptional performance; all course objectives achieved; objectives met in a consistently outstanding manner.

B: Very good performance; significantly more than the majority (at least two-thirds) of the course objectives achieved; objectives met in a consistently thorough manner.

C: Satisfactory performance; at least majority of the course objectives achieved; objectives met satisfactorily.

D: Minimally acceptable performance; less than the majority but more than the minimum required course objectives achieved.

F: Unacceptable performance; minimum required course objectives not met; objectives not met at a minimally acceptable level; no credit earned.

7. Earned credits

A course in which a student has obtained 'D' or a higher grade will be counted as credits earned by him/her. Any course in which a student has obtained 'F' grade will not be counted towards his earned credits.

8. Calculation of GPA

Grade Point Average (GPA) is the weighted average of the grade points obtained in all the courses passed/completed by a student. The Grade Point Average (GPA) is computed in the following manner:

$$\text{GPA} = \frac{\sum (\text{Grade points x Credits})}{\text{Sum of Credits Attempted}}$$

The Grade Point Average (GPA) is computed by dividing the total accumulated grade points earned during the MS programme by total credit points attempted. For successful completion of MS programme a student must earn 30 credits or more if approved with no F grade in any course. However, this minimum requirement may be raised by any department as per their programme and final GPA will be calculated using all the credits attempted.

9. Eligibility for sitting at the course final examination

(a) A student must attend **at least 75%** of the total classes held in an academic year to be eligible for appearing in the final examination of that year without paying any penalty.

(b) A student attending **at least 60%** classes but less than 75% classes will be allowed to appear for the examination after paying non-collegiate fees fixed by the university.

(c) A student attending **less than 60%** classes will not be allowed to appear for final examination for that year.

10. Publication of results

The results will be published within 6 weeks of completion of practical examination (for practical group) and after six weeks of submission of thesis paper (thesis group). Results will be published separately for non-thesis (practical group) and thesis group students.

11. Retake Examination

A student can appear in retake examination once only in one course to clear F grade within 6 weeks after announcement of the results and definitely before registration for convocation. His/her in-course assessment marks will be retained.

12. Readmission

(a) A student failing to earn the degree may seek readmission once with the next batch. For readmission, a student will have to apply within one month after announcement of the result of the concerned year. Readmission will be allowed only after the approval of the departmental academic committee.

(b) On readmission, a student may be allowed by the departmental Academic Committee to retain his/her in-course marks, earned earlier as chosen by him/her. The academic committee of the department will determine whether the re-admitted student can undertake any thesis work.

(c) If a student succeeds after taking readmission his/her transcript will bear "R" after GPA, with a foot note of mentioning "R means readmission"

13. Requirements for successful completion

A student must earn GPA of 2.50 on a 4.00 scale for obtaining MS degree.

14. Time limit for completion of Master's degree

A student must fulfill all the requirements for a master's degree within a maximum period of two academic years, starting from the year of enrolment, in case he/she appears and fails in the examination. In case the student is unable to participate he/she needs to inform the Chairman of the department. However, in case of continuing with the program for the second year he/she requires readmission upon approval of the department. In that case, his/her obtained marks obtained in the previous year will be discarded.

15. Other general regulations

(b) At the beginning of the session, a course teacher shall provide the students a course outline including the obvious, main topics, teaching approaches (e.g., labs, case studies, field work, etc.), schedule of exams, text books and other required materials.

(c) The course teacher shall announce the results of the in-course tests within two weeks of the date of holding the exams and submit the marks to the chairman of the examination committee for the respective batch and also a copy to the Controller of Examinations at least two weeks before the start of the annual examination. He/she should also submit a statement showing the total number of classes held and the number of classes attended by each student in his/her course to the chairman of the examination committee for the respective batch.

(d) Tabulation work will start only after all the marks of the course final examinations for the year are

received by the Chairman of Examination Committee. Marks received by the Chairman of the Examination Committee shall remain in the sealed envelopes as sent by the Examiner/Examiners until tabulation work is started. In case of thesis group tabulation starts only after thesis presentation.

(e) The present system of conducting course final examination and publication of results by the office of the Controller of Examinations shall continue.

(f) For any matter not covered in these rules, the existing rule of the University of Dhaka will be applicable.

16. Branch-Wise Distribution of Courses and Credits

16.1 MS in Zoology (Fisheries)

ZF 601	Aquatic Environment and Biodiversity	2 credits
ZF 602	Fish Population Dynamics and Conservation	2 credits
ZF 603	Aquatic Resources and Fisheries Management	2 credits
ZF 604	Advanced Aquaculture	2 credits
ZF 605	Fish Genetics and Biotechnology	2 credits
ZF 606	Fish Diseases and Aquatic Health Management	2 credits
ZF 607	Aquaculture Nutrition, Feed and Advanced Fish Physiology	2 credits
ZF 608	Post-harvest Technology and Quality Control	2 credits
ZF 609	Fish Ecology, Limnology and Oceanography	2 credits
ZF 610	Fisheries Economics, Fish Marketing and Extension Services	2 credits
ZF 651	Practical Fisheries (Gr-A)	6 credits
ZF 656	Thesis and presentation on thesis (Gr-B)	6 credits
ZF 657	Seminar (other than thesis)	2 credits
ZF 658	Viva voce	2 credits
	Total:	**30 credits**

16.2 MS in Zoology (Entomology)

ZE 611	Insect Systematics and Nomenclature	2 credits
ZE 612	Insect Structure and Function	2 credits
ZE 613	Insect Embryology, Endocrinology and Molecular Biology	2 credits
ZE 614	Insect Behaviour and Insect-plant Dynamics	2 credits
ZE 615	Insect Ecology	2 credits
ZE 616	Pest and Pest Management	2 credits
ZE 617	Toxicology	2 credits
ZE 618	Medical and Veterinary Entomology	2 credits
ZE 619	Bioresources, Management and Conservation	2 credits
ZE 620	Epizootiology	2 credits
ZE 652	Practical Entomology (Gr-A)	6 credits
ZE 656	Thesis and presentation on thesis (Gr-B)	6 credits
ZE 657	Seminar (other than thesis)	2 credits
ZE 658	Viva voce	2 credits
	Total:	**30 credits**

16.3 MS in Zoology (Wildlife Biology)

ZW 625	Wildlife Ecology and Biogeography	4 credits
ZW 626	Conservation Biology	4 credits
ZW 627	Behavioural Ecology and Anthrozoology	4 credits
ZW 628	Wildlife Resource Management	4 credits
ZW 629	Wildlife Conservation Outside Protected Areas and Innovative	4 credits
ZW 653	Practical Wildlife Biology (Gr-A)	6 credits
ZW 656	Thesis and presentation on thesis (Gr-B)	6 credits
ZW 657	Seminar (other than thesis)	2 credits
ZW 658	Viva voce	2 credits
	Total:	**30 credits**

16.4 MS in Zoology (Parasitology)

ZP 635	Parasite Systematics and Biology	2 credits
ZP 636	Parasite Ecology and Behaviour	2 credits
ZP 637	Parasite Biodiversity and Population Dynamics	2 credits
ZP 638	Veterinary Parasitology	2 credits
ZP 639	Epidemiology	2 credits
ZP 640	Public Health Parasitology	2 credits
ZP 641	Parasite Physiology	2 credits
ZP 642	Biochemistry and Molecular Biology of Parasites	2 credits
ZP 643	Immunology	2 credits
ZP 644	Pathology	2 credits
ZP 654	Practical Parasitology (Gr-A)	6 credits
ZP 656	Thesis and presentation on thesis (Gr-B)	6 credits
ZP 657	Seminar (other than thesis)	2 credits
ZP 658	Viva voce	2 credits
	Total:	**30 credits**

16.5 MS in Zoology (Genetics and Molecular Biology)

ZG 645	Molecular Biology	4 credits
ZG 646	Advanced Genetics	4 credits
ZG 647	Functional Genomics, Proteomics, Metabolomics and	4 credits
ZG 648	Gene Manipulation and Recombinant DNA Technology	4 credits
ZG 649	Molecular Ecology and Conservation Genetics	4 credits
ZG 655	Practical Genetics and Molecular Biology (Gr-A)	6 credits
ZG 656	Thesis and presentation on thesis (Gr-B)	6 credits
ZG 657	Seminar (other than thesis)	2 credits
ZG 658	Viva voce	2 credits
	Total:	**30 credits**

MS in Zoology (Fisheries)

Course No.	Course Title	No. of Credits	Credit Hours
ZF 601	**Aquatic Environment and Biodiversity**	**2**	**30**

Introduction to the course

Knowledge on aquatic environment and its biodiversity is a pre-requisite for planning aquaculture development and fisheries management. Wetlands encompass a variety of forms and perform a wide array of functions, contribute enormously to economic productivity and support diverse ranges of biodiversity. The aquatic environment is thus viewed from the purview of the environment-productivity complexity for the sustainable management of its resources. The course is designed to enhance student's understanding on the wetland functions from ecological and productivity perspective for designing resource conservation or production programs. Specifically, the course focuses on the ecological and hydrological characters and dynamics, biodiversity of all ranges, and discusses its relation with fish production. The course also highlights the degradation to wetland services; conservation planning; and conducting environmental impact assessment. The course will allow the students to understand the volumes of community engagement in aquatic resource management.

Specific Objectives of the course

- To provide students with a comprehensive conceptual understanding of the hydrodynamics and its relationshio with fish production cycles; also the basis for the development of fisheries management strategies.
- To enhance students' knowledge of the aquatic biodiversity and the preparation of the biodiversity conservation action plans.
- To introduces the students to the threats to the wetlands and the preparation of the wetland management plans.

Course contents and number of classes by course sub-title:

Title/sub-titles of course contents	No. of classes
Aquatic Environment	
Classification of wetlands; characteristics, ecological and productivity functions, and importance of wetlands.	**2**
Water cycles and hydrodynamic patterns in Bangladesh; flood pulse and formation of fish production systems in aquatic environment and its relevance with life cycles of fish; adaptation strategies of fish with highly oscillating hydrodynamics and flood cycles.	**5**
Degradation to aquatic environment: natural causes; FCD/I; wetland conversion and reclamation, habitat fragmentation and its impacts on aquatic biodiversity; water pollution-pollutant types, sources and impacts on different life stages.	**3**
Water quality and its ranges, spatial and temporal fluctuations; and interrelationships between the major environmental factors affecting fish community. Limiting/biotic factors and biological cycle in ponds.	**3**
Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP); strategy for protection of aquatic resources.	**2**
Aquatic Biodiversity	
Definition, origin, importance and factors of aquatic biodiversity; types, use and values of aquatic biodiversity. Conservation of aquatic biodiversity.	**3**
Conservation strategies and action plan for the biodiversity of Bangladesh.	**3**
Legislations and concerned organizations. CBD, Ramsar Convention and CITES.	**4**

Learning outcomes

After completion of the course, the students will be able to-

- explain the hydrodynamic patterns of wetlands and its relation to fish production in Bangladesh;
- know the causes of wetland degradation and describe its impacts on biodiversity and wetland productivity;
- gain knowledge and skills for conducting EIA exercise;
- gain knowledge and skills for the preparation aquatic biodiversity conservation action plan;
- know about the acts, rules and policies of the country and international conventions and treaties relevant to biodiversity conservation and wetland protection.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, models, video clips, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	No. of classes	Class/lecture types	No. of classes
Lecture and discussion	25	Review class	1
Students' group presentation	2	In-course exam	1
Feedback on In-course exam	1		

Assessment

There will be one In-course examination, consisting of 17.5 marks. Another 2.5 marks is reserved for class attendance. The students will be frequently asked questions in the classrooms to assess individual's performance. A course final examination, consisting of 30 marks will be conducted by the university.

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UNDP. 2006. *National Biodiversity Strategy and Action Plan for Bangladesh.* Ministry of Environment and Forest, Dhaka, Bangladesh.

WARPO. 2005. *Guidelines for Environmental Assessment of Water Management (Flood Control, Drainage and Irrigation) Projects*. Water Resources Planning Organization, Government of the People's Republic of Bangladesh, Dhaka.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 602	**Fish Population Dynamics and Conservation**	**2**	**30**

Introduction to the course

An understanding of wild populations is fundamental to establish successful management and conservation regime for a fish stock. Rational management of a fishery necessitates some knowledge of the dynamics of the fish population being managed. The course is designed to provide a comprehensive knowledge on population dynamics in order to understand how exploitation of a fish stock can be managed sustainably. In particular, the course focuses on the growth estimation, analysis of exploiting

population of fish, estimation of mortality and recruitment to fisheries, with particular emphasis on the estimation of maximum sustainable yield (MSY) and also will introduce the students to a number analytical models for the estimation of MSY. The course will be very useful for the students willing to develop professional career in fisheries management.

Specific objectives of the course

- To build students' knowledge and understanding on fish population, stock, abundance and sustainable management of fishery resources.
- To enhance students' knowledge and skills in acquiring and analysis of exploiting fish population to arrive at estimation of MSY.
- To enable students to use knowledge of fish population in managing a fish stock.

Course contents and number of classes by course sub-title:

Title/sub-titles of course contents	No. of classes
Fish Population Dynamics	**21**
Concept of population and stock, unit stock, distribution and abundance, relative and absolute abundance, cohort and population structure.	**2**
Fish age and growth estimation: The von Bertalanffy growth equation; seasonal and non-seasonal growth equation. Growth parameters, K, L_∞, C, etc.	**3**
Estimation of mortality rates: Methods for estimation of total mortality (Z), fishing (F) and natural mortality (M); estimating survival and mortality rates.	**2**
Stock-Assessment: General aspects of fish stock assessment; stock-recruitment relationship; over-fishing and under fishing concept; by-catches and discards estimation of stock.	**4**
Prediction models: Surplus production model, Biomass model, Yield per Recruitment (Y/R); Biomass per Recruitment (B/R); Catch curve; Maximum Sustainable Yield (MSY), and Virtual Population Analysis (VPA).	**4**
Microcomputer programme packages: Graphical and computer based analysis of growth - stock assessment based on length frequency analysis. LFDA (Length-Frequency Distribution Analysis), FISAT (FAO-ICLARM Stock Assessment Tools), ELEFAN I & II.	**3**
Fishery data collection for assessment and management: Issues and objectives of data collection, biological data, collection of length frequency data; catch assessment and fishing effort survey; estimation of CPUE and fish productivity and participatory data collection; species composition; distribution and abundance data; availability and gear selectivity; exploitation ratio; analysis of data; presentation of data for fishery management and decision making.	**3**
Fish Conservation	**4**
Concept and principles of fishery conservation. Fish Conservation Acts and Rules of Bangladesh. Fish sanctuaries, refuge, parks and reserves with special reference to hilsa and carps; ghost fishing; poison fishing; protected areas and no take zone.	**3**
Conservation strategies for marine, inland and open water fishery.	**1**

Learning outcomes

After completion of the course, the students will be able to-

- explain a fish population, stock, abundance, stock recruitment relationship, over fishing and under fishing and MSY;
- explain the ways in which catches and stock abundance respond to different levels of fishing and decide on fishing control required;
- gain skills on fishery data collection for assessment and management of a fish stovk;
- calculate age, growth, morality, stock and abundance of fish;

- establish stock recruitment relationship;
- analyse fish population/ stocks based on different prediction models; and
- suggest the catch quota and interventions for fisheries management.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, models, video clips, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom. Demonstration of the use of prediction models will be made in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	25	Review class	1
Students' group presentation	2	In-course exam	1
Feedback on In-course exam	1		

Assessment

There will be one In-course examination, consisting of 17.5 marks and 2.5 marks are allocated for class attendance. Questions for In-course test will be objective and short answer types. A course final examination of 30 marks will be conducted centrally by the university. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Bagenal, T. 1978. *Methods for Assessment of Fish Production in Freshwaters.* IBP Handbook, No. 3. Blackwell Science, London.

Hart, P.J.B. and Reynolds, J.D. 2002. *Handbook of Fish Biology and Fisheries*, Vol. 1 and 2. Blackwell Publishing, London.

Jennings, S., Kaiser, J.M. and Reynolds J.D. 2001. *Marine Fisheries Ecology.* Blackwell Science, London.

King, M. 1995. *Fisheries Biology: Assessment and Management.* Fishing News Books, Oxford, UK.

Royce, W.F. 1984. *Introduction to the Practice of Fishery Science.* Academic Press, USA.

Sparre, P. and Yenema, S.C. 1992. *Introduction to Tropical Fish Stock Assessment.* FAO *Fisheries Technical Paper No. 306*. FAO, Rome.

Welcomme, R.L. 2001. *Inland Fisheries Ecology and Management.* FAO Fishing News Books, Oxford, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 603	**Aquatic Resources and Fisheries Management**	**2**	**30**

Introduction to the course

Rapid declination in fisheries resources spurred a huge concern for its effective management in Bangladesh. To ensure the long-term sustainability, it is essential to understand the array of available fisheries resources, the issues and the driving forces responsible for Bangladesh's diminishing fisheries resources. The biological, ecological, social and legal premises of the sustainable management also play a crucial role in devising a legal framework that ensures both the abundance of the resources and human well-being. This course provides an exposure to all these basic principles, and different methods of fisheries management. It also offers a detail understanding of the existing legal instruments that are used to manage fisheries resources in Bangladesh. Students will be introduced to the processes of developing fisheries management plan under different management scenarios. The course is intended to produce professionals in fisheries management with necessary background knowledge and skills.

Specific objectives of the course

- To familiarize the students with country's fisheries resources, including fish habitats, species diversity, infra-structural facilities, support service, and existing legal instruments for management of Bangladesh fisheries.
- To introduce the students with the methods and tools, and strategies for fisheries management.
- To enhance students' knowledge and skills in identifying, planning and designing fisheries management actions and preparing Fisheries Management Plan.

Course contents and number of classes by course sub-title

Title/sub-title of course content	No. of classes
Aquatic Resources	**13**
Fish habitats: Types, extent and status. **Fish diversity:** Freshwater and marine finfishes and shellfishes with major commercial group; Abundance of different groups of fish; Other aquatic invertebrates and sea weeds; Endangered and rare fish. **Fisheries Institutions/Organizations:** Government and non-government organizations; Professional bodies; Research and academic institutions;Fisheries cooperatives. **Fisheries infrastructures:** Landing centres, fish harbours, processing plants, fish hatcheries, gear manufacturing facilities. **Resources and its statistics:** Fisheries resources survey and monitoring system in Bangladesh; Contribution of fisheries to the economy, nutrition and employment in Bangladesh; Fish production statistics of Bangladesh; Aquatic resources of the Sundarbans and Haors.	**1** **5** **2** **3** **2**
Fisheries Management	**13**
Concept and principles of fisheries management: Tragedy of the Commons in fisheries context; Issues and threats to fisheries resources; Case study: In-depth analysis on the collapse of Cod/Sole/Anchovy fisheries. **Methods and tools in fisheries management:** Regulatory methods, restrictions and control (Biological: MSY, mortality, effort, breeding season and life-history information; Ecological & physical: habitat, spatial and temporal; social & legal context); Criteria to evaluate fishery management tools/interventions; Case study: In-depth analysis of Hilsa Fisheries Management Action Plan (HFMAP) **Approaches in fisheries management:** Ecosystems, habitat and landscape approaches; Community based management; Rights-based approach. **Legal instruments in Bangladesh:** Fish Conservation Act and Rules;National Fisheries Policy 1998 and 2010; Community Based Fisheries Management Policy; Marine Fisheries Ordinance 1983. **Open water fisheries enhancement:** Different steps of developing a fisheries management plan; Case study: Hilsa Fisheries Management Action Plan (HFMAP).	**2** **4** **2** **3** **2**

Learning outcomes

After completion of the course, the students will be able to-

- tell about the available aquatics resources of Bangladesh, and its scope for its sustainable utilization; learn about the methods and tools used in fisheries management;
- describe the biological, ecological, social and legal premises that are relevant to fisheries management;
- gain knowledge and skills for designing and implementing fisheries management actions;
- prepare fisheries management plans; and
- learn and apply fisheries acts and other related policies.

Instructional strategies

The course will be primarily taught by delivering lectures, aided by power-point presentations and videos, as and when Classes related to the analysis of different case-studies, will be held with students' active participation, including role play students' presentation in the classroom At the beginning of each class, there will be a brief reviews on previous lecture and at the end topics of next class will be announced. .

Distribution of class lectures: Total number of classes/lectures: 30

Class/ lecture type	No. of classes
Lecture and Practical exercise	26
In-course exam	2
Feedback on In-course exam, and students' feedback on course contents and delivery	2

Assessment

There will be one In-course examination, consisting of 17.5 marks and 2.5 marks are reserved for class attendance. A course final examination, consisting of 30 marks, will be conducted centrally by the university. The students will be frequently asked questions in the classroom to assess individual's performance.

References

Ali, M.Y. 1997. Fish, Water and People. The University Press Limited, Dhaka, Bangladesh.

Farooque, M. 1997. Regulatory Regime in Inland Fisheries in Bangladesh: Issues and Remedies. Bangladesh Environmental Lawyers Association (BELA), Dhaka.

Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hasan, M.A., Khondker, M. and Rahman, M.M. (ed.). Encyclopedia of Flora and Fauna of Bangladesh. Vol.23. Freshwater Fishes. Asiatic Society of Bangladesh, Dhaka.

Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hasan, M.A., Khondker, M. and Rahman, M.M. (ed.). Encyclopedia of Flora and Fauna of Bangladesh. Vol. 24. Marine Fishes. Asiatic Society of Bangladesh, Dhaka.

Sissenwine, M. P., & Kirkley, J. E. 1980. Fishery management techniques, a review. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Center.

Tsai, C. and Ali, M.Y. 1997. Openwater Fisheries of Bangladesh. The University Press Limited, Dhaka,Bangladesh.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 604	**Advanced Aquaculture**	**2**	**30**

Introduction to the course

The contribution of culture fisheries to country's fish production is increasing overwhelmingly and its future prospects are also tremendous with the advancement in aquaculture technologies. The purpose of this course is to introduce and build skills of the students in the areas of aquaculture, both freshwater and marine. Specifically, the course will focus on the culture of different fish and shrimp species, different culture practices, modern techniques for intensification of fish productions and management of culture

systems. The course will discuss also the induced breeding techniques and nursery techniques in detail and breeding stock improvement with highlights on hatchery design, construction and its operation. The intent of this course is to produce fisheries professionals capable of dealing with the all aquaculture practices and its management.

