

**UNIVERSITY OF THE PUNJAB**

**NOTIFICATION**

It is hereby notified that the Syndicate at its meeting held on 17-12-2022 has approved the recommendations of the Academic Council made at its meeting dated 24-11-2022 regarding approval for grant of permission to start Ph.D. Entomology Program at the Department of Entomology and its Curriculum with effect from the Academic Session, Spring 2023.

The Curriculum of Ph.D. Program in Entomology is attached, vide Annexure 'A'.

Admin. Block,  
Quaid-i-Azam Campus,  
Lahore.

*Sd/-*  
Shahid Javed  
Registrar

No. D/ 645 /Acad.

Dated: 25-01-2023.

Copy of the above is forwarded to the following for information and further necessary action: -

1. The Dean, Faculty of Agricultural Sciences
2. The Chairman, Department of Entomology
3. Chairperson, DPCC
4. Controller of Examinations
5. Director (IT) for placement at website.
6. Admin Officer (Statutes)
7. Secretary to the Vice-Chancellor
8. Secretary to the Registrar
9. Assistant Syllabus (with file)

*Mazhar*  
Assistant Registrar (Academic)  
for Registrar

**CURRICULUM**  
**OF**  
**ENTOMOLOGY**

**BS/BSc (Hons) Agriculture**  
**MS/MSc (Hons) Agriculture**  
**PhD Entomology**

**(Revised 2014)**



**HIGHER EDUCATION COMMISSION**  
**ISLAMABAD**

# **CURRICULUM DIVISION, HEC**

Prof. Dr. Mukhtar Ahmed	Chairman HEC
Mr. Fida Hussain	Director General (Acad)
Mr. Rizwan Shoukat	Deputy Director (Curri)
Mr. Abid Wahab	Assistant Director (Curri)
Mr. Riaz-ul-Haque	Assistant Director (Curri)

Composed by: Mr. Zulfiqar Ali, HEC, Islamabad

# CONTENTS

<b>1. Introduction</b>	<b>6</b>
<b>2. Scheme of Studies for BSc (Hons)</b>	<b>10</b>
<b>Detail of Courses</b>	<b>11</b>
<b>3 Scheme of Studies (5<sup>th</sup> to 8<sup>th</sup> Semester)</b>	<b>14</b>
<b>Detail of Courses</b>	<b>16</b>
<b>4 Curriculum for MSc (Hons) and PhD</b>	<b>35</b>
<b>Detail of Courses</b>	<b>37</b>
<b>5 Recommendations</b>	<b>63</b>
<b>6 Details of Compulsory Courses</b>	<b>65</b>
<b>Annexures – A, B, C, D, E</b>	

# PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “Supervision of Curricula and Textbooks and Maintenance of Standard of Education”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

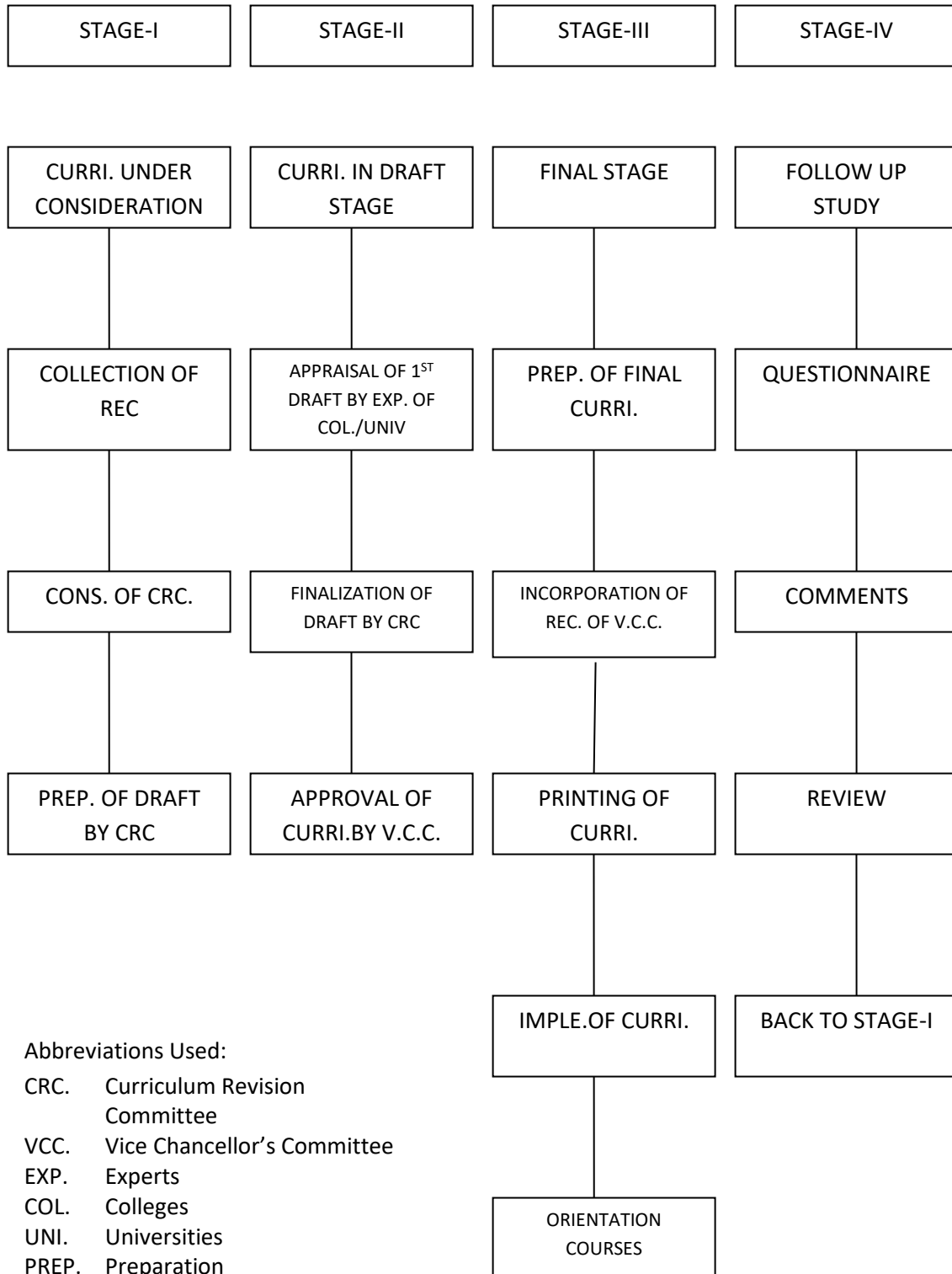
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC’s, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC ([www.hec.gov.pk](http://www.hec.gov.pk)).