Specific objectives of the course

- To enhance understanding and knowledge of the students on the principles, methods and techniques used for different types of aquaculture practices.
- To increase students' skills to undertake and operate culture programs in firm conditions and at individual level.
- To enhance students ability to design and operate fish hatcheries

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Introduction to aquaculture and its importance: History, definition, types, scope and significance of aquaculture, comparison of aquaculture with agriculture and commercial fisheries. Aquaculture - Global and Bangladesh Scenario.	**2**
GAP-Good Aquaculture Practices: Concept, applications and challenges. Role of exotic fishes in aquaculture production in Bangladesh.	**2**
Inland Aquaculture: Basis of inland aquaculture; Present practices of fish and shellfish culture in Bangladesh; Inland aquaculture with references to prawn, barbs, carps, tilapia, catfish (pungus) culture methods. Ornamental fish culture techniques. Hatchery and fish farm design: commercial fish seed production.	**11**
Coastal and marine aquaculture: Basis of coastal aquaculture; Coastal aquatic zonation and environmental process. Culture techniques and management of seaweed and *Spirulina*, mussels, scallops, mullets, milkfish and sea bass; Cage and pen culture techniques. Marine pearl and oyster culture. Intertidal farming and open water sea ranching. *Artemia* culture in salt pens.	**11**

Learning outcomes

After completion of the course, the students will be able to-

- explain the different types of aquaculture systems;
- know different methods and techniques of aquaculture of fish and shell fishes;
- identify conditioning factors of aquaculture and how they can be manipulated;
- describe water refinement mechanisms;
- describe basic culture methodologies, common problems and solutions of commercially important inland and coastal aquaculture species;
- understand the basis of Good Aquaculture Practice (GAP) & environmental impacts of aquaculture; and
- gain knowledge and skills on designing and operating fish hatcheries.

Instructional strategies and tools

The course will be delivered through lecture and discussion, aided by power point presentations, providing reading material, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms**.** Content/s of the upcoming class will be announced to the students. At the beginning of each class, there will be a brief review session on the previous lecture.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	No. of classes
Lecture and discussion	26
Students' group presentation	1
In-course exam	1
Review class	1

Students' feedback on course contents and delivery	1

Assessment

There will be two in-course examinations, each consisting of 8.75 marks, and 2.5 marks are allocated for class attendance. The students will be frequently asked questions in the classroom to assess their individual performance.

References

FAO. 2011. Cultured Aquatic Species Information Programme. Cyprinus carpio (Linnaeus, 1758). Fisheries and Aquaculture Department. (available at: www.fao.org /fishery/ culturedspecies/ Cyprinus_carpio/en).

Huet, M. 1994. *Textbook of Fish Culture- Breeding and Cultivation of Fish.* 2nd edition. Fishing News Books, Oxford, UK.

Imai, T. 1977. *Aquaculture in Shallow Seas Progress in Shallow Sea Culture.* Amerind Publishing Co., Delhi, India.

Iversen, E.S. 1977. *Farming the Edge of the Sea.* 2nd edition. Fishing News Books Ltd., Oxford, UK.

Jhingran, V.G. 1975. *Fish and Fisheries of India*. Hindustan Publ. Corp., Delhi, India.

Milne, P.H. 1972. *Fish and Shellfish Farming in Coastal Waters.* West Byfleet. Fishing News Books, Oxford, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 605	**Fish Genetics and Biotechnology**	**2**	**30**

Introduction to the course

Genetical improvement of culture species and use of genetic engineering techniques for developing high yielding and disease resistant variety have led to the increased/boosting production of fish from minimum land. Application of genetic techniques has got special attention in modern aquaculture and is considered an integral part of aquaculture study. This course is designed to familiarize the students with these modern genetical techniques in aquaculture. In particular, the course focuses on the genetic basis for fish selection, and methods and techniques for fish hybridization, ploidy production, gynonegesis, and transgenic fish production. ,

Specific objectives of the course

- To increase the conceptual understanding on the principles and genetical basis for improvement in culture fish and fish hybridization.
- To enhance knowledge and skills on methods and techniques for improved fish variety for aquaculture and maintenance of captive broodstocks.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Principles of fish genetics: Genetic selection and breeding of fish. Sex determination and sex reversal in fishes. Fish genome, genomic library, genetic markers, etc.	**5**
Chromosomal engineering: Induction of ploidy (polyploidy), gynogensis, androgenesis. Hybridization of fish: Principles, techniques and practices.	**3**
Production of monosex population and super male by combination of endocrine, sex reversal techniques.	**2**
Transgenesis: Definition, transgenic fish, detection of transgenes and application.	**2**
DNA fingerprinting: Principles and applications. Uses of RELP, RAPD, AFLP in aquaculture.	**2**
Electrophoretic techniques: General principles, classification and its application in fish.	**2**
DNA amplification: PCR – principle, types and applications; amplification of different region of fish genome using PCR technique.	**2**
DNA barcoding: Concept, methods and uses.	**2**
Gene Bank and conservation: Cryopreservation of gametes and embryos.	**2**
Bioinformatics: Concept and application.	**2**
Role of biotechnology in improving aquaculture production in Bangladesh.	**1**

Learning outcomes

- After completion of the course, the students will be able to-
- learn about sex differentiation, gametogenesis, and sex reversal techniques in aquaculture;
- learn about the basis, methods and practices of fish hybridization;
- understand reproductive biotechnologies in aquaculture, including ploidy manipulations, sex reversal, cryopreservation, induced spawning;
- gain knowledge and skills for producing transgenic fish , polyploid fish, gynogenic fish and androgenic fish;
- provide students with knowledge on how to identify genetic materials, PCR and electrophoresis;
- use the bioinformatics and its application in development of genetically improved fish for aquaculture; and
- understand the importance of biotechnology in aquaculture production in the country.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, models, video clips, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	25	Review class	1
Students' group presentation	2	In-course exam	1
Feedback on In-course exam	1		

Assessment

There will be one In-course examination, consisting of 17.5 marks and class attendance will carry 2.5 marks. The students will be frequently asked questions in the classroom to assess individual's performance.

References

Colin, E.P. 1993. *Genetics and Fish Breeding.* Chapman and Hall, UK.

Das, P. and Jhingran, A.G. 1976. *Fish Genetics in India.* Today and Tomorrow Publishers, New Delhi.

Douglas, T. 2001. *Genetics for Fish Hatchery Managers.* 2nd edition. Kluwer Academic Publishers, Baton Rouge, USA.

Fingerman, M., Nagabhushanam, R. and Thompson, M.F. 1999. *Recent Advances in Marine Biotechnology* (Vol. 1-3). Oxford and IBH Publishing Co. Ltd., New Delhi.

Lakra, W.S. 2000. *Fish Genetics and Biotechnology*, CIFE, Mumbai, India.

Sinnot, E.W., Dunn, L.C. and Dobzhansky, T. 1989. *Principles of Genetics.* McGraw Hill Publishing Company Ltd., New Delhi.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 606	**Fish Diseases and Aquatic Health Management**	**2**	**30**

Introduction to the course

Fish disease is a serious problem in modern aquaculture and in most cases, it is an important determinant of profitability in fish and shrimp farming. Recent advances in fish disease control are overwhelming and considered an integral part in fish farm management. The course offers a comprehensive package of learning opportunities with major focuses on stress and immune responses in fish, patho-physiological changes in fish diseases, methods and procedures for diagnosis and treatment of various fish diseases, including microbial, parasitic, environmental, nutritional and genetic diseases of fish. In addition, the course also highlights on prophylaxis, fish immunization, fish quarantine and detection of pathogens in fish. The course is designed to enhance students' learning aiming at producing professionals in fish disease management in the country with adequate background knowledge in the subject area.

Specific objectives of the course

- To make students' understanding on the stress response and immune functions in fish, and basis for fish disease management ;
- To increase students' knowledge on causes, pathology, etiology, treatment of various fish diseases;
- To enhance knowledge and skills of students in fish disease diagnosis, treatment and management.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Introduction to fish diseases: Terminologies related to diseases, environmental change and disease occurrence; causes and types of diseases	**1**
Stress responses in fish: Concepts, definitions, types; stressors-physical, biological and chemicals; mediation of stress responses, physiological outcomes of stress	**2**
Immune responses in fish: Concepts and types of immunity and immune responses; immune systems in fish; Physical, biochemical, cellular and humoral immune responses in fish Acquired immunity: antigens, antibody –types, structure; production and functions, immune-deficiencies	**4**
Parasitic diseases of fish: Detail study on the causes, aetiology, pathogenicity, and control measures of common protozoan, crustacean. helminth, acanthocephalan diseases of carps, catfishes and shrimps	**4**
Microbial diseases of fish: **Brief introduction** to microbes causing fish diseases and its mode of infection	**4**

Title/sub-titles of course contents	No. of classes
Causes, symptoms, pathology, etiology and control measures for common bacterial, viral and fungal diseases of fishes and shrimps	
Non-pathogenic diseases: Causes, symptoms, control measures of environmental. nutritional, genetic diseases and diseases of unknown aetiology of fish diseases	**3**
Therapeutics and medication in fish diseases Principles and concepts; treatment methods and procedures and care during treatment Therapeutic treatment for ectoparasites, endoparasites and microbial diseases Systemic and parental treatments for pathogens	**3**
Proplylaxis and metaphylaxis Principles, concepts and different prophylactic and metaphyllactic measures **Immunization of fishes:** concepts, types, inoculation materials and vaccination methods of fish	**3**
Detection of pathogens in fish	**1**
Management of fish diseases Basis for fish disease management; role of husbandry in controlling diseases in fish farms	**1**
Fish disease and public health issues; fish quarantine and certification	**1**

Learning outcomes

After completion of the course, students will be able to-

- explain the stress and immune responses in fish and understand the basis for fish disease management;
- gain knowledge on the causes, pathology, etiology and control measures of various type of fish diseases;
- learn about the methods and procedures of fish disease treatment, chemicals and its uses in treating fish disease;
- learn about the prophylactic measures and immunization methods and techniques; and
- diagnose, treat and control fish diseases.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	No. of classes	Class/lecture types	No. of classes
Lecture and discussion	26	Review class	1
Students' group presentation	1	In-course exam	1
Feedback on In-course exam	1		

Assessment

There will be one In-course examination, consisting of 17.5 marks and another 2.5 marks will be dedicated for students' class attendance. The students will be frequently asked questions in the classrooms to assess individual's performance. A course final examination, consisting of 30 marks will be conducted by the university.

References

Chemg, T.C. 1967. *The biology of animal parasites*. Saunders, London.

Dogiel, V.A., , Petrusheveski, G.K. Polyanski, Y.I. 1961. *Parasitology of fishes*. Oliver, London.

Roberts, R.J. (ed.). 2001. Fish pathology, 3rd edition. Saunders. London, New York.

Schaperclaus, W. Kulow, H. and Schrecknbachy, K. 1991. *Fish diseases*, Vo. I & II. Oxonian Press (Pvt.) Ltd.

Shuzo, E. (1999). *Infectious diseses of fish*. Oxonian Press (Pvt.) Ltd.

Sinderman, C.J. 1970. Principal diseases of marine fish and shellfishes. Academic Press, London, New Yoerk.
Van Duijn,C, 1966. Diseases of fishes, Iliffe Books, London.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 607	**Aquaculture Nutrition, Feed and Advanced Fish Physiology**	**2**	**30**

Introduction to the course

Modern fish culture practices largely depend on the external supply of fish feed. However, a quality and efficient feed with balanced dietary components may ensure an optimum fish growth. Different fish species have different dietary requirements and necessitates the species specific formulation of fish feed. Fish culture, breeding, feeding and disease management require the detail knowledge on physiological processes in fish body and in fact, physiology determines the survival, growth and reproduction performances of a fish species. The present course is designed to introduce the students with all these aspects. Specifically, the course focuses on the nutritional requirements of fish, feed formulation, method and techniques for feeding for cultured fish. The course also focuses on the physiology of digestion, reproduction, respiration, osmoregulation in fish.

Specific objectives of the course

- To provide the students with in-depth understanding on the feed formulation, preparation, feed utilization by fish and importance of quality fish in aquaculture.
- To enhance knowledge and skills of students on the formulation of fish feed and its proper storage;
- To increase students knowledge about the physiology of digestion, reproduction, osmoregulation and endocrinology.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents		No. of classes
Aquaculture Nutrition		
Nutritional requirements:	Qualitative and quantitative requirements of protein, fat and energy for fishes.	**2**
Feed preparation:	Formulations, millings and bulk storage.	**2**
Farm made aquafeeds:	On-farm feed preparation and feeding strategies for carps and shrimp. Fish meal, Fish silage.	**3**
Non-Conventional Feed Resources (NCFR):	Definition, characteristics, availability, nutritive value and constraints to utilization.	**2**
Feeding of cultured fish:	Appetite and satiation; factors influencing feeding behaviour; feed types; handling and storage of feed; feeding methods. Fish feed Act and Rules.	**3**
Selected Nutrient terms and analytical techniques:	Proximate analysis (moisture, ash, crude protein, total lipids); apparent digestibility; Total Digestible Nutrients (TDN);Digestible Dry Matter (DDM); Net energy (NE); Relative feed value (RFV); Non-protein nitrogen (NPN); Nonfiber carbohydrates (NFC); energy utilization, bioavailability.	**4**

Title/sub-titles of course contents		No. of classes
Nutritional bioassay:	Hematological and histological parameters of a healthy herbivore (*Labeorohita*) and a carnivore (*Clariasbatrachus*) fish.	**1**
Nutrient and Environment:	Environmental issues on fish feed used for aquatic systems, Environmental issues related to high density fish culture in cages.	**2**
Fish feed Acts and rules:	Salient features of Fish Feed and Animal Feed Acts 2010; Fish Feed Rules 2011	**2**
Advanced Fish Physiology		
Digestion:	Physiology of digestion of fish;	**1**
Reproduction:	Nutritional and environmental factors influencing the reproduction of fish.	**1**
Osmoregulation:	Osmoregulation of freshwater and marine fishes.	**1**
Endocrinology:	Endocrinology in fish and its application in breeding.	**1**

Learning outcomes

After completion of the course, the students will be able to-

- formulate the fish feeds by using different ingredients;
- understand the millings, storage, aqua-feeds, NCFR in fish feed;
- know the feeding techniques and analytical techniques for the feed;
- identify some environmental issues and laws that related feed and the industry; and
- know and explain the physiology of digestion, reproduction, osmoregulation and endocrinology of fish.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	No. of classes	Class/lecture types	No. of classes
Lecture and discussion	26	Review class	1
Students' group presentation	1	In-course exam	1
Feedback on In-course exam `	1		

Assessment

There will be one In-course examination and a few home works on some selected course items. The In-course exam and class attendance will carry 17.5 marks and 2.5 marks, respectively. A course final examination, consisting of 30 marks will be conducted by the university.

References

FAO. 1988. *Non-Conventional Feed Resources in Asia and Pacific*.3rd edition. Fisheries Technical Paper, FAO, APHCA Branch, Bangkok.

Goddard, S. 1996. *Feed management in Intensive Aquaculture*. Chapman and Hall, USA.

Halver, I.E. and Hardy, R.W. 2002. *Fish Nutrition*. 3rd edition. Academic Press, New York.

Hoar, W.S., Randall, D.J. and Donaldson, E.M. 1983. *Fish Physiology*. Academic Press, Orlando, USA.

Lagler, K.F., Bardach, J.E., Miller, R.R. and May, P.D.R. 1977. *Ichthyology*. John Wiley and Sons, New

York.
New, M.B., Tacon, A.G.J. and Csavas, I. 1995. *Farm Made Aquafeeds.* FAO *Press,* Washington DC, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 608	**Post-harvest Technology and Quality Control**	**2**	**30**

Introduction to the course

A variety of techniques are employed for harvesting fish from different depth ranges and different types of water body. One of the purposes of the course is to make familiar with these harvesting techniques and the gears used. Fish harvest and post-harvest technologies constitute an inter-disciplinary science and techniques applied to fisheries commodities after the harvest of fish for the purpose of preservation, conservation, quality control/enhancement, processing, packaging, storage, distribution, marketing, while maintaining to meet the food quality and nutritional quality. Food safety and security is largely determined in terms of microbial contamination. The course will highlight also on the quality control of fish products at its different stages of production.

Specific objectives of the course

- To make the students familiar with the various methods and techniques used for harvesting of fish.
- To enhance students' knowledge on the different post-harvest techniques used for fish preservation and processing and make familiar with the rules and regulation controlling quality of fish products.
- To make the students aawre and know the food safety and security aspects and methods for controlling quality of fish and fish products.

Course contents and number of classes by course sub-title

Title/sub-title of the course content		No. of classes
Post-harvest Technologies		
Fish harvesting:	Methods of harvesting freshwater and marine fishes; grading, packaging, storage, transportation of fish for consumers.	**4**
Post-harvest technologies:	Principles and methods of freezing and chilling, changes during freezing fish; quality control during freezing and chilling.	**4**
	Principles and techniques of fish drying, smoke and salt curing; fermentation, marinating and pickling of fish.	**6**
	Introduction to fish canning, principles of thermal processing, changes during canning, problems related to fish canning.	**4**
Fishery products:	Utilization of fishery products and by products - fish meal, fish body and liver oils, fish silage, fish hydrolysates and miscellaneous by products - fish maws and isinglass, pearl essence and chitin processing from shrimp and crab shell.	**3**
Quality Control		

Title/sub-title of the course content		No. of classes
Quality determination and standard:	Methods for determining quality of raw materials and fishery products. Factors affecting the quality of raw materials and finished products. Estimation of total viable bacteria in fish and fishery products. Determination of coliform and faecal coliforms in fish or fishery products.	**2**
Quality assurance:	Introduction to HACCP, its principles and applications. Stages for developing a HACCP Plan. Best Manufacturing Practices (BMP). Quality Certifications.	**1**
Fisheries products laws and rules:	Salient features of Fish and Fish Products (Inspection and Quality control) Ordinance, 1983 and its updates (1997, 2008).	**1**

Learning outcomes

After completion of the course, the students will be able to-

- describe methods and techniques of harvesting of fish and gear used for fish harvest;
- learn about the safe handling and transportation of harvested fish;
- know the fish processing and preservation methods and techniques;
- know about the quality issues of fish and fish products and their control measures;
- explain HACCP procedures and plan; and
- know the related laws and policies related to marketing of fish and fish products.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, models, video clips, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	No. of classes	Class/lecture types	No. of classes
Lecture and discussion	25	Review class	1
Students' group presentation	2	In-course exam	1
Feedback on In-course exam	1		

Assessment

There will be one In-course examination, consisting of 17.5 marks. Class attendance will carry 2.5 marks. A course final examination will be of 30 marks and be conducted by the university. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Alam, A.K.M.N. 2014. *Post harvest Fishery Losses and Mitigation Measures.* Department of Fish Technology, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Balachandran, K.K. 2001. *Post harvest technology of fish and fish products.* Daya Publishing House, New Delhi.

Clucas, I.J. and Ward, A.R. 1996. *Post Harvest Fisheries Development: A Guide to Handling. Preservation, Processing and Quality.* Natural Resources Institute, Overseas Development Administration, UK.

Connell, J.J. 1980/1990. *Control of Fish Quality.* 2nd Edition. Fishing News Books Ltd., Farnham, Surrey, England.

Cutting, C.L. 1999. *Fish Processing and Preservation.* Agro-botanical Publishers, India.

Govindan, T. K. 1985. *Fish Processing Technology.* Oxford & IBH Publ. Co. Pvt. Ltd., New Delhi.

Regenstein, J.M. and Regenstein, C.E. 1997. *Introduction to fish Technology*. 1st edition, CBS Publishers and Distributors. India.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 609	**Fish Ecology, Limnology and Oceanography**	**2**	**30**

Introduction to the course

Fish ecology is the general study of factors influencing the distribution and abundance of fishes and how they interact with their environment. We will begin this course with an overview of patterns of fish diversity and how fishes interact with their environment. This course will give the student an understanding on interrelationships between the physical, chemical and biological aspects of aquatic ecosystems, including land-water interactions. The students will learn how water parameters influence the productivity of a water body. This course will also highlight the existing connection between freshwater organisms, aquatic ecosystems and the human community. The students will be able to explain how inland water ecosystems work, and in which way they are affected by human perturbations, such as overexploitation, eutrophication and climate change. The course will address the sustainable use of water resources therefore requires solid knowledge of aquatic ecosystems, to understand how and why ecosystems are affected by changes in biological, chemical or physical conditions.

Specific objectives of the course

- To make understand students how the fishes interact with its biotic and abiotic environment, and the ecological and evolutionary processes impacting on individuals, populations and species;
- To know the water chemistry and its influences on the aquatic productivity and limnological requirements for fish culture;
- To familiar with the physiography of oceans and ocean functions.

Course contents and number of classes by course sub-title

Title/sub-title of course content	No. of classes
Fish Ecology: Aquatic organisms and global ecology: Ecology of freshwater column, coastal ecosystems, deep-water marine zones. The role of the oceans in global warming. Role of gases in sea level rise. Effects of climate change in world ocean and freshwaters. Aquatic communities and Fish assemblages: Competition, predation and disturbances, coexistence and succession; effects of predation in communities, disturbances and patchy dynamic concepts. General patterns of species richness; species diversity and diversity indices. Life-history strategy: Cost of reproduction and the consequences. Bioenergetics of life history patterns. Impacts of man's activities on ecosystem: Harvesting natural product, ocean dumping and disposal, accidental discharge, ballast discharge and its ecological significance. Eutrophication: causes, process, impact and mitigation. Harmful algal blooms and bioactive marine products. Invasive alien fish and its impact on ecosystem. Freshwater, estuarine, marine fisheries ecosystems in Bangladesh.	**9**
Limnology: **Water as a substance**: Hydrological cycle, global water balance, nutrients and micro nutrients of waters; eutrophication, problems and remedial measures, sediment and its physical and chemical characteristics.	**7**

Title/sub-title of course content	No. of classes
Water quality requirements of tropical fish; limnological basis for fish culture; limnological effects of fertilization, liming and feeding on water quality, Concepts of water budgeting; water budgets for pond and polders; estimation methods of carrying capacity of water bodies; models and its interpretation. **Biotic limnology**: Plankton and fish community; phytoplankton, zooplankton and benthos and their interrelationship.	
Oceanography: Oceanography definition and concept; A historic perspective of ocean planet; Plate tectonic and Ocean floor; Evidence of continental drift; Marine sediments; lithogenous, biogenouus and hydrogenous sediments; Ocean circulation, upwelling and downwelling; Ocean tides; theory, patterns and phenomena; Biological productivity and energy transfer; Blue economy; prospects and challenge for Bangladesh; The ocean weather and climate Marine environment concern.	**6**

Learning outcomes

After completion of the course, the students will be able to-

- familiar with different aquatic habitats and ecosystems and understand the principles of limnology;
- learn about the ranges of interactions between freshwater organisms & aquatic ecosystems;
- explain the conceptual basis of the hydrological cycle, global water balance.
- carry out biotic and abiotic parameter assessment in aquatic environment;
- identify conditioning factors of aquatic ecosystem and how they can be manipulated.
- describe water quality requirement for aquaculture ;
- know the zonation of the sea, animal communities and ocean functions.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video clipping. At times students will be supplied with notes and other reading materials. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms**.** At the beginning of each class, there will be a brief review session on previous lecture topic.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	No. of classes
Lecture and discussion	24
Students' group presentation	1
In-course exam	2
Review class	2
Students' feedback on course contents and delivery	1

Assessment

There will be two in-course examinations. 8.75 marks each and 2.5marks are reserved for class attendance. The course final examination, consisting of 30 marks, will be conducted centrally by the university. The students will be frequently asked questions in the classrooms to assess their individual performance.