**(Fida Hussain)**  
**Director General (Academics)**

# CURRICULUM DEVELOPMENT PROCESS



**Abbreviations Used:**

- CRC. Curriculum Revision Committee
- VCC. Vice Chancellor's Committee
- EXP. Experts
- COL. Colleges
- UNI. Universities
- PREP. Preparation
- REC. Recommendations

## INTRODUCTION

The meetings of National Curriculum Revision Committee for BS/BSc (Hons) (4 years), MS/MSc (Hons) (2 years) and PhD courses of Agriculture in Entomology were held on 09-11 October, 2013 at HEC Regional Centre, Islamia University Bahawalpur and 17-19 March, 2014 at HEC Regional Centre, Peshawar to revise and finalize the curricula at Graduate (4 years Program) and Post-Graduate (MS and PhD) level. Following members attended the meeting:-

Prof. Dr. Mohammad Naeem,  
Chairman,  
Department of Entomology,  
The University of Agriculture, Peshawar.

Convener/  
President

Prof. Dr. Muhammad Afzal,  
Dean,  
Faculty of Agriculture,  
Department of Entomology,  
University College of Agriculture,  
University of Sargodha, Sargodha

Member

Prof. Dr. Mian Inayatullah,  
Dean,  
Faculty of Crop Protection Sciences  
Department of Entomology,  
The University of Agriculture, Peshawar

Member

Prof. Dr. Farkhanda Manzoor,  
Department of Zoology,  
Lahore College for Women University,  
Lahore.

Member

Prof. Dr. Rana Hadi,  
Department of Zoology,  
Jinnah University for Women,  
5-C, Nazimabad, Karachi-74600

Member

Prof. Dr. Mansoor ul Hassan,  
Department of Entomology,  
University of Agriculture,  
Faisalabad

Member

Prof. Dr. Muhammad Faheem Malik,  
Dean / Director  
Faculty of Science,  
University of Gujrat

Member

Prof. Dr. Muhammad Naeem, Chairman, Department of Entomology, PMAS, Arid Agriculture University, Rawalpindi.	Member
Dr. Ehsan ul Haq, Principal Scientific Officer/Associate Professor, Department of Plant & Environmental Protection, Park Road, Islamabad. National Agricultural Research Centre (NARC).	Member
Dr. Abdul Ghani Lanjar, Associate Professor, Faculty of Crop Protection, Department of Entomology, Sindh Agriculture University, Tandojam.	Member
Dr. Muhammad Waqar Hassan, Assistant Professor, Department of Entomology, University College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Bahawalpur.	Member
Dr. Sumaira Afsheen, Assistant Professor, Department of Entomology, Hafiz Hayat Campus, Gujrat University of Gujrat.	Member (in preliminary meeting)
Dr. Abdul Manan Shaikh, Assistant Professor, Department of Zoology, Shah Abdul Latif University, Khairpur Mirs.	Member
Dr. Syed Basit Rasheed , Assistant Professor, Department of Zoology, University of Peshawar, Peshawar.	Member
Dr. M. Anjum Aqeel, Assistant Professor, Department of Entomology, University College of Agriculture, University of Sargodha, Sargodha.	Member



Dr. Muhammad Kashif Zahoor, Member  
Assistant Professor,  
Department of Zoology, Wildlife & Fisheries,  
Government College University, Faisalabad.