References

Barnes, R.S.K. and Mann, K.H. 1991. *Fundamentals of Aquatic Ecology.* Blackwell Scientific Publication, UK.

Charles, R.G., Michio, K. and Richard, D.R. 2012.*Climatic Change and Global Warming of Inland Waters*: *Impacts and Mitigation for Ecosystems and Societies.* Wiley-Blackwell, USA.
Payne, A.I. 1986. *The ecology of tropical lakes and rivers*. John Wiley & Sons., USA.
Ruttner, F.1984. *Fundamentals of Limnology.* University of Toronto Press, Canada.
Thurman, V.H. and Trujillo, A.P. 2004. Introductory Oceanography. 10th edit. Pearson Prentice Hall, NJ, USA.
Wetzel, R. 2001. *Limnology, Lake and River Ecosystem.* Academic Press, USA.
Wootton, R.J. 1999. *Ecology of Teleost Fishes.* Blackwell Scientific Publication, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 610	**Fisheries Economics, Fish Marketing and Extension Services**	**2**	**30**

Introduction to the course

Fisheries economics are crucial to understand the context of this sector and make wise decisions that led to maximising social-economic benefits for country's fisherfolks. It is intertwined with how different entities in a system decides to exploit the fisheries resources, their mode of production, use of market channels along with the demand for the target fish or fisheries products in the market. This course is designed to introduce students with these facets of fisheries economics. It also offers an exposure to different non-state market-led approaches that can be harnessed to attain eco-label certification. Students will be introduced with different national and international case studies that demonstrate the theory of fisheries economics in practice.

Specific objectives of the courses

- To make the students to understand how principles and techniques of economics could be applied to fish and its product marketing, while maximizing the benefits to the fisherfolk.
- To enable the students to appreciate the marketing channels and mechanism and thoughts for its improvement.
- To enhance students skills on methods and techniques for the extension of aquaculture across the country.

Course contents and number of classes by course sub-title:

Title/sub-title of course content	No. of classes
Fisheries Economics	

Title/sub-title of course content	No. of classes
Economics and decision making: Basic concept of scarcity and economics; Decision making (at individual, societal and national level) in Economics; Case study: Decision making in the context of hilsa fisheries and its management in Bangladesh. **Demand and supply of fish**: Concept of supply and demand; Elasticity of demand and supply; Implications of supply and demand in markets and fisheries sector. **Production**: Purpose of production and its function; Short-run and long-run production inputs factors, profit maximization; Government's role in aquaculture in Bangladesh; Growth of aquaculture and its role in the economic development of Bangladesh.	**5** **4** **4**
Fish Marketing	
Market channels: Introduction and approach to assess fish marketing and its channels; Market channels for fish and fisheries products in Bangladesh; Case study: Shrimp/Hilsa/mud crab. **Market-led approaches for sustainable fisheries**: Eco-label certification schemes for seafood; Criteria to achieve certification for eco-label; Case study: Marine steward Council/SeaChoice/Ocean Wise.	**5** **5**
Extension Services	
Concept of Extension services: for whom, how and why? **Sustainable livelihood Approach (SLA)**: Concept and approach; Framework, livelihood assets and strategies in SLA; Livelihood security and vulnerability context in SLA.	**2** **3**

Learning outcomes

After completion of the course, the students will be able to-

- understand the economic considerations and its application in fish marketing;
- make a wise decision that accounts the socio-ecological and economic contexts of fisheries and fishing folks;
- explain how production, supply and demand in market work under different scenarios;
- describe different marketing channels for fish and fisheries products, and what changes need to be made to attain eco-labelling certification; and
- know the methods and techniques for extension of fish culture practices among fisher producers and fishermen.

Instructional strategies

The course will be primarily taught by using lectures, aided by powerpoint presentation and videos. Role play exercises will be employed in delivering some special topics or section of a topic. Reading materials

will be supplied to students prior to each lecture so that students could participate in the discussion. Where necessary, students will be asked to perform group exercises in the classroom. At the end of each class, students will given the outline of the next class and similarly, at the begging of a lecture, a very short review of the last lecture will be done with question and answer practices. .

Distribution of class lectures: Total number of classes: 30

Class/ lecture type	No. of classes
Lecture and Practical exercise	28
In-course exam	1
Feedback on In-course exam, and students' feedback on course contents and delivery	1

Assessment

There will be one In-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for class attendance. A course final examination will be conducted by the university and will carry 30 marks. .

References

Cambell, J. and Salagrama, V. 2000. New Approaches to Participation in Fisheries Research: A Discussion Document. FAO and SIFAR.

CRS. 2002. RRA and PRA manual. Catholic Relief Support, USA.

IIRR. 2003. Participatory Methods in Community-based Coastal Resource Management. IIRR, The Philippines.

Kleih, U., Greenhalgh, P., & Oudwater, N. 2003. A guide to the analysis of fish marketing systems using a combination of sub-sector analysis and the sustainable livelihoods approach.

Mankiw, N. G. (2014). Principles of macroeconomics. Cengage Learning.

Phillip, T. 1996. Rapid Rural Appraisal and Participatory Rural Appraisal and Aquaculture. FAO Tech Paper 358. FAO, Rome.

Sen, A. 1986. Poverty and Famines, an essay on entitlement and deprivation. ELBS, Oxford University Press, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 651	**Practical Fisheries**	**6**	**90**

Introduction to the course

The course is designed to provide and equip students with adequate practical knowledge and skills in a wide ranges of field of the fisheries sciences and are aligned with most theoretical the fisheries courses of the MS program . The intent of the practical course is that the students will be able to apply methods and techniques of fisheries in the field and in the laboratory. A wide range of practical activities are prioritized, like species identification, study of planktons and benthos, effective quality monitoring , methods and techniques for, induced breeding , population estimation , age determination, fish feed formulation,, study of reproduction biology, feeding habits, nutritional requirements, diseases causing agents and control.

Specific objectives of the courses are

- To create basic understanding on the taxonomic identification of fish/shellfish;
- To learn reproductive biology of fish and shellfish;
- To create basic understanding on the planktons and benthos;
- To learn induced breeding technique;
- To learn effective water quality monitoring practices;
- To learn population estimation methods;

- To learn age determination techniques;
- To create basic understanding on the fish food and their feeding habits and nutritional requirements of fish/shellfish and feed manufacture;
- To provide holistic knowledge on fish and shellfish pathogens and their control measures;
- To interact with others in the field and learn from others, allowing them to view practical examples in the field;
- To explain their observation and experiences through reports; and
- To analyze the data they collected from the field and share their observation with evidence.

Course contents and number of classes by course sub-title

Title/sub-title of course content	No. of classes
Taxonomic study of fishes (fin fish & shell fish)	**4**
Brief study on biology and morphology of finfishes and shellfishes; Study the morphometry of finfishes and shellfishes Identification of common finfishes and shellfishes of Bangladesh;	
Reproductive stages, fecundity and GSI	**2**
Different reproductive stages; Brief study on fecundity and GSI – application.	
Study of plankton and benthos	**3**
Study of plankton and benthos community and their types; Collection and identification of planktons and benthos from an aquatic ecosystems; Analysis of planktonic and benthic composition.	
Induced breeding technique	**1**
Dissection and display of reproductive system (male and female) of fish; Dissection and display of pituitary gland and preparation of pituitary gland extracts and its application in fish breeding.	
Water Quality Analysis	**1**
Equipments used in water analysis; Water sampling and water quality parameters; Measurements of temperature, pH, conductivity, salinity, transparency, turbidity and solids; Analyses of dissolved oxygen, alkalinity and hardness, phosphorus, nitrogen; chlorophyll a; Application of fertilizers and pond liming.	
Estimation of fish population parameters using LFDA and FiSAT	**1**
Fish population estimation parameters and estimation methods (using LFDA and FiSAT); Benefits of Fish population monitoring.	
Determination of age with scale, otolith and vertebrae methods	**1**
Brief discussion on fish biology and importance of age determination; Different techniques of age with scale, otolith and vertebrae methods.	
Length-weight relationship and condition factors	**1**

Title/sub-title of course content	No. of classes
Feeding habits of fish and preparation of fish feeds	**2**
Different food and feeding habits of fishes; Practical Formulation and preparation of a balanced fish feed; Proximate analysis- moisture, crude protein, crude lipid, ash, acid insoluble ash content of feed; Estimation of crude fibre, nitrogen free extract, calcium and phosphorus content of feed; Estimation of protein and lipid quality; Determination of gross energy content of feed and feed ingredients; Determination of the digestibility of feed using markers; Estimation of FCR from feeding trials and preparation of feeding table; Estimation of growth parameters from feeding trials; Analysis of gut content analysis to study artificial and natural food intake.	
General procedure for inspection of fish health	**2**
General procedures for disease diagnosis; Taxonomy and identification of fish parasites; Techniques for disease diagnosis; Challenge tests; Purification of virus; Stress related study of fish and shellfish; Disease treatments.	
Exposure visit and demonstration:	**8**
Molecular taxonomy and DNA barcoding of fish; Fertilization, liming and feeding trails in a hatchery/fish farm; Fish processing industry; and Catch assessment survey and monitoring (open water).	
Project and seminar:	**2**

Learning outcomes

After completion of the course the students will be able to-

- Apply different techniques and tools that are important to manage fisheries recourses;
- Increase knowledge on different applied issues in fisheries biology as part of the cross learning and sharing of knowledge and information through the exposure visit and demonstration; &
- Work in group to develop SMART project and disseminate the findings through report and presentation.
    - To create basic understanding on the taxonomic identification of fish/shellfish;
    - To learn reproductive biology of fish and shellfish;
    - To create basic understanding on the planktons and benthos;
    - To learn induced breeding technique;
    - To learn effective water quality monitoring practices;
    - To learn population estimation methods;
    - To learn age determination techniques;
    - To create basic understanding on the fish food and their feeding habits and nutritional requirements of fish/shellfish and feed manufacture;
    - To provide holistic knowledge on fish and shellfish pathogens and their control measures;
    - To interact with others in the field and learn from others, allowing them to view practical examples in the field;

- To explain their observation and experiences through reports; and
- To analyze the data they collected from the field and share their observation with evidence.

Instructional strategies

The course will be delivered by practical demonstrations in the laboratory, hands-on training and field tours. A number of teachers will demonstrate and guide the individual students in the practical class. There will be lot of group exercises in the laboratory. Necesary logistics and equipment will be provided in the laboratory for use in the practical classes. Reference books will also available from the departmental seminar library. The students will get lot of opportunities to interact with the teachers and classes will be made participatory through questions and answers.

Distribution of class lectures: Total number of classes: 33

Class/ lecture type	No. of classes
Lectures and Practical exercise	22
Exposure visit and seminar	3
In-course exam	2
Students' SMART project presentation (Planning, data collection and writing are not accounted within class hours)	2
Feedback on in-course exam, and students' feedback on course contents and delivery	1

Assessment

Assessment will be done on class attendance (5%), In-course examination (35%), and final examination (60%). There will be two In-course examinations. In-course examination will consist of class exams, assignments, notebooks, project and field reports. Students will be frequently asked questions in the classroom as part of the continuous assessment. A group of teachers will guide students to develop their SMART project. Teachers will also join students in their exposure visits and guide them for report writing.

References

Ahmed, A.T.A., Kabir, S.M.H., Ahmed, M., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A., and Khondker, M. (ed.). 2008. *Encyclopedia of Flora and Fauna of Bangladesh, Vol. 18. Part 11. Arthropoda: Crustacea*. Asiatic Society of Bangladesh, Dhaka.

Jhingran, V.G. 1983. *Fish and Fisheries of India*. Hindustan Publishing Corporation, Delhi, India

Jhingran, V.G. and Pullin, R.S.V. 1988. *A Hatchery Mannal for the Common, Chinese and Indian Major Carps*. ADB and ICLARM.

Nikerson, J.T. and Sinskey, A.J. 1977. *Microbiology of Foods and Food Processing*. 3rd edition. Elsevier, New York, Oxford, Amsterdam.

Rahman, A.K.A. 1989. *Freshwater Fishes of Bangladesh*. The Zoological Society of Bangladesh, Dhaka.

Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmed, M., Ahmed, A.T.A., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A., Khondker, M. and Rahman, M.M. 2007. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol. 17, 23 and 24. Molluscs, Freshwater Fishes and Marine Fishes. Asiatic Society of Bangladesh, Dhaka.

Shafi, M. and Quddus, M.M.A. 1982. *Bangladesher Matsya Sampad* (in Bangla). Bangla Academy, Dhaka.

Welch, P.S. 1952. *Limnology*. McGraw-Hill Book Co., New York.
Wetzel, R.G. 1983. *Limnology*. CBS College Publishing. The Dryden Press, California.

MS in Zoology (Entomology)

Course No.	Course Title	No. of Credits	Credit Hours
ZE 611	**Insect Systematics and Nomenclature**	**2**	**30**

Introduction to the course

Insects are the most diverse group of animals on the planet with long history of evolution. Knowing the diversity of animals offers a fascinating challenge. The purpose of this course is to familiarize students with different orders and families of insects and enable them to study and identify the insects. The course specifically focuses on the methods and techniques of taxonomic study of insects, collection and preservation and identification of insects, rule governing the naming the species. The course will also highlight on the phylogenetic relationship of various groups of insects.

Specific objectives of the course

- To introduce the students with the detailed classification schemes of insects and familiarize them with insect orders and families with distinguishing characters.
  To enable the students to carry out taxonomic study of insects following the methods and identify insects.
- To introduce students with fossil insects, their depositories, time period, and phylogenetic relationship;
- Provide knowledge to interpret the rules of insect nomenclature.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Insect systematics	
Introduction to insect systematics: Introduction, definition of some terms used in insect systematics.	**1**
Fossil insects: Paleozoic and Mesozoic insects; localities of these fossil insects; phylogenetic development of insects (orders); evolution of insects.	**6**
An overview of the orders of insects: Diagnostic characters of all insect orders; important families of insect orders.	**6**
Insect collection, preservation, identification, cataloguing, description, and publications; reference works in insect taxonomy.	**7**
Insect nomenclature:	
Interpretation of the rules of nomenclature in terms of the following aspects: Stability, priority, name changing, name given to hybrids, synonymy, date of publication, validity, formation of names, infra-specific names, authorship, homonymy, genus group names, the type methods, and ICZN.	**5**

Learning outcomes

After completion of the course, the students will be able to-

- describe the group of fossil insects existing in prehistoric localities and explain the phylogenetic relationship of insects;
- know the procedures and technique of taxonomic study;
- identify insects belonging to different groups through learning their diagnostic characteristics; and
- explain the rules of nomenclature.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	25	Review class	1
Students' group presentation	2	In-course exam	1
Student feedback on course contents and delivery	1		

Assessment

There will be an in-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for students' attendance in the class. The students will be frequently asked questions in the classroom to assess individual's performance. A course final examination will be conducted by the university, which will carry 30 marks.

References

Johnson, N.F. and Triplehorn, C.A. 2004. *Borror and DeLong's Introduction to the study of Insects*. 7th edition. Belmont, CA: Thomson Brooks/Cole, Australia.

Gullan, P.J. and Cranston, P.S. 2010. *The insects: An outline of entomology.* 4th edition. Blackwell Publishing, Ltd., Malden, MA, USA.

ICZN. 1999. *International Code of Zoological Nomenclature*. Published by International Trust for Zoological Nomenclature in association with British Museum (Natural History), London, New York.

Kapoor, V.C. 2017. *Theory and Practice of Animal Taxonomy and Biodiversity*. 8th edition. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Mayr, E. 1991.*Principles of Systematic Zoology*. 2nd edition. McGraw-Hill Co., New York.

Richards, O.W. and Davies, R.G. (revised by Imm's, A.D.). 1997. *A General Text Book of Entomology*. The English Language Book Society and Mathuen & Co. Ltd., UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 612	**Insect Structure and Function**	**2**	**30**

Introduction to the course

Insects are the most abundant and diverse invertebrates, show a great variety of modifications in their structural and functional systems. This course introduces the student with the diverse morphological and anatomical features of the insects. In particular the course focuses on detailed external structure of insects, viz. the integument and its derivatives and the internal structures and systems of the insects in relation to their functions. The course will also describe the modifications in different systems, and discusses how these systems allowed the insects group to adapt in different environment and different life stages.

Specific objectives of the course

- To introduce the students with morphological details of insect's organ systems and its modifications across different insect groups. ;
- To make students to appreciate how the morphology of a structure is related to its function.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Insect structure	
Integument derivatives: Apodeme and apophysis, seta, tentorium. **Chitin:** Structure, formula, function. **Head segmentation:** Theories regarding head segmentation. **Sound producing organs, light producing organs and colour production process.**	**1** **1** **2** **1**
Functional system	
Digestive system: Morphology and histology of the alimentary canal; modifications of the digestive tract. Filter chamber- structure, types and functions. **Respiratory system:** Structure and function; spiracles - structure and types. **Circulatory system:** Morphology, function and haemocytes. **Excretory system:** Morphology and types of Malpighian tubules; cryptonephridia. **Reproductive system:** Morphology, male and female reproductive organs; types of ovarioles. **Nervous system:** Morphology, central, peripheral and sympathetic nervous system.	**7** **4** **3** **3** **4** **4**

Learning outcomes

After completion of the course, the students will be able to-

- describe the morphological accounts of different organ systems;
- appreciate variations in the organs in different insects; and
- classify and tell about the function of different insect organ systems.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	No. of classes	Class/lecture types	No. of classes
Lecture and discussion	26	Review class	1
Students' group presentation	1	In-course exam	1
Student feedback on course contents and delivery	1		

Assessment

There will be one in-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for students' attendance. Questions for In-course examination will be of objective and short answer types. The course final examination will carry 30 marks. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Chapman, R.F., Simpson, S.J. and Douglas, A.E. 2013. *The Insects: Structure and Function.* 5th edition. Cambridge University Press, New York.

Johnson, N.F. and Triplehorn, C.A. 2004. *Borror and DeLong's Introduction to the study of Insects*. 7th edition. Belmont, CA: Thomson Brooks/Cole, Australia.

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Ross, H.H. 1964. *A text book of entomology.* John Wiley and Sons, New York.

Snodgrass, R.E. 2004. *Principles of Insect Morphology*. Tata McGraw Hill Publ. Co. Ltd., New Delhi, India.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 613	**Insect Embryology, Endocrinology and Molecular Biology**	**2**	**30**

Introduction to the course

Insects are the most successful life form and they make up more than half of all living things on Earth. These are the first metazoan which resemble to the higher vertebrates. Insects show a range of fascinating morphological embryonic developmental and extra-embryonic events. The purpose of this course is to introduce the students with these morphogenetic events and the action of some genes in the formation of embryo. This course will also highlight the neuro-anatomy and hormonal regulation of insect development. Moreover, this course will offer to study Genes, Genome organization of insects as well as use of Molecular Biological Techniques in different Entomological Problems.

Specific objectives of the course

- To provide knowledge and detail understanding on the embryonic developmental events and metamorphic events in insects.
- To enhance students' knowledge and understanding on insect hormones and neuro-hormonal regulation of insect development and metamorphosis.
- To provide knowledge on the Molecular Entomology.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Insect embryology	
General concept of embryology.	**1**
Development in Insects:	
Embryonic Development: Vitellogenesis and oogenesis; Insect egg and their types, fertilization, zygote formation, cleavage, formation of blastoderm and germ band; gastrulation; Germ band elongation and blastokinesis; organogenesis and hatching. Genetic control of embryogenesis.	**4**
Post Embryonic Development: Metamorphosis of insect**;** Types, larva and pupa.	**2**
Irregular development, parthenogenesis, paedogenesis, neoteny, hermaphroditism (mode of reproduction), viviparity.	**1**
Insect endocrinology	
Introduction to endocrinology: General concepts and branches of endocrinology; types and function of hormone; types and function of pheromone.	**3**
Endocrine system: Neurohaemal organ in insect; endocrine control of insect reproduction, development.	**2**
Role of hormone in insect development and metamorphosis.	**2**
Insect Molecular Biology	

Chromosomal and Extrachromosomal organisation of DNA in Insects.	**1**
Insect Genes and Genome organisation	**1**
Some basic tools of Molecular Biology: How to cut, copy, paste, measure and visualize DNA, Polymerase Chain Reaction, cDNA Cloning, DNA sequencing and Analyzing the Sequence Data.	**2**
Application of Molecular Biology in Entomological Problems: Application in sex determination, Insect behavior, Insects systematics and Evolution, and for Pest Management Programs.	**3**

Learning outcomes

After completion of the course, the students will be able to-

- know about various developmental events and stages during embryonic development;
- describe explain the different larval and pupal developmental stages;
- learn about parthenogenesis, paedogenesis, neoteny, hermaphroditism, viviparity in insects;
- know about the insect hormones and pheromones; and
- explain the role of hormones and genes in insect development.
- know about different molecular biological tools used in insect molecular biology as well as learn about application of molecular biology in different entomological problems.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	22	Review class	2
Students' group presentation	1	In-course exam	1
Feedback on In-course exam	1	Management / Action Plans development exercise	2
Student feedback on course contents and delivery	1		

Assessment

There will be one in-course examination, consisting of 17.5 marks 2.5 marks will be allocated for students' class attendance. The students will be frequently asked questions in the classrooms to assess individual's performance. A course final examination of this course will be conducted centrally by the university and will carry 30 marks.

References

Chapman, R.F., Simpson, S.J. and Douglas, A.E. 2013. *The Insects: Structure and Function.* 5th edition. Cambridge University Press, New York.

Hoy, M. A. 1994. *Insect Molecular Genetics: An Introduction to Principles and Applications*. Academic Press.

Kapoor, V.C. 1990. *Origin and evolution of insects*. Kalyani Publishers, New Delhi.

Klowden.M.J.2007. *Physiological systems in insects*. 2nd edition. Academic Press.

Nation, J.L. 2002. *Insect Biochemistry and Physiology.* 2nd edition. CRC Press, Florida, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 614	**Insect Behaviour and Insect-plant Dynamics**	**2**	**30**

Introduction to the course

Animal behaviour is always a matter of curiosity and insects are ideal subjects for basic behavioural studies. Insect behaviour has enormous economic implications. The successful management of both beneficial and harmful species depends on a thorough understanding of all aspects of their behavioural biology. Insect-plant relationship is also an important component in this regard. We may be able to avoid crop damage caused by an influx of pests thorough an understanding of their migratory behaviour. We may be able to suppress a pest population by disrupting a pattern of communication important to its reproduction. All these aspects are addressed in this course.

Specific objectives of the course

- To make the students to understand the basic responses and patterns of behaviour and the functional aspect of insect behaviour.
- To provide knowledge about the social behaviour of insects and their parental care.
- To enable the students to attain a thorough knowledge on plant-insect dynamics.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Phylum Arthropoda	
Basic responses and patterns of behaviour: Habituation; behavioural periodicity and clocks.	**4**
Functional aspects of behaviour: Displacement; orientation, navigation and homing.	**5**
Communications: Chemical, audio, visual, tactile and inter-specific communications.	**2**
Host selection and feeding: Phytophagous, blood feeding and entomophagous insects.	**5**
Defence: Behavioural, structural, chemical and defences; colourational defenses (e.g. cryptic colouration, flash patterns, warning colouration, mimicry) and group defenses; Parental care and presocial behaviour.	**2**
Eusocial behaviour: Social wasps, bees, ants and termites.	**4**
Insect-plant Dynamics	
Plant-insect herbivore relationships; mutualistic associations; pollination and insects.	**2**
Life histories and reproductive strategies.	**2**

Learning outcomes

After completion of the course, the students will be able to-

- understand and describe the basic responses and patterns of behavior,
- learn about the functional aspect of insect behavior and its their social behavior;
- explain insect-plant dynamics; and
- understand the life histories and reproductive strategies of insects.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations.
At times, students will be eganged in group work in the classroom on selected topics. Classes will be made participatory and interactive through questions and answers.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	26	Review class	1
Management / Action Plans development exercise	1	In-course exam	1
Student feedback on in-course exam	1		

Assessment

There will be one In-course examinations, consisting of 17.5 marks and 2.5 marks for class attendance. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Atkins, M.D.1980. *Introduction to insect behavior*. Macmillan Publishing Co. Inc., New York.

Matthews, R.W. and Matthews, J.R. 2009. *Insect behavior.* 2nd edition. Springer, New York.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 615	**Insect Ecology**	**2**	**30**

Introduction to the course

Insect ecology involves a wide range of aspects for study; in particular, it is concerned with the influences and interactions of insect populations and insect communities on ecosystem processes that affect landscape structure, function, and change. The level of focus is the ecosystem, the levels of explanation include populations and communities, and the level of interpretation is the landscape. Insects are affected by the climate and results of studies can tell us much about what is going on in the world around us. This course is designed to cover major aspects of insect ecology, highlighting on trophic relations, impacts of climate change on insect population, regulation of population, ecological genetics, interaction between species, photoperiodism, dispersal, migration, etc.

Specific objectives of the course

- To increase students conceptual understanding on the principles and functions of insect ecology.
- To introduce to ecological process and interactions at levels, species, population and community.
- To provide knowledge about the impacts of climate change on the life of insects and different theories on insect population regulation.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Introduction	**1**
Trophic relationship: Trophic structure of community; coevolution of plants and herbivores; coevolution of prey and predator; energy flow.	**5**
Impact of climate change on the life of insects; Theories on population regulation.	**2**
Ecological genetics: Polymorphism, balanced and transient polymorphism, industrial melanism and insect under pesticide stress.	**1**
Insect interactions: Competition, predation and parasitoidism, and the models proposed on these.	**3**
Insect dispersal; Insect migration; Photoperiodism.	**2**
Life budget: Concepts; life table on insects - construction and analysis.	**2**
Systems ecology: Concept; system measurement; system modelling.	**2**

Title/sub-titles of course contents	No. of classes
Phase variations in insects, with particular emphasis on locust.	**1**
Insects of soil, litter, carrion and dung.	
Diversity and stability at community level: Relative abundance (commonness and rarity of species), species diversity [species richness, species evenness, measures of diversity].	**4**

Learning outcomes

After completion of the course the students will be able to-

- describe the trophic structure of a community and explain the flow of energy through it;
- explain competitive interactions between individuals of the same or between different species of animals;
- analyze and construct life table;
- understand the system ecology and perform modeling;
- understand population theories and prey-predator interactions; and
- know about impact of climate change on insect behaviour; explain rolr of gene in insect behaviour.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	25	Review class	2
Students' group presentation	2	In-course exam	1

Assessment

There will be an in-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for students' attendance in the class. In-course question will be objective and short answer types. A course final examination, consisting of 30 marks will be conducted by the university. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Begon, M. and Mortimer, M. 1981. *Population ecology - a unified study of animals and plants.* 3rd edition. Blackwell Science, Oxford, UK.

Krebs, C.J. 2009. Ecology - *The experimental analysis of distribution and abundance.* 6th edition. Pearson Benjamin Cummings, San Francisco.

Odum, E.P. 2004. *Fundamentals of Ecology.* 5th edition. Cengage Learning, Boston, MA, USA.

Price, P. W., Denno, R. F., Eubanks, M. D., Finke, D. L. and Kaplin, I. 2011. *Insect Ecology.* Cambridge University Press.

Riklefs, R.E. 1979. *Ecology.* Thomas Nelson and Sons Ltd., USA.

Varley, G.C., Gradwell, G.R. and Hassell, M.P. 1980. *Insect population ecology- an analytical approach.* Blackwell Scientific Publications, Oxford, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 616	**Pest and Pest Management**	**2**	**30**

Introduction to the course

Insect pests cause great harm to our economy by destroying our crops, crop products, other commodities and our health. Pest control and management involves a wide range methods and techniques. This course introduces with different types of pest, pest control methods and bioassay techniques. The course also discusses the application of control techniques in environment friendly way.

Specific objectives of the course

- To familiatize the students with a range of pest and the nature of damage caused by them.
- To enhance students' knowledge and skills on methods and techniques for pest control and management,
- To make familiar with the sampling technique, bioassay technique and pesticide application methods.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Status of pests and nature of damage.	**3**
Pest control methods: Physical, cultural, biological, and legal control.	**4**
Integrated Pest Management (IPM): Components and advantages; Cost-benefit analysis; How to design, develop and implement a practical IPM system. A successful case study of IPM. Methods of pesticide application.	**6**
Insect pest sampling techniques; Bioassay techniques.	**3**
Development of pest management programmes for certain pests and crops: Jute hairy caterpillar on jute plant, rice hispa on rice crops and sugarcane stem borer on sugarcane.	**4**
Biology, life history, nature of damage and control measures of the following pests: Jute pests- jute semilooper and jute mites; Sugarcane pests- sugarcane stem borer; Rice pests- rice ear-cutting caterpillar and rice hispa; Vegetable pests- potato tuber worm, epilachna beetle and mustard aphid; Fruit tree pests and fruit pests- mango stem and shoot borer, citrus leaf miner and palm beetle; Tea pests- flush pests and root pests.	**4**
Biology, nature of injury and control measures of major and minor insect pests of: Forest trees and vegetation; Stored grains- red flour beetle, rice meal moth and saw- toothed grain beetle.	**2**

Learning outcomes

After completion of the course, the students will be able to-

- know the pests and understand the nature of damage;
- learn about methods and techniques of pest control and management;
- learn about the sampling and bioassay techniques;
- develop pest management programme for pest of different plants; and
- gain knowledge on different control methods.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations. Group will be done on some selected lecture topics. Classes will be made participatory and interactive through questions and answers.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	26	Review class	1
Management / Action Plans development exercise	1	In-course exam	1
Student feedback on in-course exam	1		

Assessment

There will be an in-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for students' attendance in the class. A course final examination, consisting of 30 marks, will be conducted by the university. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Kabir, A.K.M.F. 1975. *Jute pests of Bangladesh.* Bangladesh Jute Research Institute, Dhaka, Bangladesh.

Metcalf, C.L., Flint, W.P. and Metcalf, R.L. 1962. *Destructive and useful insects*. McGraw Hill Book company, New York.

Pedigo, L.P. 2002. *Entomology and Pest Management.* 4th edition. Prentice-Hall of India Pvt. Ltd., New Delhi, India.

Proceedings of the SAAR. *Workshop on Rice Hispa 28-29 December, 1986.* Organized jointly by BRRI & BARC, Bangladesh Rice Research Institute, Dhaka.

Sana, R.I. 1989. *Tea Science.* Ashrafia Boi Ghar, Bangla Bazar, Dhaka.

Van Driesche, R.G. and Bellows, T.S. 1996. *Biological Control.* Chapman and Hall, New York.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 617	**Toxicology**	**2**	**30**

Introduction to the course

Expansion of agricultural activities, transportation and industrial development resulted in the environmental contamination of toxic substances with great threat to human, wildlife and our assets and created a great concern for its management and safe handling. This course is designed to enhance students' knowledge on inorganic and organic synthetic and natural insecticides including botanicals, their effects and its safe handling. The course will also discuss about the residual period and effects, effectiveness, doses, mode of action and insecticides resistance to insects.

Specific objectives of the course

- To classify toxic compounds according to their origin, hazardousness and doses and provide knowledge about residual period, method of use and mode of action of these compounds;
- To provide knowledge about the proper use of systemic, non-systemic natural and synthetic organic and inorganic insecticides and understand formulation, detoxification mechanism and general precaution;
- To enable students to understand the toxic effects of insecticides on environment as well as animal and human health.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Definition, classification of toxic compounds: The WHO recommended classification of pesticides by hazards. Brief outlines of insecticides, acaricides, nematocides, rodenticides, fungicides, and herbicides Systemic insecticides for plants and animals.	**5**
Inorganic insecticides and Synthetic organic insecticides: Arsenic, fluorine, lead and sulphur compounds preparation – Residual period, doses, method of use and mode of action of these compounds. Phenolic compounds, chlorinated hydrocarbons, organophosphates, carbamates, cyclodiene compound and naphthalene derivatives. Residual period, doses, method of use and mode of action of these compounds.	**5**
Organic insecticides of plant origin: Pyrethrines, nicotine, rotenone. Sources, use, doses, types and mode of action of these compounds	**3**
Fumigants: Methyl bromide, HCN, carbon bisulphides, sulphur dioxide, chloropicrin, carbon tetrachloride, ethyl dibromide, nicotin and phostoxin. Use, mode of action and general precautions to be followed in fumigation.	**5**
Miscellaneous	
Attractants, repellents, antifeedants, chemosterilants, insect growth regulators and synergistic compounds. Insecticide resistance including detoxification mechanisms. Formulation of insecticides. Appliances for dissemination of insecticides. Dose determination.	**4**

Learning outcomes

After completion of the course, the students will be able to-

- explain the chemical formula and structure, properties, sources and residual period of different types of pesticides;
- explain the toxic effect of different types of insecticides on human and animal health as well as plants;
- design action for safe use of toxic compounds as an insect control agent; and
- prepare proper management plan for pesticide use and its storage.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	22	Review class	2
Students' group presentation	2	In-course exam	1
Feedback on In-course exam	1	Student feedback on course contents and delivery	2

Assessment

There will be one In-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for students' class attendance. A course final examination on the course will be conducted by the university and will carry 30 marks. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

FAO and WHO. 2002. *Manual on development and use of FAO and WHO specifications for pesticides.* FAO and WHO joint meeting on pesticide specifications. 255pp.

Metcalf, C.L. and Flint, W.P. 1962. (revised by R.I. Metcalf). *Destructive and Useful Insects- their habits and control.* Tata McGraw Hill Pub. Co. Ltd., New Delhi.

Pedigo, L.P. 2002. *Entomology and Pest Management.* 4th edition. Prentice-Hall of India Pvt. Ltd., New Delhi.

International programme on chemical safety, a cooperative agreement among FAO, ILO, UNEP, UNIDO, UNITAR, WHO and OECD. 2009. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification. 78pp.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 618	**Medical and Veterinary Entomology**	**2**	**30**

Introduction to the course

Medical and veterinary entomology involves the study of insects and other arthropods, especially arachnids that cause and transmit diseases in human and livestocks. It is a broad science that includes studies on biology, ecology, morphology, taxonomy and many aspects related to disease and disease transmission. Veterinary entomology is included in this category, because many animal diseases become a human health threat. It is difficult to implement control measures of insects, without some knowledge of medical entomology. In addition, with increasing globalization, new and emerging vector borne diseases are becoming worldwide health priorities. The course focuses on these all aspects and intends to produce students capable of handling such parasites and vectors.

Specific objectives of the course

- To enhance the knowledge of pathogen- host- arthropod interactions, recognition and identification of vectors, and an understanding of epidemiology;
- To increase students learning about biology and control of disease vectors and the human pathogens they transmit;
- To introduce the students about recent global trends in insect borne diseases and impacts of emerging vector borne diseases.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Medical entomology	
General introduction; Biology, life-history, host-parasite relationship and control measures of the following: General introduction; Biology, life-history, host-parasite relationship and control measures of the following: (a) mosquitoes; (b) sandflies; (c) fleas; and (d) ticks and mites.	**5**
Brief outline of the following insects and the diseases they carry: (a) house flies; (b) horseflies and deerflies; (c) black flies; (d) tsetse flies; (e) bed bugs; (f) triatomine bugs; and (g) lice. Myiasis: definition and types;	**5**
Epidemiology: Including infection, dispersion, life cycle of pathogen and control measures of the following diseases: (a) malaria; (b) leishmaniasis; (c) filariasis; (d) arbovirus diseases (dengue and yellow fever). Maggot therapy.	**5**
Forensic entomology: Concept; Insect in crime detection and significance.	**2**
Veterinary entomology	
General introduction; ectoparasites of cattle sheep, goats and birds: ticks, mites, flies, fleas and lice. (Clinical features, diagnosis and treatment).	**6**

Title/sub-titles of course contents	No. of classes
Emerging vector borne diseases and global impact	
Global climate change, important vector borne diseases of the world, and new dynamics in global veterinary and public health. Medical and Veterinary entomology influencing public policy: Vector-control programs in underdeveloped, developing and developed countries.	**3**

Learning outcomes

After completion of the course, the students will be able to-

- identify existing public health problems related to arthropods;
- know the geographical distribution of important vector borne diseases and to explain the environmental factors determining such distribution;
- learn the impact of different insect species on human health and learn about potential control strategies; and
- design guidelines for a control program for a particular disease.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	25	Review class	1
Students' group presentation	2	In-course exam	1
Student feedback on course contents and delivery	1		

Assessment

There will be one in-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for students' attendance. The students will be frequently asked questions in the classrooms to assess individual's performance. A course final examination of 30 marks will be conducted by the university.

References

Herms, W.B. and James, M.T. 1961. *Medical Entomology*. The Macmillan Company, New York.

Kettle, D.S. 1984. *Medical and Veterinary Entomology*. Croom and Helm Publishing, UK.

Lane, R.P. and Crosskey, R.W. 1993. *Medical insects and arachnids*. The Natural History Museum and Chapman & Hall, London.

Service, M.W. 1997. *Medical entomology*. Chapman and Hall, London.

Shearer, R.W. 1997. *Veterinary Entomology*. Chapman and Hall, London.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 619	**Bioresources, Management and Conservation**	**2**	**30**

Introduction to the course

Many insects produce commodities for human use or supply raw materials for industrial uses and thus have got immense economic importance. This course introduces with a range of economically important insects, its culture and management. Specifically, the course will focus on apiculture, lac culture, and sericulture highlighting their culture techniques, maintenance and management aspects. The course also

discusses about butterfly farming and explore the possibility of the use of knowledge on butterfly in biodiversity conservation.
Bioresources play a key role in present and future socio-economic evolutions. The rapid degradation of bioresources is a serious concern worldwide. Global and national efforts are in place to conserve bioresources for attaining sustainable development and presently it is envisaged a priority area of biology study. The course is designed to develop comprehensive skill necessary to work confidently in areas such as pragmatic applications, management and conservation of bioresources, environmental management plan and monitoring and to create professional capacity among students by encouraging them through scientific and realistic approach to environmental biological issues.

Specific objectives of the course

- To enhance conceptual understanding of students on bioresources, its value and service, and relationship with the environment.
- To introduce the student with the culture methods and techniques of some insects related commercial production of commodities.
- To enhance students' capacity in understanding bioresources management and conservation.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Bioresources	
Introduction to bioresources: Definition, value of bioresources, category of bioresources, bioresource pool, classification of natural resources, insects as bioresource.	**4**
Apiculture: Introduction, scope, honey producing bees, bee colony, caste system, development of bee, relationship between the elements of a bee colony, swarming, methods of apiculture, seasonal management of honey bees, organization of work in apiculture, origin and importance of beekeeping, pests and diseases, royal jelly, pollination.	**3**
Sericulture: Introduction, scope, silk producing moths, rearing of silk worms, methods of sericulture, seasonal management of silk worms, organization of work in sericulture, pests and diseases.	**3**
Lac culture: Introduction, scope, lac producing insects, rearing of lac insects, methods of lac culture, seasonal management of lac insects, organization of work in lac culture, pests and diseases.	**3**
Colonization of butterflies: Introduction, scopes, colonizing materials, colonization process and a model of colonization system.	**2**
Butterfly farming: Introduction, scopes, brief history, farming process with examples.	**2**
Management and conservation	
Management and conservation: Definition and concepts; conservation methods and techniques - *ex-situ* and *in-situ*. Conservation of beneficial insects. Prey-predator conservation. Diversity assessment; protected area management through insect conservation.	**7**

Learning outcomes

After completion of the course, the students will be able to-

- explain bioresources, its types and conservation aspects;
- know about the methods and techniques related to apiculture, sericulture and lac culture;
- apply the knowledge on bee, silk worm and lac insect management design and maintain butterfly colonization center, farm and park; and
- tell about how to conserve biodiversity through bioresource management.

Instructional strategies
The course will be delivered through lecture and discussion, aided by power point presentations. Classes will be made participatory through questions and answers and group work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	24	Review class	1
Students' group presentation	2	In-course exam	1
Student feedback on course contents and delivery	1	Feedback on In-course exam	1

Assessment
There will be one in-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for class attendance. There will be a course final examination, consisting of 30 marks on this course and will carry 30 marks to be conducted by the university. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Bashar, M. A. 2004. *Instant Basics of Environment.* Positron Publication, Dhaka, Bangladesh.

Bashar, M. A. 2013. *Butterfiles of Bangladesh.* Vols. 1 & 2. Biodiversity Conservation Trust Fund (BCTF) Publications, Dhaka, Bangladesh.

Ganga, G. and Chetty, J. S. 1991. *An Introduction to Sericulture*. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi, India.

Glover, P.M. 1937. *Lac Cultivation in India*. 2nd edition., Indian Lac Research Institute, Ranchi, India.

Jean-Prost, P. 1994. *Apiculture*. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, India.

Jordan, C.F. 1995. *Conservation.* John Wiley & Sons Inc., New York.

Primack, R. B. 2008. *A Primer of Conservation Biology*. 4th edition., Sinauer Associates, Inc., Sunderland, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 620	**Epizootiology**	**2**	**30**

Introduction to the course
Insect epizootiology is the study of disease patterns within insect populations. It deals with the character, ecology, and causes of diseases in insects, especially epizootic diseases. Insect are diseased by viral, bacterial, fungal, protozoan and nematode pathogens. To protect beneficial and economically important insects, it is necessary to know the nature of diseases, their transmission and prevention measures. This course is designed to introduce the students with diseases of economically important insects and its control measures.

Specific objectives of the course
- To make students understanding principle, concept and scope insect epizootiology and its relation with epidemiology;
- To introduce the students with various types of insect diseases, its patterns of spread, their pathogens, and the methods of diseases transmission through insect population;To enhance students' knowledge on methods and techniques of control of insect diseases, particularly maintenance of sanitation in culture stocks of insect

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Definition, introduction, objectives and etiology. Causes of disease; Difference between epidemiology and epizootiology. Epizootic and enzootic infections;	**2**
Measurements: Basic measurements and observations in Epizootiology; Prevalence and Incidence.	**2**
Pathogen transmission in insects: Methods of pathogen transmission; dissemination in insects.	**3**
Insect diseases caused by viruses, bacteria, fungi, protozoans and nematodes: pathogenic families; route of entry of pathogen into insect host, dissemination of diseases into insects.	**14**
Prevention of insect diseases.	**2**
Applied Epizootiology: Microbial control of insects.	**2**

Learning outcomes

After completion of the course the students will be able to-

- know about the insect diseases and its implication in insect culture system;
- tell about the measurements of epizootic insect diseases;
- learn about different insect diseases caused by virus, bacteria, protozoa, fungi and nematode;
- explain the route of entry of various pathogens into insect host body; and
- take preventive measure for insect rearing in the laboratory against insect diseases.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	27	Review class	1
Students' group presentation	1	In-course exam	1
Student feedback on course contents and delivery	1		

Assessment

There will be an in-course examination, consisting of 17.5 marks and 2.5 marks will be allocated for students' attendance in the class. A course final examination will be taken by the university and will carry 30 marks. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

James, R.F. and Tanada, Y. 1987. *Epizootiology of insect diseases*. John Wiley & Sons, New York.

Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. 2006. *Microbiology.* Tata MacGraw Hill Co., New Delhi, India.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 652	**Practical Entomology**	**6**	**90**

Introduction

The course will cover the science of entomology by focusing on the basic principles of morphology (external and internal), development, behavior, ecology, and control of insects. Field trips provide opportunities to collect insects and study their adaptations to a wide variety of natural environments.

Specific objectives of the course are to

- Familiar students with comparative external structure and anatomical details of different systems (viz. digestive, circulatory, reproductive, nervous and endocrine systems) through dissection of common insects including muscular system (viz. flight muscle) of representative insects.
- Identify insects up to species level and also identify immature stages of different insects.
- Provide knowledge on understanding Insecticide formulations and mixtures, bioassay techniques and learning insect sampling and rearing technique.
- Identify medical and veterinary and economically important insects.

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Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Comparative external structures of the common insects of following orders: Exopterygote orders - Odonata, Orthoptera, Hemiptera and Homoptera; Endopterygote orders - Coleoptera, Diptera, Lepidoptera and Hymenoptera.	**4**
a.Head: Including antennae and types; mouthparts - their types and modification due to feeding habits;	
b.Thorax: Including segments; legs and their functional modifications; wings - their articulation and venations;	
c.Abdomen: Segmentation; appendages, male and female genitalia, ovipositor, and aedeagus and associated structures.	
Study of the functional systems of insects through dissection of common insects of following orders: Orthoptera, Hemiptera, Diptera, Coleoptera and Hymenoptera:	**3**
a. Digestive system: Structural variations related to feeding habits;	
b. Circulatory and Endocrine system: Different types of haemocytes and neuro-haemal organs of insects.	
c. Reproductive system: Male and female systems- testis, ovary and ovariole;	
d. Nervous system: Nerve cord, ganglia and connectives;	
Study of the flight muscles of insects.	**1**
Identification of insects up to family, genus and species (including both exopterygote and endopterygote insects).	**4**
Insects, ticks, mites and spiders of medical and veterinary importance.	**2**
Economically important insects (beneficial and harmful).	**1**
Types of larvae and pupae of insects.	**1**
Rearing of insects in the laboratory: Mosquitoes, fruit flies, potato tuber moth, and stored grain pests.	**2**
Insect sampling: Sampling methods; data collection, procedure of data analysis and concluding remarks.	**2**
Bioassay technique (Dose-Response Technique): Test procedure, data recording, data analysis and concluding remarks.	**2**

Learning outcomes

After completion of the course, the students will be able to-

- Understand economic importance of the insects as well as the morphological, anatomical and biological features of insects belong to different orders;
- Enhance their knowledge of insecticide formulation, application, data recording and data analysis technique and understand different insect sampling and rearing methods and its associated equipment;
- Differentiate between insect of medical and veterinary importance and state how they affect man;
- Classify insects into basic taxonomic categories and develop learning skills for further studies.

Instructional strategies

The course will be delivered through lecture and practical application. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Practical classes	22	Review class	2
Management / Action Plans development exercise	2	In-course exam	2
Student feedback on In-course exam	2		

Assessment

Assessment will be done on class attendance (5%), In-course examination (35%) and final examination (60%). Two in-course examinations will be taken for this course. In-course assessment will consist of class examinations, assignments, notebooks and field reports and consisting 27.5 marks. Project report 25 marks and class attendance 7.5 marks. A portion of in-course marks will be allocated for continuous assessment through observations of student at work and assignments.

References

Chapman, R.F., Simpson, S.J. and Douglas, A.E. 2013. *The Insects: Structure and Function.* 5th edition. Cambridge University Press, New York.

Johnson, N.F. and Triplehorn, C.A. 2004. *Borror and DeLong's Introduction to the study of Insects*. 7th edition. Belmont, CA : Thomson Brooks/Cole, Australia.

Kettle, D.S. 1984. *Medical and Veterinary Entomology*. Croom and Helm Publishing, UK.

Metcalf, C.L., Flint, W.P. and Metcalf, R.L. 1962. *Destructive and useful insects.* McGraw Hill Book company, New York.

Pedigo, L.P. 2002. *Entomology and Pest Management*. 4th edition. Prentice-Hall of India Private Ltd., New Delhi, India. India Pvt. Ltd., India.

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Snodgrass, R.E. 2004. *Principles of Insect Morphology*. Tata McGraw Hill Publ. Co. Ltd., New Delhi, India.

MS in Zoology (Wildlife Biology)

Course No.	Course Title	No. of Credits	Credit Hours
ZW 625	**Wildlife Ecology and Biogeography**	**4**	**60**

Introduction to the course

The life processes are fundamentally linked to ecological processes in which wildlife is a part. Knowledge on interactions of animals within its ecosystem and understanding the ecological requirements of animals provide the fundamental basis for designing conservation strategies and actions. For management purpose, wildlife should be viewed from its organization at the level of individual species, population and community. All these aspects are addressed in this course and designed to provide students with conceptual understanding of the principles, methods and ecological processes that apply to wildlife conservation and management. Specifically, the course focuses the fundamental ecological processes, the limiting factors and barriers that affect wildlife, habitat assessment, structure and functions of communities. This course introduces the spatial distribution of animals , and ecological and historical foundations for understanding the distribution and abundance of species, and the changes in distribution and abundance over time. The course is very useful to the students willing to develop career as a wildlife biologist.

Specific objectives of the course

- To provide the students with the fundamental understanding of the relationship between ecological processes and wildlife conservation.
- To provide knowledge of the types of interactions, limiting factors and barriers that affect wildlife population and understand the wildlife from population and community perspectives.
- To provide insights into the ecological and historical foundations for understanding the distribution and abundance of species, and the changes in distribution pattern and abundance over time.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Wildlife Ecology	**32**
Ecosystem and population process: Concept and types of biomes and ecosystems; edge, ecotones, interspersion; population dynamics; dispersal, distribution, population regulation, fluctuation and competition within and between species; predation (behaviour of prey and predators, effects of predators on prey density). **Wildlife and habitat surveys**: Census, estimates, total counts, indices; methods and logic of sampled counts; indirect estimates of population size; point and quadrat sampling of habitats; successional changes in wildlife habitats. **Community ecology**: Community structure, resource partitioning, niche and competitive exclusion. **Adaptation**: Types of adaptation and adaptive radiation; examples of adaptations; theory of natural selection; types and characteristics of abiotic environment. **Environmental Impact Assessment (EIA)**: Concept and application; scoping methods and baseline studies of EIA; monitoring and auditing of EIA; uncertainty and evaluation of EIA.	
Biogeography	**16**
Biogeographic patterns: Status and distribution of species at individual and population levels; distribution of communities in space and time; continental drift. **Biogeographic process**: dispersal and range extension; mechanism of movement; nature of barriers; dispersal routes.	

Title/sub-titles of course contents	No. of classes
Geography of diversification: Endemism and cosmopolitanism; disjunction; barriers between biographic realms; biotic interchange; divergence and convergence of isolated biotas. **Ecological biogeography**: Patterns in species richness in islands; island biogeography theory; assembly and evolution of insular communities.	

Learning outcomes

After completion of the course the students will be able to-

- understand the ecological principles and processes, such as succession, competition, adaptation, and predation that affect wildlife populations;
- know and apply the methods, techniques and tools for wildlife survey and habitat assessment;
- describe the methods and techniques for environmental impact assessment;
- demonstrate an ability to analyze wildlife population dynamics and structure;
- develop a management plan for a threatened or endangered species, as well as an over-abundant species;
- learn about the distribution pattern of wildlife and factors affecting the distribution;
- know about the insular fauna and its adaptation; and
- understand the processes that affect how biota responds to a changing climate and the challenges.

Instructional strategies

The delivery of the course will be based mainly on lectures and discussions, aided by power point presentations, flip charts, video films, etc. It will also include in class discussions and group work exercises in the classroom to promote learning via interactions between the students and the teacher.

Distribution of class lectures: Total number of classes/lectures: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Class Lecture	48	Review class	3
Students' group presentation	4	In-course exam	2
Assignments and discussion	3		

Assessment

There will be two In-course examinations, each consisting of 17.5 marks. For class attendance 5 marks are allocated. A course final examination will be of 60 marks, to be conducted by the university. The students will be frequently asked questions in the classrooms to assess individual the performances.

References

Sinclair, A.R.E., John, M.F. and Cavghley, G. 2006. *Wildlife Ecology, Conservation and Management*. Blackwell Publishing Ltd., UK.

Bolen, E.G. and Robinson, W.L. 2003. *Wildlife Ecology and Management*, 5th edition. Prentice Hall, Upper Saddle River, New Jersey, USA.

Chapman, J.L. and Reiss, M.J. 1998. *Ecology: Principles and Applications*. Cambridge University Press, Cambridge, UK.

Lomolino, M.V., Riddle, B.R and Brown, J.H. 2006. *Biogeography*. 3rd edition. Sinauer Associates, Inc. Sunderland, USA.

Maurer, B.A. 1994. *Geographical population analysis: Tools for the analysis of biodiversity. Methods in ecology*. Blackwell Scientific, Oxford, U.K.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 626	**Conservation Biology**	**4**	**60**

Introduction to the course

Conservation of biodiversity, wildlife in particular, primarily requires a comprehensive understanding of the root causes of the problem, appreciating the conservation priority and conservation methods in practice, and biological and social factors that affects the success of conservation efforts. This course offers a comprehensive package of learning opportunities aiming at protecting and maintaining the genes, species, communities, habitats, ecosystems from extinction and erosion of biotic interactions with emphasis on principles, methods and tools of conservation that integrates biological, ecological and social factors. The course also introduces the students with emerging issues in conservation sector, including effects of climate change and application of genetics in conserving wildlife, and aspects of protected area management. This course is not only a fascinating one, but also essential to people willing to build career as a wildlife biologist.

Specific objectives of the course

- To elucidate the theories and principles of conservation biology.
- To develop students' skills for conserving wild species, population and habitats.
- To make the students aware of the climate change impacts on wildlife, and the application of genetics in conserving biodiversity.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Conservation Biology History, concepts and scopes Emergence of conservation biology Setting conservation priorities- distinctiveness, endangerment and utility Concepts of sustainable development, measures for conservation and sustainable use of wildlife resources Invasive species and their management	**10**
Biodiversity conservation and climate change Global fingerprint of climate change on biodiversity; Climate change in ecosystems – species loss and system degradation; Conservation planning and policy initiatives for climate change and conservation	**5**
Conservation genetics and genetic management Genetics and conservation Genetic drift Genetic consequences of small population Inbreeding and species extinction Genetic management of endangered species in the wild	**10**
Conservation of populations Basic population processes Effective and small population Metapopulations and population fragmentation Population viability analysis and minimum viable population Management of small population Recovery strategies for threatened species	**10**

Conservation of habitat and landscape Concept and importance of habitat heterogeneity Landscape gradients and patch dynamics Problem of habitat loss. Isolation and fragmentation Managing habitat connectivity and role of corridors Strategies for restoration of degraded habitats and ecosystems Planning for protected areas	**10**

Learning outcomes

After completion of the course, the students will be able to-

- explain the principles and theories in conservation of wildlife;
- perform threat analysis and set conservation priorities;
- describe and apply the methods and tools for conservation of small populations;
- develop skills for conservation and management of ecosystems and habitats;
- understand climate change impact on wildlife; and
- understand the application of genetics in conserving wildlife populations.

Instructional strategies

The course will be delivered through lectures and discussions, aided by power point presentations, video films, etc. Classes will be made participatory and interactive through questions and answers, and individual/group work presentations/exercises in the classroom**.**

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	45	Conservation documentary/movie	5-7
Students' individual/group presentation	6	In-course exam	2

Assessment

There will be two in-course examinations, each comprising 17.5 marks; 5 marks are allocated for students' attendance in classes. The questions for In-course examinations will be of objective and subjective types. A course final examination of 60 marks will be conducted by the university after the completion of the course. There will be assignments in addition to the individual/group presentations.

References

Arora, B.M. 1994. *Wildlife Diseases in India: Infectious and Parasitic Diseases of Mammals, Reptiles and Amphibians.*

Dyke, F.V. 2008. *Conservation Biology – Foundations, Concepts and Applications.* Springer Science - Business Media, New York.

Ferriere, R., Dieckmann, U. and Couvet, D. 2004. *Evolutionary Conservation Biology.* Cambridge University Press, Cambridge, UK.

Macdonald, D.W. and Service, K. 2007. *Key Topics in Conservation Biology*. Blackwell Publishing Ltd., UK.

Miffe, O.K. and Carroll, C.R. 1997. *Principles of Conservation Biology*. Sinauer Associates. Inc. Publ., Sunderland, Massachusetts, USA.

Mills, L.S. 2007. *Conservation of Wildlife Populations: Demography, Genetics, and Management.* Blackwell Publishing Ltd., UK.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A. and Kent, J. 2000. *Biodiversity hotspots for conservation priorities. Nature* 403 (6772): 853-858.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 627	**Behavioural Ecology and Anthrozoology**	**4**	**60**

Introduction to the course

Animal behaviour has been always an interesting subject for zoologists and wildlife biologists. This course aims to elucidate understandings of the behavioural aspects of wildlife, and human-wildlife interactions. The course mainly deals with various important aspects of behavioural ecology such as inter and intra-specific interactions, breeding activities, feeding, grooming and social behaviour of all the groups of wildlife. Emphasis is given to human-wildlife conflicts and conflict mitigation.

Specific objectives of the course

- To enhance students' understanding about the scientific study of animal behaviour involving a variety of approaches.
- To give a comprehensive understanding of the various aspects of human-wildlife conflict and its mitigation measures for co-existence. It addresses various wildlife management issues.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Natural selection, ethology and behaviour	**4**
Principles and theories of natural selection Questions about behaviour Environmental influences upon behaviour Sensitive periods during behaviour	
Feeding behaviour of amphibians, reptiles, birds and mammals	**5**
Food selection Seasonal variation and feeding adaptation Competition for resources	
Reproductive behaviour of amphibians, reptiles, birds and mammals	**5**
Migration and dispersion; Orientation and navigation.	**4**
Inter-species Interaction	**6**
Inter-species territoriality Symbiosis Predation and anti-predation adaptations Evolutionary arms race	
Intra-species Interaction	**8**
Intra-species territoriality Sexual selection and conflicts Mating systems and sex allocation Group living- cost and benefits Optimum group size Selfishness Altruism Kin selection Parental care and family conflicts Reciprocal altruism Cooperation	

Title/sub-titles of course contents	No. of classes
Human-wildlife co-existence	**6**
Relationship between humankind and nature with special reference to wild animals; human attitude towards wildlife Human-wildlife conflict and co-existence Anthropogenic factors influencing human-wildlife conflict Mitigation strategies of human-wildlife conflict	
Economics of human-wildlife coexistence:	**6**
Economic and social impact of human-wildlife co-existence Evaluation of economic loss and other damages due to - human-elephant; human-primates; and human-tiger co-existence in Bangladesh	
Overview of the compensation policy for casualties caused by wildlife in Bangladesh	**1**

Learning outcomes

After completion of the course, the students will be able to-

- understand evolutionary basis for the development of animal behaviour;
- learn about feeding behaviour, reproductive behaviour, social behaviour, parental care, inter- and intra-specific interactions, etc.;
- explain the causes of human-wildlife conflicts with particular reference to Bangladesh and to know how human wildlife conflict could be mitigated ; and
- learn about the compensation plan of the goverment for the victims of human-wildlife conflict.

Instructional strategies

The course will be delivered through lectures and discussions, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises**.**

Distribution of class lectures: Total number of classes/lectures: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	45	Conservation documentary/movie	7
Students' group presentation	6	In-course exam	2

Assessment

There will be two in-course examinations, each comprising 17.5 marks; 5 marks are allocated for class attendance. Questions for In-course examinations will be of objective and short types. A course final examination will be of 60 marks, to be conducted by the university.

References

Barnard, C.J. 2004. *Animal Behaviour: Mechanism, Development, Function and Evolution.* Pearson Education Limited, England.

Conover, M. 2002. *Resolving Human-wildlife Conflicts. The science of Wildlife Damage Management*. Lewis publication, Washington DC, USA.

Dewsbury, D.A. 1978. *Comparative Animal Behavior.* McGraw-Hill Company, USA.

Goin, C.J. and Goin, O.B. 1971. Introduction to Herpetology. W.H. Freeman & Co., San Francisco, USA.

Kappeler, P. (ed.). 2010. *Animal Behaviour: Evolution and Mechanisms.* Springer Science – Business Media, New York.

Krebs, J.R. and Davies, N.B. 1987. *An Introduction to Behavioural Ecology.* Blackwell Scientific Publications, London.

Martin, P. and Bateson, P. 2009. *Measuring Behaviour- An Introductory Guide.* 3rd edition. Cambridge University Press, UK.

MaCFarlans, D. 1993. *Animal behaviour: Psychobiology, ethology, and evolution.* Longman Scientific and Technical, Essex, England, UK.

Woodroffe, R., Thirgood, S. and Robinwitz, A. 2008. *People and Wildlife – Conflict or Coexistence?* Cambridge University Press, Cambridge, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 628	**Wildlife Resource Management**	**4**	**60**

Introduction to the course

As a renewable natural resource, wildlife has got enormous use values to human and therefore, implicates for its sustainable management. Protected areas (PA) of Bangladesh harbour major important and threatened wildlife and have got the major focus of protection, supported by country's legal instruments. This course mainly focuses on wildlife resources of Bangladesh, wildlife management strategies, methods and tools for wildlife management with a particular focus on protected areas and the legal regime that govern the wildlife protection and protected area management. The course also highlights the captive breeding and re-introduction of depleted wildlife. Wildlife diseases and its control measures are also discussed here.

Specific objectives of the course

- To enhance knowledge of wildlife resources of Bangladesh and its importance.
- To develop skills for wildlife management in protected areas.
- To familiarize the students with wildlife farming, captive breeding, disease management of wildlife and species re-introduction strategies.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Human Dimension of wildlife	**10**
Values of wildlife to human Wildlife resources of Bangladesh with special reference to economically important species; farming of frog, crocodile, turtle, snake and deer.	
Wildlife resource management strategies	**8**
Managing population of wild animals and their habitats; endangered species management; managing landscapes and modified habitats (e.g., fragmentation and corridors); use of satellite imagery and GIS in assessing modified habitats	
Protected area management	**8**
Coverage, spatial distribution and management of protected areas [national parks, sanctuaries, Ramsar sites, World heritage sites, Ecologically Critical Areas (ECA), Important Bird Areas (IBAs) in Bangladesh]; management of protected areas and case studies from Southeast Asian countries.	
Captive breeding and re-introduction	**8**
Role of zoological garden and safari park in wildlife conservation; development and maintenance of captive habitat and their management; role of captive breeding in re-introduction of endangered species.	

Title/sub-titles of course contents	No. of classes
Disease management in wild animals	**6**
Basic principles; disease investigation and management strategies; management of over bounded and pest populations.	
Wildlife Conservation Laws and Acts	**10**
Principles, overview and roles of laws, acts, conventions and treaties relating to wildlife conservation; wildlife crimes and their impacts; wildlife forensics, salient features of wildlife (conservation and security) Act, 2012.	

Learning outcomes

After completion of the course, the students will be able to-

- know the wildlife resources of Bangaldesh and understand its importance for conservation;
- acquire knowledge of the captive breeding of wildlife and its farming;
- know about the methods and tools for wildlife management, particularly in protected areas;
- prepare wildlife management plans;
- develop skills on wildlife disease management; and
- become familiar with country's wildlife laws, rules, and international conventions and treaties related to wildlife conservation .

Instructional strategies

The course will be delivered through lectures and discussions, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises.

Distribution of class lectures: Total number of classes/lectures: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	50	Management plan development exercise	3
Students' group presentation	5	In-course exam	2

Assessment

There will be two in-course examinations, each comprising 17.5 marks. Students' class attendance will carry 5 marks. The question for In-course examinations will be of objective and subjective types. A course final examination, consisting of 60 marks, will be taken by the university.

References

Gilbert, F.F. and Dodds, D.G. 2001. The Philosophy and Practice of Wildlife Management. *Krieger Publishing* COmpany, Malabar, Florida, USA.

Giles, R.H. (ed.). 1971. Wildlife *Management Techniques*. The Wildlife Society, Washington, USA.

Hobbs, R.J. (ed.). 2000. *Invasive species in a changing world*. Island Press, Washington DC., USA.

Hosetti, B.B. 2005. *Concepts in Wildlife Management*, Daya Publishing House, Delhi, India.

2008. *Guidelines for Applying Protected Area Management Categories*-IUCN.

McFarland, D. 1985. *Animal Behaviour: Psychobiology, Ethology and Evolution.* ELBS/Longman, Avon, U.K.

Ranga, M.M. 2005. *Wildlife Management and Conservation*. Gland, Switzerland. Dr. Updesh Purohit for Agrobios, India.

Wobeser, G.A. 2007. *Disease in Wild Animals – Investigation and Management*. Springer-Verlag Berlin Heidelberg, Germany.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 629	**Wildlife Conservation Outside Protected Areas and Innovative Approaches for Wildlife Research**	**4**	**60**

Introduction to the course

Bangladesh has a vast area that falls beyond the jurisdiction of protected areas. These are basically public and private lands and harbour a wide variety of wildlife including many threatened species. These areas are traditionally managed and maintained by the local people, hence there is little scope for legal jurisdiction over those areas. Threats to wildlife in these areas are a serious concern. Both public and private efforts are necessary to conserve these areas for effective conservation of wildlife. The course provides comprehensive learning opportunities on the status, distribution and threats to wildlife living in these areas; also addresses the strategies, approaches, legal frameworks and tools for their conservation and management in Bangladesh. The course also familiarizes the students with data collection methods, and tools for scientific study of wildlife. The course is designed to produce professionals in the country with adequate background knowledge of the subject area, capable of assessing the status of wildlife diversity and implementing wildlife conservation tools outside the protected areas.

Specific objectives of the course

- To understand the wildlife communities in the non-protected areas, their threats and conservation issues.
- To familiarize the students about the tools applicable for the management of wildlife in the non-protected areas of the country.
- To expose the students to the modern researches on wildlife by using modern equipment.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Conservation Outside Protected Areas	**29**
Wildlife in public and private lands: (a) city, town, bazaar, road, highway, (b) river, stream, lake, haor, baor, (c) homestead forest, jungle, bushe, (d) area of religious and cultural belief. **Status and distribution of wildlife**: past and present status and distribution of the wildlife fauna beyond protected areas; threats and causes of decline of wildlife population and diversity in these areas of Bangladesh and their protection/conservation measures. **Management of human-dominated landscapes**: Human dominated landscape types and nature; **Community Conserved Areas (CCAs)**: Definition, concept, types and nature of CCAs, Significance of CCAs, threats and challenges to CCAs and management practices of CCAs in Bangladesh; **Social forestry**: Definition, concept, impacts of social forestry on ecosystems and wildlife, laws and rules of social forestry. **Conservation strategies**: Community-based awareness programmes; role of different stakeholder groups including relevant government departments and NGOs; restoring damaged ecosystems and wildlife habitats through payments for ecosystem services; legal and policy aspects related to CCAs and other private land management.	
Innovative Approaches for Wildlife Research	**20**
Camera trap: History and types; basic structure and operation in the field; monitoring and data recording; uses in wildlife studies. **Tranquillizer gun**: History and basic structure, chemical bullets and calculation of doses for different animals; application of tranquilizer gun.	

Title/sub-titles of course contents	No. of classes
Telescope: Types and uses of telescope in wildlife studies. **Radiotelemetry and radio transmitters**: History and basic concepts; types of radio transmitters and collars for different animals; basic operations; data recording and analysis; real-time locating system (RTLS). **Hydrometer**: Principle, ranges, scales, specialized hydrometers, use in fresh and marine water analysis. **Global Positioning System (GPS)**: History and basic concept of GPS; structure and basic functions; calibration and datum setting; use of GPS in wildlife studies. **Bird ringing**: History and types of rings; terminology and techniques; wing tags, field readable rings and leg-flags. **Instrument use methods**: Night vision binoculars, night vision camera, digital video camera, automatic time laps camera, electronic pocket balance, electronic digital caliper, led-forehead lamp, sensitive electronic balance.	

Learning outcomes

After completion of the course, the students will be able to-

- gather knowledge of the past and present status and distribution of wildlife in non-protected areas of Bangladesh and its importance, the threats to wildlife and the mitigation measures;
- design and implement conservation strategies, tools and programmes for wildlife conservation and management in non-protected areas;
- know the roles of different conservation agencies, stakeholders and mandated authorities in wildlife conservation;
- know the methods of data collection, data recording and analysis, and monitoring and assessment ; and
- know the application of bioinstrumentation in wildlife studies.

Instructional strategies

The course will be delivered through lectures and discussions, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms. Wildlife conservation planning sessions will also be designed in the classroom will be conducted. Planning sessions for the preparation of wildlife conservation management plan.

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	49	Review class	2
Students' group presentation	5	In-course exam	2
Feedback on In-course exam	1		
Student feedback on course contents and delivery	1		

Assessment

There will be two In-course examinations, each consisting of 17.5 marks; 5 marks are allocated for class attendance. A course final examination will be taken by the university, which will carry 60 marks. The students will be frequently asked questions in the classrooms to assess performances.

References

Abbasi, A. and Chari, K.B. 2005. *Application of GIS and Remote Sensing in Environmental Management.* Discovery, New Delhi, India.

Agarwal, S. and Rana, M.S. 1995. *Application of Telemetry in Wildlife Conservation.* Wildlife Institute India, Dehra Dun, India.

DeMers, M.N. 2005. *Fundamentals of Geographic Information Systems*. John Wiley & Sons, USA.

Gordon, I.J. (ed.). 2009. *The Theory and Practice of Community Based Wildlife Management.* Springer Science – Business Media, New York.

IUCN Bangladesh. 2015. *Red List of Bangladesh Volume 2, 3 and 4: Mammals, Birds and Amphibians and Reptiles*. international Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh.

Islam, M.A., Feeroz, M.M., Kabir, M.M., Begum, S., Muzaffar, S.B. and Aziz, M.A. 2007. Hoolock Gibbon Conservation Manual. Wildlife Trust of Bangladesh and Wildlife Rescue Centre, Dhaka.

Khan, M.H., Aziz, M.A., Uddin, M., Saif, S., Chowdhury, S.U., Chakma, S., Chowdhury, G.W., Jahan, I., Aktar, R., Myant, M.H., Mohsanin, S. 2012. Community Conserved Areas in Chittagong Hill Tracts of Bangladesh. Islam, M.A. (ed.). Wildlife Trust of Bangladesh, Dhaka, Bangladesh.

Khan, M.A.R. 2015. *Wildlife of Bangladesh*: *Checklist and Guide*. Chayabithi Publication, Dhaka.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 653	**Practical Wildlife Biology**	**6**	**90**

Introduction

This course offers students to assess wildlife ecology, management policies and practices in Bangladesh. The aim of this course is to provide an environmental analysis toolkit to students; a toolkit that contains skills and abilities to measure and evaluate observations of wildlife made within the diverse and challenging ecosystems of Bangladesh that can be used in other global environmental contexts.

The Specific objectives of the course are

- to provide students with a strong practical background in wildlife management and research techniques and to be professional to study wildlife;
- to expose students to various techniques and methods in wildlife study with their contribution to the conservation issues;
- to enhance students' capacity in understanding and applying the instruments for wildlife study.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Practical:	**20**
Use of basic field equipment: map, compass, GPS, camera trap, and basic field equipment. Making field observations and taking notes: Assignments and field exercises. Describing wildlife habitats: Assignments and field exercises. Measuring and preserving specimens: Assignments and field exercises. Tracks and sign surveys: Assignments and field exercises. Interview surveys: Assignments and field exercises. Wildlife Census techniques using plot counting, line transects and block counting methods: Assignments and field exercises. Ecological and biological studies of individuals and communities: Assignments and field exercises. Designing a management plan. Research article writing and review. Study of morphological modification and ecological adaptation of wild animals. Determination of age and sex of different groups of wild animals. Observing and recording behaviour: Feeding, foraging, resting, moving, diving,	

Title/sub-titles of course contents	No. of classes
preying, aggression and submission. Wildlife Study Techniques: (a) Netting, trapping and ringing; (b) Animal handling and care; (c) Animal ranging patterns: determination of home range and territory; (d) Behavioral study techniques: scan and focal sampling; (e) Mark-recapture; (f) Radiotelemetry; (g) Collection and preservation of biological samples for genetics/forensic study. Animal preservation techniques: Stuffing. Computer simulation: Field data analysis using excel and SPSS.	

Learning outcomes

After completion of the course the students will be able to-

- know how to prepare a GIS map by using GPS coordinates for animal distribution, ranging, habitat demarcation, etc.;
- use different instrument for sampling wildlife and vegetation;
- capture, handle and mark the different groups of wildlife;
- determine the age, sex and estimation of population size of wildlife by using best methods;
- preserve different wild animals (including herpetofauna, birds and mammals) following proper preservation techniques (wet and dry preservation).

Instructional strategies

The learning process will be achieved through interactive learning, field exercises, class discussions, and field lectures conducted by a group of faculties. Each practical class lasts for 3 hours.

Distribution of class lectures: Total number of classes/lectures: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Preliminary class on course content, code of conduct, mode of class and what to learn from the course	1	In-course exam	2
Class lecture	20	Local field visit	7

Assessment

There will be two In-course examinations, consisting of 52.5 marks including assignments, research report; 7.5 marks will be dedicated for daily class attendance. The students will be frequently asked questions in the classrooms to assess performances. Students will also be assessed through a final examination containing 90 marks.

References

Altman, J. 1974. Observational study of behavior: Sampling methods. *Behaviour*. 49: 227-267.

Martin, P. and Bateson, P.P.G. 2007. *Measuring behaviour: an introductory guide*. Cambridge University press, Cambridge. pp. 176.

Rabinowitz, A. 1997. *Wildlife Field Research and Conservation Training Manual.* Wildlife Conservation Society, USA.

Sinclair, A.R.E., John, M.F. and Cavghley, G. 2006. *Wildlife Ecology, Conservation and Management.* Blackwell Publishing Ltd., UK.

MS in Zoology (Parasitology)

Course No.	Course Title	No. of Credits	Credit Hours
ZP 635	**Parasite Systematics and Biology**	**2**	**30**

Introduction to the course

This course comprises two distinct disciplines of biological sciences. Taxonomic names and phylogenetic hypotheses are essential tools for modern biological research, both basic and applied. This course concentrates on the systematic position and general biology of the parasites of medical, veterinary, environmental and economic significance. In particular students have the opportunities to learn the classification schemes of major group of parasites and taxonomic procedures for identifying parasites. The course also high lights on reproduction, development, adaptation and transmission of parasites. The course is intended to provide a good foundation for students aiming at developing parasitology based career.

Specific objectives of the course

- to provide basic knowledge on systematics of parasites;
- to provide foundation knowledge on parasitic life stages and overall biology;
- to familiarize them with parasitic adaptation and parasite transmission.

Course contents and number of classes

Sub-title of the course contents	No. of classes
Classification; discovering and naming parasite species. Systematic inventory, managing systematic knowledge bases.	**9**
Sub-title: Parasite Biology	**18**
Parasitic life cycle and developmental stages; vacating stage, infective stage, entry into the host, auto-infection, re-infection, maintenance in the host. Reproduction of parasites; basic concept and types. Parasitic adaptations; morphological, physiological, immunological and life cycle adaptation of parasites. Transmission of parasites; basic concept; common pathways of transmission. Role of metazoan parasites in the transmission of microbial infections.	

Learning outcomes

After completion of the course, the students will be able to-

- learn the detail classification scheme of different parasite groups and procedures for identification of parasites;
- determine the taxonomic position of parasites;
- describe and explain the life cycle and developmental stages of parasites;
- describe different types of parasitic adaptation;
- explain transmission strategies and probable pathways of infection; and
- design preventive measures to avoid transmission.

Instructional strategies

The course will be delivered through lectures and open discussion after each lecture. An introductory class will be dedicated to explain how teaching-learning will proceed for the course. Classes will be made participatory and interactive through questions and answers, group and individual work exercises in the

classroom. Tools, like power point presentations, video shows will be used for delivering some special topics.

Distribution of class lectures: Total number of classes/lecture: 30

Class/ lecture type	Number of classes	Class/ lecture type	Number of classes
Lecture with discussion	27	In-course exam	1
Review class	1	Feedback on In-course exam.	1

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Cheng, T.C. 1997. *General Parasitology*. Academic Press, USA.

Cox, F.E.G. 1993. *Modern Parasitology*. 2nd edition. Blackwell Science, UK.

Nobel, E.R. and Nobel, G.A. 1971. *Parasitology, The biology of animal Parasites.* Henry Kimpton, London.

Schmidt, G.D. and Roberts, L.S. 2000. *Foundations of Parasitology.* Wm. C. Brown Publishers, USA.

Smyth, J.D. 1976. *Introduction to Animal Parasitology.* Cambridge Univ. Press, UK.

Soulsby, E.J.L. 1982. *Helminths, Arthropods and Protozoa of Domesticated Animals.* Bailliere Tindall Publishers, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 636	**Parasite Ecology and Behaviour**	**2**	**30**

Introduction to the course

Ecological parasitology is concerned with the factors for establishment of parasites in or on the host. This course highlights on parasite and its abundance in space, in time and in different hosts, and involves consideration of the factors regulating host-parasite interactions at both the individual and the population levels. Parasites of all kinds are known to modify the behaviour of their hosts in ways that appear to enhance the chances of completing its life cycle. This course provides some powerful conceptual tools allowing rigorous, quantitative predictions to be made when a parasite should manipulate its host.

Specific objectives of the course

- to enhance students conceptual understanding on parasite ecology;
- to provide knowledge on behavioural aspects of parasite and its significance;
- to increase students' knowledge about host specificity in parasitic organism;
- to enhance students understanding on behaviour of the infected host and parasite.

Course contents and number of classes by course sub-title

Sub-titles of course contents	No. of classes
Parasite Ecology Introduction to parasite ecology, Existence of parasite in the host as a milieu, Morphological, physiological and ecological factors favouring establishment of ecto-and endo-parasites. Host specificity: Definition, kinds of parasite-host specificity; establishment of host-parasite system, phylogenetic aspects and factors responsible for host specificity. Ecological	**5**

Sub-titles of course contents	No. of classes
consequences of specificity. Comparative host specificity to genus and species levels.	**6**
Inter- and intra-specific relationships within a host: Intra- specific competition and crowding effects; Inter-specific relationships and ecological consequences of inter-specific reactions.	**5**
Parasite Behaviour Introduction to behavioral ecology, Behaviour of infected host or modified host behaviour owing to parasites; behaviour of parasites within their host; parasite manipulation of host behaviour; parasite manipulation of vector behaviour.	**5**
Dispersion of parasites: Introduction, dispersion of parasites through a host population in relation to age, sex, behavior and movement of host.	**5**

Learning outcomes

After completion of the course, the students will be able to-

- explain the factors responsible for the existence of parasite;
- compare host specificity in generic and specific level;
- explain the reasons that parasite alter the behaviour of its host; and
- explain the factors of dispersion of parasite in a host population.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms**.**

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	26	Review class	1
Students group presentation	1	In-course exam	1
Students feedback on course contents and delivery	1		

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Bush, A.O., Fernandez, J.C., Esch, G.W. and Seed, R. 2001. *Parasitism: the diversity and ecology of animal parasites.* University Press. Cambridge, UK.

Cheng, T.C. 1997. *General Parasitology*. Academic Press, USA.

Kennedy, C.R. 1975. *Ecological Animal Parasitology.* Blackwell Scientific Publication, Oxford, UK.

Lewis, E.E., Campbell, J.F. and Sukhdeo, M.V.K. 2002. *The behavioral ecology of Parasites.* CABI Publishing, UK.

Nobel, E.R. and Nobel, G.A. 1971. *Parasitology, The biology of animal Parasites.* Henry Kimpton, London.

Schmidt, G.D. and Roberts, L.S. 2000. *Foundations of Parasitology.* Wm. C. Brown Publishers, USA.

Course No	Course title	No. of credits	Credit Hours
ZP 637	**Parasite Biodiversity and Population Dynamics**	**2**	**30**

Introduction to the course

This comprises of two essential aspects of Parasitology. Variations within and among the parasite species and its abundances within a host are often expressed in various quantitative terms. Parasites are also natural selection agents influencing a variety of host attributes. These effects ultimately drive biological diversification, through influencing host reproductive isolation and speciation. Recent discussions of the importance of parasites in food webs as modulators of host behavior, drivers of community composition, competitive interactions and biological invasions; and as selective agents, provide multiple lines of evidence for the ecological and evolutionary relevance of parasitic biodiversity. Parasites show fluctuations in their abundances and occurrences within the host body and show dynamism in their population parameters, including birth, mortality, immigration and emigration etc. This course provides an opportunity for developing a foundation for professionalism in this area of parasitology.

Specific objectives of the course

- to enhance students' knowledge on diversity of parasites and understand why they are important;
- to enhance skills of students to estimate parasite diversity of a particular host population;
- to make students ability to appreciate parasite diversity for conservation and maintaining ecosystem integrity.
- To enhance students' understanding on the dynamic aspects of a parasite population

Course contents and number of classes by course sub-title

Sub-titles of course contents	Number of classes
Diversity of parasites Concept, estimating parasite diversity, survey and inventory of parasites; Parasite diversity as conservation target; Epidemiology and parasite diversity. Parasite features and parasite diversification.	**10**
Host and parasite diversity Host as the driver of parasite diversity. Biogeography of parasite diversity. Speciation and extinction of parasite diversity. Parasite diversity and host evolution. Evolutionary history of parasite biodiversity	**10**
Population Dynamics Basic concept; specialty of parasite population dynamics. Factors governing parasite population dynamics. Anderson model of Parasite population dynamics.	**6**

Learning Outcomes

After completion of the course, the students will be able to-

- understand what parasite biodiversity is and why it is an important part of learning;
- understand parasite biogeography, speciation and extinction;
- understand history of parasite biodiversity and its relationship with host evolution.
- design and implement survey works for inventorying of parasites.
- understand the population dynamics of parasites.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	26	Review class	1
Students' group presentation	1	In-course exam	1
Students feedback on course contents and delivery	1		

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Bush, A.O., Fernandez, J.C., Esch, G.W. and Seed, R. 2001. *Parasitism: the diversity and ecology of animal parasites.* University Press. Cambridge, UK.

Poulin, R. and Morand, S. 2004. *Parasite Biodiversity*. Smithsonian Books, Washington DC, USA.

Course No.	Course Title	No. of credits	Credit hours
ZP 638	**Veterinary Parasitology**	**2**	**30**

Introduction to the course

Veterinary health management is very important for production of dairy and food products of a country. It is an integral part of animal health and one health approaches. A wide variety of animals are parasitic to our livestock and pet animals. In addition to damages made to our live stocks, there are good numbers of animal diseases with zoonotic potential. This course focuses on the diagnosis, pathology and treatment of various common parasitic veterinary diseases. So the scope of Veterinary Parasitology is wide for students of animal science. Students of MS in Parasitology should have detail idea about parasites of veterinary importance.

Specific objectives of the course

- to provide basic idea to students about importance of veterinary parasites;
- to enhance learning about biology, importance, injury and control of common veterinary parasites;
- to enhance students' knowledge on distribution of veterinary parasite.

Course contents and number of classes by course sub-title

Sub title of contents	No. of classes
General introduction; parasites of livestock and companion animals. Opportunities and importance of veterinary parasitology.	**2**
Protozoology: Brief biology, distribution, veterinary importance and control of following parasites: *Eimeriatenella, Sarcocystisneurona, Trypanosomaequiperdum. T. evansi, Cytauxyzoonosisfelis, Babesiadivergens, Haemoproteuscolumbae, Histomonasmeleagridis, Leucocytozoonsymondi, Plasmodium gallinaceum.*	**7**
Helminthology: Brief biology, distribution, veterinary importance and control of following parasites: *Ascaridiagalli, Ascarissuum, Capillaria hepatica, Haemonchuscontortus, Ancylostomacanium, Dicrocoeliumdendriticum, Dictyocaulus viviparous, Dipylidiumcaninum, Dirofilariaimmitis, Echinococcusgranulosus, Elaeophorapoeli, E. schneideri, Fasciolagiganticus, Fascioloides magna.*	**8**
Entomology: Brief biology, distribution, veterinary importance and control of following parasites: *Haematomyzuse;ephantis, Goniocotesgallinae, Columbicolacolumbae, Haematopinussuis, Comexlectularius, Nosopsyllusfasciatus, Ctenocephalides spp. Xenopsyllacheopis, Tabanusatratus, Musca domestica, Gasterophilusintestinalis, Ixodes spp., Dermacenterandersoni, Argas* spp.	**6**
Zoonosis: Basic concept, types, factors and potential zoonotic diseases.	**2**
Sustainable food production through livestock health management.	**1**

Learning outcomes

At the end of this course the students, will be able to

- understand the importance of veterinary parasitology;
- assess the damage caused by veterinary parasites;
- understand distribution of parasites in space and time;
- learn about how to control both parasites and vectors of veterinary diseases.

Instructional strategies

Classes will be of interactive type. Students will be asked to have an idea about their presupposition on the tropic at the very beginning of the lecture. Students will take part in discussion after lecture hours. Lectures will be added by multimedia, video clips and web browsing etc.

Distribution of class lectures: Total number of classes/lecture: 30

Class/ lecture type	Number of classes	Class/ lecture type	Number of classes
Lecture with discussion	26	In-course exam	1
Students' presentation	1	Feedback on In-course exam.	1
Review class	1		

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Cheng, T.C. 1997. *General Parasitology*. Academic Press, USA.

Reinecke, R. K. 1983. Veterinary Helminthology. Butterworths Professional Publishers, South Africa.

Schmidt, G.D. and Roberts, L.S. 2000. *Foundations of Parasitology.* Wm. C. Brown Publishers, USA.

Soulsby, E.J.L. 1982. *Helminths, Arthropods and Protozoa of Domesticated Animals.* Bailliere Tindall Publishers, UK.

Williams, R. E. 2010. Veterinary Entomology Livestock and Companion Animals. CRC Press, USA.

Wobeser, G. A.1994. Investigation and Management of Disease in Wild Animals. Plenum Press, New York and London.

Course No.	Course Title	No. of Credits	No. Credit hours
ZP 639	**Epidemiology**	**2**	**30**

Introduction to the course

Epidemiology is the study and analysis of the distribution and determinants of health and disease conditions in defined populations. Many parasitic diseases are fatal as well as take the epidemiological manifestations. The control of such parasitic epidemic diseases requires a wide array of information including transmission across the population, pattern of distribution, etc. to plan a control programme. This course will introduce with the epidemiological factors and their measurements. The course will be very useful for students willing to develop career in parasitology.

Specific objectives of the course

- To provide conceptual understanding on the epidemiological factors and their study of parasite mediated epidemic diseases.
- To provide students with the knowledge and skills on the techniques for the measurement of epidemiological parameters.
- To familiar students with different types of distribution of parasites.

Course contents and number of classes by course sub-title

Sub title of contents	No. of classes
Epidemiology	
Basic concept and scope of epidemiology in Parasitology.	**3**
Techniques for epidemiological studies; branches of epidemiology; types of epidemiological studies.	**5**
Measurement issues - measures of disease occurrence and measures of association.	**2**
Transmission and exposure status.	**2**
Sampling techniques for epidemiological studies.	**2**
Epidemiological analysis and biological monitoring.	**2**
Importance of epidemiological information of aquatic animals as biological tag for assessment of host movement, migration, stock separation and environmental pollution.	**4**
Distribution of parasites: Macro - and micro distribution; spatial and temporal distribution.	**3**
Parasite control: Principles and designs; case studies. Vector control: principles and designs, case studies.	**3**

Learning outcomes

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

- understand the basic principles and concepts epidemic diseases and the epidemiology;
- describe methods and techniques for measuring the epidemiological parameters; the
- conduct epidemiological research;
- understand distribution of parasites in space and time; and
- learn about how to control both parasites and vectors.

Instructional strategies

Classes will be of interactive type. Students will be asked to have an idea about their presupposition on the tropic at the very beginning of the lecture. Students will take part in discussion after lecture hours. Lectures will be aided by multimedia, video clips and web browsing etc.

Distribution of class lectures: Total number of classes/lecture: 30

Class/ lecture type	Number of classes	Class/ lecture type	Number of classes
Lecture with discussion	26	In-course exam	1
Students' presentation	1	Feedback on In-course exam.	1
Review class	1		

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Basheer, A. 1995. *Environmental Epidemiology*. Rawat Publications, New Delhi, India.

Cox, F.E.G. 1993. *Modern Parasitology.* 2nd edition. Blackwell Science, UK.

Lewis, E.E., Campbell, J.F. and Sukhdeo, M.V.K. 2002. *The behavioral ecology of parasites*. CABI Publishing, New York.

Moore, J. 2002. *Parasites and the behavior of animals.* Oxford University Press, UK.

Whilefield, P.J. 1976. *The Biology of Parasitism.* Edward Arnold Publishers Ltd., UK.

Wobeser, G.A. 1994. *Investigation and Management of Disease in Wild Animals.* Plenum press, New York and London.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 640	**Public Health Parasitology**	**2**	**30**

Introduction to the course

A great variety of parasites infect human, both externally and internally, causing a health concern of considerable magnitude worldwide, some of which cause fatal diseases. Having poor sanitation and medical services the problems of parasitic diseases are more prevalent in Bangladesh.

Some societal change influences the infectious diseases by increasing international traffic, ecological changes, microbial adaptation, changing contact patterns and societal breakdown. Bangladesh has experienced a variety of diseases caused by natural dissemination of an array of pathogenic organisms into the environment. Specifically, the course focuses on the communicable diseases, methods and techniques for controlling such diseases, knowledge about primary health care and learning different health indicators. The course will be useful for tose willing to build career in public health.

Specific objectives of the course

- to provide students understanding on community health care;
- to enhance students' knowledge on procedures for examining and determining the public health status from the perspective of parasitic diseases;
- to enhance students understanding about relation between disease and community behaviour; and
- to increase students' capability to assess the impact of diseases.

Course contents and number of classes by course sub-title

Sub-titles of course contents	No. of classes
Basic concept of Public Health: Definition, significance, evolution of public and community health, terms related to Public Health.	**3**
Concept of health and disease: Definition of health, new philosophy of health, changing concepts of health, definition of disease, causation or theories of disease, factors of disease, international classification of disease.	**4**
Determinants and indicators of health: Genetic or biological, behaviour or socio-cultural, environmental, socio-economic and political conditions, health and family welfare services, aging of the population, gender and other factors. Purposes of health indicators, criteria and list of health indicators.	**3**
Concept of primary health care: Definition, basic principles, essential components, levels of health care services, role of hospital in primary health care.	**2**
Public Health in Bangladesh: History, laws, principles and ethics;	**3**
Health programmes of Bangladesh: Health status of Banglsdesh, health, population and nutritional sector development programme (HPNSDP), Major health programs during fifth five-year plan. International health organizations.	**3**
Introduction to communicable diseases: enteric organisms; helminth and parasitic diseases; skin infection; acute infection; STDs. Principles of control of communicable diseases.	**3**
Introduction to non- communicable diseases: Cardiovascular diseases, cancer and diabetes. Prevention and control of non-communicable diseases.	**2**
Emerging diseases: definition, significant impacts, factors favouring emergence of new diseases and qualification and quantification of EID.	**2**
Modern travel and transmittable diseases: mode of transmission, quarantine and control measures.	**1**

Learning outcomes

After completion of the course, the students will be able to-

- explain how to protect and improve the health of the population;
- identify current public health problems all around the community ;
- assess different health indicators and determinants.
- understand the mode of transmission of communicable diseases across population and across a country; and
- know about the emerging diseases in public health sector.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms**.**

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	26	Review class	1
Students group presentation	1	In-course exam	1
Student feedback on course contents and delivery	1		

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Park, K. 2014. *Park's Text Book Preventive and Social Medicine.* 22nd edition. M/S Banarsidas Bhanot Publishers, India.

Rahman, M., Alamgir, A.K.M and Hafez, A. 2012. *Rashid, Kabir, Hyders' Text book of Community Medicine and Public Health.* 5th edition, MAP Publishers, Dhaka, Bangladesh.

Rashid, K.M. Rahman, M. and Hyder, S. 2004. *Community Medicine and Public Health*. 4th edition. RHM Publishers, Dhaka, Bangladesh.

Reza, S. 2014 -2015. *The Essential of Community Medicine.* 12th Edition. Media Plex Medical Publisher and Distributor, Dhaka, Bangladesh.

Roger D., J. Mcewen, R. Beaglehole., and H. Tanaka., *Oxford textbook of Public Health Ed.* Oxford University Press (OUP) 4th Edition: 2002.28

Course No.	Course Title	No. of Credits	Credit Hours
ZP 641	**Parasite Physiology**	**2**	**30**

Introduction to the course

The major focus of this course is to study the complex and dynamic physiological relationships between parasites and their hosts. It presents an overview of the biological and physiological bases of important parasite group and an understanding of the metabolic processes of the parasites. The course describes by which mechanisms a parasite survives in the host body or also in the habitat peculiar to it.

Specific objectives of the course

- to provide basic knowledge on parasitic nutrition;
- to make understand of the students about the metabolic processes in parasites;
- to provide knowledge on host-parasite interactions and its impacts.

Course contents and number of classes by course sub-title

Sub-titles of course contents	No. of classes
Nutrition of helminthes	**16**
Structure of helminths aid in obtaining nutrition, ultrastructure of tegument and its role in feeding. Alimentary canal as biotope for parasites. Absorption mechanism. Carbohydrate, protein and other essential food material uptake. Oxygen consumption in helminths; requirements and utilization. O_2 as a terminal electron acceptor.	
Metabolic processes	**11**
Carbohydrate, protein and energy metabolism in helminths. Pathways of metabolism in helminths. Metabolism in protozoan; *Entamoeba* and *Trichomonas*	

Learning outcomes

After completion of the course, the students will be able to-

- explain the structures involved with obtaining food in helminths;
- tell about the oxygen consumption and utilization in parasites;

- explain the function of the cells, tissues, organs and organ systems of parasites;
- appraise the metabolic processes of parasites;
- explain the physiological differences among the different group of parasites;

Instructional strategies

An introductory class will be taken to explain the method of teaching and how teaching-learning of the course will advance. The course will be delivered through lectures and discussion, Teaching tools like power point presentation, flip chart and video films will also be used to aid lecture delivery. Classes will be made participatory and interactive through questions and answers, group and individual work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/ lecture type	Number of classes	Class/ lecture type	Number of classes
Lecture with discussion	27	In-course exam	1
Review class	1	Feedback on In-course exam.	1

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Smyth, J. D. *The Physiology of Cestodes.* 1969. Oliver and Boyd.

Smyth, J. D. *The Physiology of Trematodes.* 1966. Oliver and Boyd.

Smyth, J. D. *Introduction to Animal Parasitology.* 1994. Cambridge University Press.

Lee, D. L. *The Physiology of Nematodes.* 1965. Oliver and Boyd.

Course No.	Course Title	No. of credits	Credit Hours
ZP 642	**Biochemistry and Molecular Biology of Parasites**	**2**	**30**

Introduction to the course

In the course of their lives, parasites undergo significant metabolic and genetic alternations. For these reasons, parasitic organisms have become model systems for the study of biochemistry and molecular biology. The phenomena of metabolic shifts to accompany morphological changes, compartmentalization of enzyme system, rapid alterations in membrane chemistry, and genetic changes associated with adaptation to the host have recommended parasites to be the attention of scientists of many disciplines. The molecular biology of parasites which has been presented as it relates to the cell biology of parasitic organisms. The course is designed to introduce students with the basics of biochemistry and molecular facts having relevance to parasitological study. and will better allow the parasitologists to plan quality researches.

Specific objectives of the course

- to provide students with basic knowledge on biochemistry of parasitic organisms and its application in parasitology;
- to enhance students' knowledge to appreciate the relevance of molecular biology in parasitological study.

Course Contents and Number of Classes by Course Sub-title

Sub-titles of Course Contents	Number of Classes
Biochemistry of Parasites	
Biochemical Aspects of Developmental Processes Egg shell formation in cestode, trematode and nematode. Mechanism of egg hatching, Transformation of larval stages. Structure and function of nematodes surface. Hormones influencing development (Pheromones and other reproductive cues). In-Vitro development in cestode, trematode and nematode.	**10**
Invasion Mechanism Cellular invasion by protozoa and helminths. Specific steps and pathways of invasion by helminths.	**4**
Molecular Biology of Parasites	
Molecular Phylogeny Molecular phylogeny of helminths. The importance of phylogenetic study in the evolution of Parasites.	**5**
Molecular Biology Molecular biology of protozoa and helminth parasites. Genetics and Gene expression. Advantages and launching of genetics investigations. Transcription in Trypasomes and Nematodes. Tran splicing mechanism.	**5**
Molecular interaction of transmission Molecular aspects of an intimate association between trematode and snails.	**2**

Learning outcomes

After completion of the course, the students will be able to-

- understand the biochemical components involved in developmental processes of parasitic organisms;
- explain different mechanisms for egg shell formation and egg hatching;
- explain the role of hormones in parasite development;describe mechanism of parasites and in vitro development of these organisms;
- explain molecular phylogenetic tree and its application in parasite study; and
- explain molecular interactions between host and parasites.

Instructional strategies

The course will be delivered through lectures and discussions, power point presentations, video films etc. In the introductory class the students will be informed how the course will proceed. Classes will be made participatory and interactive through questions and answers, group and individual work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/ lecture type	Number of classes	Class/ lecture type	Number of classes
Lecture with discussion	27	In-course exam	1
Review class	1	Feedback on In-course exam.	1

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Boothroyd, J. C. and Komuniecki, R. 1995. *Molecular approaches to parasitology*. Vol. 2.
Lee, D. L. 1965. *The Physiology of Nematodes*. Oliver and Boyd.
Marr, J. J. and Mukker, M. 1995. *Biochemistry and molecular biology of Parasites*. Academic Press, Harcourt Brace and Company, New York.
Saleuddin, A. S. M. and Fenton, M. B. 2004. *Canadian Journal of Zoology*. Vol. 82 (2).
Smyth, J. D. *Introduction to Animal Parasitology*. 1994. Cambridge University Press.
Smyth, J. D. *The Physiology of Cestodes*. 1969. Oliver and Boyd.
Smyth, J. D. *The Physiology of Trematodes*. 1966. Oliver and Boyd.

Course No	Course title	No. of credits	No. Credit Hours
ZP 643	**Immunology**	**2**	**30**

Introduction to the course

A highly discriminatory immune system is fundamental to survival. How the immune system accomplishes this level of discrimination remains deeply enigmatic, but such questions are among the many that make immunology a fascinating discipline. Immunology as a distinctive subject developed in the 20th century as researchers started to understand how the adaptive immune system aids in defense against pathogens. The course will allow the students to learn how the immune system in the body is organised and how it works to provide protection against pathogens and foreign molecules.

Specific objectives of the course

- To provide conceptual understanding on immunity, its types and ,the make up of the immune system.
- To increase students' knowledge on the mechanism of different type of immune responses in vertebrates.
- To introduce the students with some immunological techniques.

Sub-titles of course contents	Number of classes
Components of Immune System Introduction to the Immune System; Cells, tissues and organs of the Immune system; Antibodies and Immunoglobulins; Complement; T cell receptors and MHC molecules	**7**
Modes of Immune Response Mechanisms of Innate Immunity; Antigen Presentation and Processing; T cell Maturation, Activation and Differentiation; B- cell Generation; Activation and Differentiation; Immune responses in tissues.	**5**
Defence Against Infectous agents Immunity to viruses; Immunity to bacteria and fungi; Immunity to protozoa and worms; Primary Immunodefeciency; AIDS and secondary Immunodeficiency; Vaccination	**4**
Immune Responses against tissues Immunological tolerance; Autoimmunity and autoimmune diseases; Transplantation and rejection; Immunity to cancers	**3**
Hypersensitivity Immediate hypersensitivity type I; Hypersensitivity type II; Type IV hypersensitivity	**3**
Immunological Techniques	**4**

Learning outcomes

After completion of the course the students, will be able to-

- compare and contrast innate vs. acquired immunity and cell mediated and humoral immunity;
- differentiate the recognition and effectors functions of T cells and B cells;
- distinguish primary and secondary immune responses and primary and secondary immune organs;
- name the major lymphoid organs and describe their functions;
- describe the basic structures of immunoglobulin molecules and its functions; and
- learn about a variety of immunological techniques.

Instructional strategies

The course will be delivered through lectures and discussions, power point presentations, video films etc. In the introductory class the students will be informed how the course will proceed. Classes will be made participatory and interactive through questions and answers, group and individual work exercises in the classroom.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	26	Review class	1
Students group presentation	1	In-course exam	1
Student feedback on course contents and delivery	1		

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Roitt, I., Brostoff, J. and Male, D. 2001. Immunology. 6th edition. The University of Wisconsin Press, Medison, Wisconsin, USA.

Osborne, B.A. and Kuby, J. 2000. Immunology. 7th edition. Macmillan International Publication, USA.

Course No.	Course Title	No. of Credits	No. Credit Hours
ZP 644	**Pathology**	**2**	**30**

Introduction

Parasites cause a wide array of pathological changes in host body, many of which are manifested as disease symptoms and helps pathologist to understand the background and significance of diseases and provides basis for its treatment. This course deals with the study of pathological mechanisms common to all tissue-cell pathology with emphasis on cellular changes, inflammation, healing, laboratory techniques and many more. The course is intended to provide students with a solid foundation in pathological study with a view to developing future career in this area, capable of monitoring health status, and designing and conducting researches in this area of biological sciences.

Specific objectives of the course

- to enable the students to understand basic pathologic processes and responses;

- to familiarize the students with the ranges of pathological changes in hosts' body brought about by parasitic diseases;
- to enhance learning and skills of students on the methods and techniques used in clinical pathology.

Course contents and number of classes by course sub-title

Sub-titles of course contents	Number of classes
General pathology Aetiology of diseases. Histopathology of infected host tissues; Types of cellular changes. Inflammation and its types. Healing processes. Tumors, ulcers and anaemia. Pathology of parasitic diseases of fish, birds and mammals.	**18**
Clinical pathology Planning a clinical chemistry laboratory. Collection and transport of specimens. Biochemical analysis; constituents of blood and urine. Techniques for examination of-stool, urine and blood.	**8**

Learning outcomes

Upon completion of this course the student should be able to-

- understand the pathogenesis of the common and important diseases;.
- recognize and describe the major cell and tissue alterations associated with parasitic diseases;
- learn about the methods and techniques used for measuring pathological changes in body caused by diseases;
- describe how pathological analysis and techniques are used to recognize the abnormalities; and
- provide knowledge on the techniques used in clinical pathology.

Instructional strategies

The course will be delivered through lecture and discussions. An introductory class will taken to guide the students on teaching-learning strategy to be followed in the subsequent class. Classes will be made participatory and interactive through questions and answers, group and individual work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	26	Review class	1
Students group presentation	1	In-course exam	1
Students feedback on course contents and delivery	1		

Assessment

One In-course examination, consisting of 15 marks and one hour duration will be taken for this course. Some 2.5 mark is allocated for class attendance. Another 2.5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 30 marks will be conducted centrally by the university.

References

Cheesbrough, M. 1987. Medical Laboratory Manual for Tropical Countries. ELBS Publishing, UK.

Jawed, E., Melnik J.L. and Edward, A. 1980. Review of Medical Microbiology. Adel berg, Lange Medical Publications, California, USA.

Khaleque, K.A. and Mannan, K.Z. 2001. Practical Pathology and Microbiology.Aleya House, Dhaka, Bangladesh.

Ribulin, W.E. and Migaki, G. 1975. Pathology of fishes. The University of Wisconsin Press, Wisconsin, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 654	**Practical Parasitology**	**6**	**90**

Introduction

The purpose of this course is to enhance students practical skills in carrying out a range of activities aligned with the theoretical courses of the MS in Zoology (Parasitology) programme. The course will be based on practical demonstration classes in the laboratory, hands-on training, experimental trails, and filed work. This will allow the student to equip with knowledge and skills required in ones research and professional career.

Specific objectives of the course

- to make students capable of identifying parasites from blood and other body fluids of various hosts;
- to demonstrate students' standard protocols of parasitological works;
- to increase students' capacity of understanding and applying the molecular methods for parasitological works;
- to investigate histopathological changes caused due to parasitic infestation;
- to enhance their capability to prepare inventory, reports, scientific papers etc.
- to make them capable of developing experimental design.

Course contents and number of classes

Sub-titles of course contents	Number of Classes
Collection and preparation of blood and other body fluids for parasitological studies.	**3**
Necropsy - procedure for different types of hosts.	**2**
Procedures for inventory of ectoand endo-parasites of vertebrate hosts like fish, birds and mammals.	**3**
Survey of parasitic diseases.	**2**
Recording data for parasitological research.	**2**
Epidemiological analysis of parasitic infection.	**2**
Culture techniques for parasites.	**2**
Histopathology of infected tissue and organs of vertebrate hosts.	**3**
Demonstration of molecular techniques: ELISA, Gel Electrophoresis, PCR.	**2**
Research article writing and review.	**2**
Designing plan for parasite control.	**2**
Project	

Learning outcomes

After completion of the course the students will be able to-

- collect and prepare parasites for study and identification;
- record data properly;
- learn standard protocols to make inventory of parasites of any host;
- learn molecular techniques; culture and histopathology.
- learn culture techniques of parasites; and
- develop experimental design and write up reports.

Instructional strategies

The students will be briefed about the training, demonstration and protocols before starting work. They will be asked to maintain a laboratory note book to record their day to day working procedures in it. They will be asked to demonstrate their performance during classes. Classes will be made participatory and interactive through questions and answers, group and individual work exercises in the classrooms.

Distribution of class lectures: Total number of classes/lecture: 30

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Demonstration and discussion	25	Review class	1
Students group assignments	1	In-course exam	2
Students feedback on course contents and delivery	1		

Assessment

Two in-course examinations consisting 3 hours each will be taken for this 6-credit course. A portion (20-25%) of in-course marks will be allocated for continuous assessment through observations of student at work and assignments. Course final examination will be held as per university's existing system.

References

Garcia, L.S. and Ash, L.R. 1975. Diagnostic Parasitology Clinical Laboratory Manual. The C.V. Mosby Company, USA.

Soulsby, E.J.L. 1982. Helminths, Arthropods and Protozoa of Domesticated Animals. Bailliere Tindall Publishers, UK.

Svobodova, Z. and Vykusova, B. (ed.). 1991. Diagnostics, preservation and therapy of fish diseases and intoxications. Research Institute of Fish Culture and Hydrobiology, Vondnany, Czechoslovakia.

Tonguthai, K., Chinabut, S., Somsiri, T., Chanratchakool, P. and Kanchanakhan, S. 1999. Diagnostic procedures and finfish diseases. Aquatic Animal Health Institute, Bangkok, Thailand.

Yamaguti, S. 1959. Systema Helminthum. Vol. II. The cestodes of vertebrates. Interscience Publishers Inc., New York.

Yamaguti, S. 1961. Systema Helminthum. Vol III. The nematodes of vertebrates. Interscience Publishers Inc., New York.

Yamaguti, S.1958. Systema Helminthum. Vol I. The trematodes of vertebrates. Interscience Publishers Inc., New Yor

MS in Zoology (Genetics and Molecular Biology)

Course No.	Course Title	No. of Credits	Credit Hours
ZG 645	**Molecular Biology**	**4**	**60**

Introduction to the course

Recent advancement in molecular biology is overwhelming and unveils many mysteries in gene functions, its regulation and its application in human needs. Students will get an exposure to those innovations and be able to further enhance their knowledge on structural and functional organization of the biomolecules, viz. DNA, RNA and proteins. The course will also provide opportunity to learn in more detail about inheritance mechanism at the molecular level, gene expressions and its regulation. The course will also highlight on gene mutation, mobile genes, meiotic drive genes, stem cells, extra-chromosomal inheritance and application of genes in therapeutic uses.

Specific objectives of the course

- To provide the students with detailed conceptual understanding on the structure and functions of biomolecules, molecular basis of gene functions and its regulation.
- To familiarize the students with modern thoughts and molecular techniques, particularly about the modern innovations, and its application in gene therapy.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Organization of the prokaryote and eukaryote genome	
Genes and gene numbers, C-value paradox.	**5**
Organization of replication, Gene amplification, Chromosomal redundancy, Repetitive DNA and its relevance to animals; Inverted tandem repeats.	**5**
The mitochondrial and chloroplast genome	**2**
Gene Expression Organization of the eukaryote DNA, Role of chromatin structure in gene expression.	**3**
Transcriptional regulation	
Promoter, Control elements, Enhancers;	**2**
Regulation by gene rearrangement (alternative splicing), RNA-editing, Translational control.	**3**
Ribosome	
Structure and function of ribosome, Location of functional sites in the ribosome, Protein-tRNA interaction, Protein-RNA interaction assembly map;	**5**
Genetics of ribosomal RNA and regulation of the synthesis of ribosome.	**2**
Mutation and repair of DNA Types of mutation, spontaneous and included mutation, reverse and suppressor mutations;	**2**
Mutation rate, physical and chemical mutagens, molecular basis of mutation, *in vitro* mutagenesis, site-directed mutagenesis;	**3**
Types of DNA repair, repair mechanism in mutation.	**2**
Mutations in mitochondrial genome causing human disorders.	**2**
Gene therapy Ex-vivo and in-vivo gene activation therapy; viral gene delivery systems; pro-drug activation therapy, nucleic acid therapeutic agents, oligonucleotide correction of genetic	**5**

Title/sub-titles of course contents	No. of classes
conditions.	
Transposons and intentional elements, Meiotic drive genes their molecular basis, potential applications, Symbiotic genes and their heredity-based infection	**6**
Stem cells Potential in regenerative medicine, source and types of stem cells, harvesting and culture, induced pluripotent stem cells, problems, challenges and ethical issues regarding stem cells	**5**

Learning outcomes

After completion of the course, the students will be able to-

- know more in detail about structural and functional organization of DNA, RNA and the proteins;
- explain and describe the molecular basis of inheritance, gene expressions and its regulation;
- learn about the application of genes in therapeutic purposes; and
- get familiarity with mobile genes, meiotic drive genes, stem cells, extra-chromosomal inheritance.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip charts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom. Students will be encouraged and guided for eLearning assessments based on lecture material and other reading materials.

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture, discussion and review classes	52	In-course exam	2
Feedback on in-course exam Plus group presentation	4	eLearning and assessments	2

Assessment

There will have at least two In-course tests. A total of 30 marks will be allocated for In-course exams and 5 marks for class attendance. Another 5 marks will be allocated for surprise test/oral presentation/assignment. The students will be frequently asked questions in the classrooms to assess individual performance. A course final examination, consisting of 60 marks, will be conducted by the university.

References

Alberts B., Johnson A., Lewis J., Raff M., Roberts K. and Walter, P. 2004. Molecular Biology of the Cell (4th edition). Garland Science Publisher, UK.

Brown, T. 2012. Introduction to Genetics: A Molecular Approach. Garland Science Publisher, UK.

Hartl, Daniel L. and Ruvolo Maryellen. 2012. Genetics: Analysis of Genes and Genomes. 8th edition. Jones and Barlett Pvt. Ltd., India.

Klug, W.S. and Cummings, M.R. 2017. Concepts of Genetics. 11th edition. Pearson Education, Inc., New Jersey, USA. (e-Book available: https://smtebooks.com/book/7787/concepts-genetics-11th-edition-pdf)

Lehninger, A.L., Nelson. D.L. and Cox, M.M. 1993. Principles of Biochemistry. CBS Publishers and distributors, Delhi, India.

Snustad and M.J. Simmons. 2015. Principles of Genetics. 7th Ed. John Willey and Sons. Inc. New York, USA. (PDF available:https://www.slideshare.net/hijobaba/principles-of-genetics-6-e-isbn-978-0470903599- snustad-simmons)

Turner, P. C., McLennan, A.G., Bates, A.D. and White, M.R.H. 2000. Instant Notes on Molecular Biology. 2nd edition. BIOS Scientific Publishers Limited, Oxford, England.

Course No.	Course Title	No. of Credits	Credit Hours
ZG 646	**Advanced Genetics**	**4**	**60**

Introduction to the course

As with other branches of biology, classical genetics is also advancing with new innovations leading to revealing many genetic issues and its application for human welfare. This course will provide advanced knowledge on some modern innovations in genetics, such as microbial genetics, immune system, cancer, diseases and development. The course also offers a package of learning opportunities on the microbial genetic systems, mapping techniques, mechanism of development, aging and various genetic diseases including cancer. The course is designed to produce professionals in modern genetics with adequate background knowledge on the subject area.

Specific objectives of the course

- To enhance conceptual understanding of students on modern thoughts in genetics.
- To familiarize students with aspects of developmental genetics, genetic diseases, genetic basis of cancer, ageing.
- To provide an understanding of the genetic basis of immune system and immune responses.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Genetics of bacteria and viruses Bacterial conjugation, chromosomal transfer, plaque formation and mapping; Lytic cycle, Lysogeny; Genetic screening and selection.	**10**
Immunogenetics Molecular and cellular basis of Immune responses, The humoral and cell mediated immune response, Clonal theory of immune response; Antibodies, structure, diversity, function and mechanism of action; Recognition of antigen by T cells; Major histo-compatibility proteins.	**10**
Oncogenetics Cancer-type of cancer cells, Chemical carcinogens, oncogenes and tumor suppressor genes; Cell cycle signaling, control and cancer (with typical signaling example); Hematological malignancies, leukemia, myeloma. Chemotherapy, activity of chemotherapy, antimetabolites, alkaloids, antibiotics and miscellaneous compounds.	**12**
Disease Genetics Diabetes mellitus-Type I, Type II and other classes, genetic basis of Type-I and II. Insulin gene, mechanism of Insulin action, complications, diagnosis and treatment. AIDS-Biology of HIV, mode of transmission, diagnostic test, anti-AIDS drug and vaccine. Brain diseases-Genetic basis of Alzheimer's, Huntington's and Parkinson's diseases.	**10**
Developmental Genetics Developmental potential, determination and differentiation; genetic mechanism of sex differentiation. Pre-pattern and organization of embryo and its genetic mechanism of development in *Drosophila.* Developmental biology and Cell aging.	**10**

Learning outcomes

After completion of the course, the students will be able to-

- construct gene map using microbial gene transfer system;
- explain the genetic mechanism of immunity;
- learn about some major genetic diseases, its diagnosis and treatment;
- know about the genetic issues in developmental biology and cell ageing;
- provide counselling on various genetic diseases; and

- design and implement various genetic research in the area of aging and developmental biology.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, video clip, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classrooms. Student feedback on the overall course delivery and content will be taken in the last class through a questionnaire survey.

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	52	Review and Questionnaire survey	2
Students' group presentation	4	In-course exam	2

Assessment

There will have at least two In-course tests. A total of 30 marks will be allocated for In-course exams and 5 marks for class attendance. Another 5 marks will be allocated for surprise test/oral presentation/assignment. The students will be frequently asked questions in the classrooms to assess individual performance. A course final examination, consisting of 60 marks, will be conducted by the university.

References

Abbas, A. K., Lichtman, A. H. and Pillai, S. 2014. *Cellular and Molecular Immunology*. 5th edition.

Alberts, B. 2017. *Molecular Biology of the Cell*. 6th edition. Garland Science, USA.

Nelson, D. L., and Cox, M.M. 2016. *Lehninger Principles of Biochemistry*. Sixth Edition. W.H. Freeman and company, New York, USA.

Klug, W.S. and Cummings, M.R. 2017. Concepts of Genetics. 11th edition. Pearson Education, Inc., New Jersey, USA. (e-Book available: https://smtebooks.com/book/7787/concepts-genetics-11th-edition-pdf)

Snustad and M.J. Simmons. 2015. Principles of Genetics. 7th Ed. John Willey and Sons. Inc. New York, USA. (PDF available:https://www.slideshare.net/hijobaba/principles-of-genetics-6-e-isbn-978-0470903599- snustad-simmons)

Course No.	Course Title	No. of Credits	Credit Hours
ZG 647	**Functional Genomics, Proteomics, Metabolomics and Bioinformatics**	**4**	**60**

Introduction to the course

One of the recent innovations and developments in molecular biology relates to "omic" technologies surrounding the genomics, proteomics and use of bioinformatics. In fact, Omic technologies are regularly applied in medical research and throughout the drug-development process. High throughput technologies are being used to study gene regulation, protein function and quantification of metabolites and metabolic networks within an organism. Rather investigating single genes, single proteins or single metabolites, omic methods simultaneously investigate large numbers of genes, proteins or metabolites in one single experiment. This cours

e will focus on these technologies to provide an exposure to the key applications, techniques and recent advances in this field and is useful for career build up in this area of molecular biology.

Specific objectives of the course

- To provide an in-depth conceptual understanding on the genomic, proteomic, metabolomics technologies.

- To familiarize the students with the omic techniques used in medical sciences and drug development process.
- To enhance students skills in applying bioinformatics in researches and studies.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Genomics and Bioinformatics tools	
Gene, Genome and Genomics Classification of genomics; Microbial genomics and genome epidemiology; Evolution and structure of mitochondrial genomes; Telomeric and sub-telomeric regions; Whole genome sequencing methods i.e. genome-wide association study (GWAS), microarray and next generation sequencing; metagenomics and methods of metagenomics; nutritional genomics, epigenomics and methods of epigenomics.	**15**
Online genomics databases and tools Major databases of genomes; application of various standard bioinformatics techniques to experimental planning and analysis, including microarray data etc.	**5**
Proteomics and metabolomics	
Introduction History & Basic concepts of Proteomics and metabolomics *i.e* chemical structure of proteins; conformation of the polypeptide chain; protein folding patterns; post-translational modifications, and metabolic outcome.	**5**
Tools of proteomics and metabolomics SDS PAGE, 2D PAGE, Liquid chromatography, Mass Spectrometry, Protein identification by peptide mass fingerprinting, Gas chromatography and Capillary electrophoresis.	**5**
Bioinformatics' analysis of proteomics and metabolomics Prediction of protein structure and RNA and structure alignment of proteins; introduction to public data bases for protein and metabolites; raw data analysis to study proteome and metabolome using mass spectroscopy and NMR-spectroscopy; network analysis etc.	**15**
Application of Proteomic and metabolomics techniques in real life Biomedical and biological applications in pharmacology, pathology, toxicology and cell biology.	**10**

Learning outcomes

After completion of the course, the students will be able to -

- understand the basics of genomics, proteomics and bioinformatics;
- gain skills in applied bioinformatics and functional genomics; and
- get familiarity with omic techniques, particularly related to drug development process.

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, flip c harts, video films, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom. Students will be made engaged with eLearning assessments based on lecture material and supplementary lecture-related materials.

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture, discussion and review classes	55	In-course exam	2
Feedback on in-course exam and group presentation	2	Learning and assessment	1

Assessment

There will have at least two In-course tests. A total of 30 marks will be allocated for In-course exams and 5 marks for class attendance. Another 5 marks will be allocated for surprise test/oral presentation/assignment. The students will be frequently asked questions in the classrooms to assess individual performance. A course final examination, consisting of 60 marks, will be conducted by the university.

References

Andreas, D.B. and Francis O.B.F. 2005. *Bioinformatics – a practical guide to the analysis of genes and proteins*. John Wiley and Sons, USA.

Bino RJ, Hall RD, Fiehn O, Kopka J, Saito K, Draper J, Nikolau BJ, Mendes P, Roessner-Tunali U, Beale MH, Trethewey RN, Lange BM, Wurtele ES, Sumner LW. 2004. *Potential of metabolomics as a functional genomics tool. Trends in Plant Science 9*: 418-425.

Campbell, A.M. and Heyer, L.J. 2009. *Discovering Genomics, Proteomics, and Bioinformatics.* 2nd edition. Pearson Education, Inc., UK.

Dan, E.K. and Michael, L.R. 2003. *Fundamental Concepts of Bioinformatics.* Pearson Education Inc., UK.

Dunn WB, Ellis DI. 2005. Metabolomics: current analytical platforms and methodologies. *Trends in Analytical Chemistry 24*: 285-294.

Klug, W.S. and Cummings, M.R. 2003. *Concepts of Genetics.* 7th edition. Pearson Education Pvt. Ltd., Singapore.

Lesk, A.M. 2007. *Introduction to Genomics.* Oxford University Press Inc., New York, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZG 648	**Gene Manipulation and Recombinant DNA Technology**	**4**	**60**

Introduction to the course

The tremendous development in molecular biology, genetic engineering in particular, has resulted in the wider applications of molecular techniques in industrial sectors. This course focuses on the basic techniques required for the study of genetic engineering and recombinant DNA technology. It includes different cloning vectors of different genes into a vector designing, construction of DNA libraries and identification of cloned genes using hybridization techniques with emphasis on application of recombinant DNA technology in the field of medicine, agriculture, industry and forensic sciences. The course also provides comprehensive details on the ethical, legal issues and social concerns. . The course is designed to develop professionals in this area off biotechnology.

Specific objectives of the course

- To introduces the students to the creative use of modern tools and techniques for manipulation and analysis of genomic sequences.
- To expose students to the applications of recombinant DNA technology in various sectors of applied biological sciences. .
- To expose the students to research methodologies employing genetic engineering techniques.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Gene Manipulation	
Fundamental techniques Introduction, Fundamental techniques of gene manipulation, Agarose and Poly acrylamide Gel Electrophoresis; Southern, Northern, Western and other blotting techniques; electroporation, Polymerase Chain Reaction, Primer design.	**11**
Restriction enzymes and Vectors Types, nomenclature and applications of restriction enzymes; cutting and joining DNA molecules; plasmid, cosmids, phasmids, Yeast Artificial Chromosomes (YAC) and other advanced vector.	**6**
Gene cloning Strategies Cloning in *Escherichia coli* and other bacteria; cloning in *Saccharomyces cerevisae* and other fungi.	**2**
DNA Library construction Construction of genomic DNA and cDNA libraries.	**2**
Marker genes Selectable markers, screen able markers, non-antibiotic markers, etc.	**3**
Sequencing methods Maxam Gilbert, Sanger, NGS, RNA-sequencing and other techniques.	**4**
Recombinant DNA Technology	
Medical application Diagnosis of diseases; transgenic animal models of human diseases; gene medicine; DNA vaccines, gene therapy; HBVs antigen; insulin; growth hormone; antibody.	**8**
Industrial application Production of food-beverages, antibiotics; antimicrobials; vaccines and enzymes.	**5**
Agricultural application Improving agronomic traits by genetic modification - *Bt* gene resistant strains; Genetically modified foods (GMOs) - benefits and risks.	**3**
DNA fingerprinting Principles of DNA fingerprinting; application of DNA fingerprinting in criminal investigation (person identification), paternity dispute, immigration, identification of missing children or bodies found in accidents.	**3**
Ethical and Environmental issues Biosafety regulations to protect producers, consumers and nature. Ethical and environmental issues concerning use of cloned gene in medicine, industry and agriculture.	**4**

Learning outcomes

After completion of the course, the students will be able to-

- gain conceptual understanding on gene manipulation and recombinant DNA technique;
- learn and describe methods and techniques for gene manipulation;
- gain knowledge and skills for producing cloned animals;
- get familiarity with application of DNA recombinant techniques in various sectors; and
- design and conduct experiments involving genetic manipulation;

Instructional strategies

The course will be delivered through lecture and discussion, aided by power point presentations, video clips, etc. Classes will be made participatory and interactive through questions and answers, and group work exercises in the classroom. At the beginning of each class student feedback on previous class lecture

will be taken. Student feedback on the overall course delivery and content will be taken in the last class through a questionnaire survey.

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	52	Review and Questionnaire survey	2
Students' group presentation	4	In-course exam	2

Assessment

There will have at least two In-course tests. A total of 30 marks will be allocated for In-course exams and 5 marks for class attendance. Another 5 marks will be allocated for surprise test/oral presentation/assignment. A course final examination, consisting of 60 marks will be conducted centrally by the university. The students will be frequently asked questions in the classrooms to assess individual's performance.

References

Brown, T. 2012. Introduction to Genetics: A Molecular Approach. Garland Science Publisher, UK.

Glick, B.R and Pasterniak, J.J. 2003. *Molecular Biotechnology- Principles and Applications of Recombinant DNA*. 4th edition. ASM Press, Washington, DC, USA. (https://www.academia.edu/28272521/Molecular_BiochemistryBernard_R_Glick_Jack_J_Pasternak_Cheryl_L_Patten_pdf)

Primrose, S.B. and Twyman, R.M. 2010. *Principles of Gene Manipulation and Genomics.* 7th edition. Blackwell Publishing, UK.

Sambrook, J. and Russell, D.W. 2001. *Molecular Cloning (A Laboratory Manual)*, Vol. 1, 2 & 3, 3rd edition. Cold Spring Harbor Laboratory Press, USA.

Snustad D.P. and M.J. Simmons. 2015. *Principles of Genetics*. 7th Ed. John Willey and Sons. Inc, USA. (PDF available: https://www.slideshare.net/hijobaba/principles-of-genetics-6-e-isbn-978-0470903599-snustad-simmons)

Course No.	Course Title	No. of Credits	Credit Hours
ZG 649	**Molecular Ecology and Conservation Genetics**	**4**	**60**

Introduction to the course

Abundance of many animal species on the earth are declining and facing the risk of extinction and thus causing loss in all components of biodiversity. Reduction in faunal and floral diversity and population results in the erosion of genetic diversity. On other way, loss of genetic diversity enhances further reduction of population size. Genetic architecture of the species population is a major factor to be considered while devising strategies to save a species from extinction. This course is designed to equip student with appropriate knowledge and skills of molecular biology and population genetics required for studying, managing and conserving species or populations under extinction risks.

Specific objectives of the course

- To make the students understanding on how genetics can be used in species conservation.
- To enhance students; knowledge on the population genetic factors that influence species extinction
- To help students to devise appropriate strategies for the management of a species population

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Molecular Ecology	
Concepts in molecular ecology;	**1**
Molecular markers (mitochondrial and nuclear) – ribosomal DNAs, RAPD, RFLP, AFLP, microsatellites;	**5**
Hardy-Weinberg Principle; mutation; migration; genetic drift and effective population size;	**9**
Natural Selection on genotypes;	**1**
Measuring population structure with F-statistic;	**1**
Quantitative genetics; estimating heritability;	**1**
Phenotypic plasticity;	**1**
Epigenetics;	**1**
Invasive species;	**1**
Molecular evolution;	**1**
Population genetic analyses and computer simulations (POPULUS).	**1** **1**
Conservation Genetics	
Application of genetics in conservation;	**1**
Characterizing and observing genetic diversity;	**2**
Population size reduction and loss of genetic diversity;	**3**
Inbreeding depression;	**4**
Fragmentation of populations and gene flow;	**3**
Defining genetic management units;	**1**
Genetic management of wild and captive populations;	**6**
Genetic management considerations for re-introduction;	**3**
Population Viability Analysis (PVA), endangerment and extinction.	**2**

Learning outcomes

After completion of the course, the students will be able to-

- know the relevance of the use molecular approach in species conservation;
- use molecular markers relevant for studying a population;
- measure genetic diversity of a population;
- take appropriate strategies for the revival of an endangered species; and
- use molecular data in solving ecological problems.

Instructional strategies

The course will be delivered through lectures and discussions, aided by power point presentations, video clips, etc. Classes will be made participatory and interactive through questions and answers, brainstorming, oral presentations and group exercises in the classroom**.**

Distribution of class lectures: Total number of classes/lecture: 60

Class/lecture types	Number of classes	Class/lecture types	Number of classes
Lecture and discussion	50	Review class	2
Students' group presentation	3	In-course exam	2
Feedback on in-course exams	2	Student feedback on course contents and delivery	1

Assessment

There will have at least two In-course tests. A total of 30 marks will be allocated for In-course exams and 5 marks for class attendance. Another 5 marks will be allocated for surprise test/oral presentation/assignment. Questions for In-course tests will be subjective or objective types as per instruction of the course teacher. The students will be frequently asked questions in the classrooms to assess individual performance. A course final examination, consisting of 60 marks, will be conducted by the university.

References

Allendorf, F.W. and Luikart, G. 2007. *Conservation and the Genetics of Populations.* Blackwell Publishing, UK.

Frankham, R., Ballou, J.D. and Briscoe, D.A. 2002. *Introduction to Conservation Genetics.* Cambridge University Press, UK.

Frankham, R., Ballou, J.D., Briscoe, D.A. and McInnes, K.H. 2004. *A Primer of Conservation Genetics.* Cambridge University Press, UK.

Hedrick, P.W. 2011. *Genetics of Populations.* 4th edition. Jones and Bartlett Publishers, USA.

Pierce, B.A. 2005. *Genetics: A Conceptual Approach.* 2nd edition. W.H. Freeman and Company, New York, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZG 655	**Practical Genetics and Molecular Biology**	**6**	**90**

Introduction to the course

This course is designed to enhance student's ability and practical skills in extraction and analytical procedures and techniques related to DNA study, karyotyping, phylogenetic analysis, interpreting genetic data, etc. It will provide hands-on experience in many modern techniques used in genetics and molecular biology. The experiments have been chosen to give students a solid foundation on the areas concerned. A strong emphasis is also placed in the acquisition of basic skills (such as writing, communication, computing, problem-solving and experimental design) in the laboratory.

Specific objectives of the course

- To introduce the students to the methods and techniques related to DNA study, karyotyping and population study, and gather skills in the extraction and analysis of DNA and related analytical procedures.
- To enable student data mining, pairwise and multiple sequence alignment using bioinformatics tools such as NCBI blast, SeaView, Serial Cloner, MEGA.
- To enable students to perform experimental trail and culture, maintain experimental species in the laboratory conditions.

Course contents and number of classes by course sub-title

Title/sub-titles of course contents	No. of classes
Basic Genetics Animal models of genetics – Culturing fruit fly, mosquito, zebra fish, ornamental fish, mouse etc. as instructed by the course teachers	**6**
Cytogenetics Karyotyping of selected animal species	**3**

Molecular Genetics a) Estimation of total protein/nucleic acids; b) Isozyme study using PAGE; c) Genomic DNA isolation and PCR analysis	**6**
Bioinformatics a) Gene annotation (BLAST, Annotation programmes); b) Primer design; c) Regulatory elements analysis; d) Multiple sequence alignment; e) Molecular phylogenetic tree construction; f) Protein modelling, docking	**5**
Population Genetics Data analysis- a) measuring genetic diversity; b) Use of software's (e.g. POPULUS)	**2**
Assignments	**2**

Learning Outcomes

After completion of the course, the students will be able to-

- perform karyotyping and make appropriate diagnosis from background information of the karyotype performed;
- use DNA extraction techniques and to isolate genomic DNA from a variety of organisms;
- screen for any part of the extracted DNA using the Polymerase Chain Reaction (PCR);
- perform spectrophotometry to identify compounds and measure their concentrations in a wide variety of experimental situations;
- perform data mining, pairwise and multiple sequence alignment using bioinformatics tools such as NCBI blast, SeaView, Serial Cloner, MEGA ;
- carry out phylogenetic analysis and predict protein structure;
- culture, maintain genetic model organism different environmental conditions;
- appreciate the basics of the karyotyping and identify selected chromosomal abnormalities and their clinical outcomes;
- design quality PCR primers and understand directionality and specificity; and
- align pairwise and multiple sequence, construct phylogenetic tree and predict protein structures.

Instructional Strategies

This practical course will be based on practical demonstration classes, hands-on training, lectures and performing a few laboratory based experimentations. Two-three teachers will demonstrate and guide every individual student in the laboratory.

Classes will be made participatory and interactive through questions and answers. Students' analytical ability and problem-solving capacity will be tested by creating different imaginary problems related to respective topics. All necessary equipment and chemicals will be provided to the students during demonstration class or laboratory experimental trails. Students are also supposed to prepare practical assignment on a particular topic and to report/present the findings as per class room instructions. A number of field/laboratory visits will be organized by course teachers.

Distribution of class lectures: Total number of classes/lecture: 30 (3 hours per class)

Class/lecture types	Number of practical classes	Class/lecture types	Number of practical classes
Lecture, discussion, laboratory experiments and hands-on training	24	Research project design and assessment	2
Feedback on in-course exam and group presentation	2	In-course exam	2

Assessment

Assessment will be done on class attendance (5%), In-course examination (35%) and final examination (60%). Two in-course examinations will be taken for this course. In-course assessment will consist of class examinations, assignments, notebooks and field reports and

consisting 27.5 marks. Project report 25 marks and class attendance 7.5 marks. A portion of in-course marks will be allocated for continuous assessment through observations of student at work and assignments.

References

Dubey R.C. 2014. *A Text Book of Biotechnology*. 5th Ed. SC & Co. Pvt. Ltd. India.

Glick, B.R. and Pasterniak J.J. 2003. *Molecular Biotechnology- Principles and Applications of Recombinant DNA*. 3rd edt. ASM Press, Washington, DC, USA.

Maniatis T. 1991. *Molecular Cloning (A Laboratory Manual),* 1st ed., Cold Spring Harbor Laboratory Press, New York, USA.

Sambrook, J. and Russell, D.W. 2001. *Molecular Cloning - A Laboratory Manual,* Vol. 1, 2 & 3, 3rd edition. Cold Spring Harbor Laboratory Press, New York, USA.