Dr. Muhammad Razaq, Member  
Chairman/Teacher In-charge,  
Department of Entomology,  
Bahauddin Zakariya University, Multan.

Dr. Shahbaz Ahmad, Member  
Assistant Professor  
Institute of Agricultural Sciences  
University of the Punjab.

Dr. Javaid Iqbal, Member /  
Secretary  
Head, Department of Entomology  
University College of Agriculture and Environmental  
Sciences, The Islamia University,  
Bahawalpur

The meeting started with recitation of few Verses from the Holy Quran by Mr. Riaz-ul-Haque, Assistant Director (Curriculum), HEC while Mr. Fida Hussain, Director General (Academics), presided over the inaugural session and highlighted the aims and objectives of the National Curriculum Revision Committee. He emphasized that the main purpose of revision and devising the curriculum is to bring it at par with the international standard and meet the demand of local market comprising public and private sector. He also stressed the need of new curriculum to facilitate colleges / universities / institutes for teaching Entomology according to the requirements of the agricultural departments / universities of Pakistan. He requested the experts to adhere to the template already proposed in the earlier meeting of Deans / Heads at the HEC. The Committee unanimously nominated Dr. Mohammad Naeem, Professor & Chairman Department of Entomology, the University of Agriculture, Peshawar as Convener/ President and Dr. Javaid Iqbal, Head, Department of Entomology, University College of Agriculture & Environmental Sciences, the Islamia University Bahawalpur as Secretary of the meeting. Both the nominated personnel's thanked the participants and pledged that in drafting the course, the opinion of each and every member would be given utmost importance.

Before formal session, the members were requested to deliberate on the different issues of curriculum revision of Entomology. Each honorable member actively participated and proposed the desired amendments keeping in view the above mentioned objectives of HEC.

The Committee unanimously decided the template for 4 year BSc (Hons) Agriculture in Entomology with the following number of credit hours.

<b>Semester</b>	<b>Credit Hours</b>	<b>Total</b>
1+2+3+4	18+18+18+18	72
5+6+7+8	15+16+16+13	60
Total= 132 Credit Hours		

It was also requested that the universities may add 3 courses of 8 credit hours thus making grand total of not exceeding 140 credit hours keeping in view their available facilities and expertise. The Committee further improved the objectives, course contents pertaining to theory and practical, and books recommended for each subject to be taught to the students of BSc (Hons) Entomology, MSc (Hons) Entomology and PhD Entomology.

### **AIMS AND OBJECTIVE:**

1. Entomology, the study of insects has developed into a very large division of the animal sciences owing to their huge proportion in the animal kingdom and their importance in the applied fields. Substantial changes were made throughout the curriculum which has been updated/expanded.
2. The main objective was to provide broad and balanced courses of Entomology. The intimacy between insect and environment was emphasized to the entomological research in many direction which later proved of immense value in the indigenous control measures so as to provide more food for the ever-growing population of Pakistan.

# CURRICULUM FOR MSc (Hons) and PhD ENTOMOLOGY

## SCHEME OF STUDIES

### NOTE:

1. For the award of degree for MSc (Hons) Entomology, thesis carries minimum of 6 credit hours.
2. Minimum credit hours of course work for MSc (Hons) Entomology (excluding thesis) should be 24 including minor subjects which shall not exceed one-third of the total course work.
3. For award of PhD degree, minimum credit hours of course work should be 18 (excluding thesis) followed by a comprehensive examination for granting candidacy as PhD researcher as per HEC guidelines.
4. PhD thesis must be evaluated by at least two PhD experts from technologically/academically advanced foreign countries in addition to local committee members as per HEC guidelines.

The following titles are recommended for Post-graduate courses for all the universities. However, each university shall be free to add more or re-arrange these in accordance with the facilities available. A student will take only those courses which the Supervisory Committee recommends for him/her.

<b>S.No.</b>	<b>Course No.</b>	<b>Title</b>	<b>Credit Hours</b>
1.	ENT-701	Research Methods in Entomology	3(2-1)
2.	ENT-702	Origin and Phylogeny of Insects	3(3-0)
3.	ENT-703	Environmental Entomology	2(2-0)
4.	ENT-704	Advanced Insect Morphology	3(2-1)
5.	ENT-705	Advanced Insect Ecology	3(2-1)
6.	ENT-706	Numerical Taxonomy	3(2-1)
7.	ENT-707	Advanced Insect Physiology and Embryology	3(2-1)
8.	ENT-708	Molecular Entomology	3(2-1)
9.	ENT-709	Insecticide Resistance and Management	3(2-1)

10.	ENT-710	Insects in Relation to Plant Diseases	3(2-1)
11.	ENT-711	Medical and Veterinary Entomology	3(2-1)
12.	ENT-712	Acarology	3(2-1)
13.	ENT-713	Classification of Immature Insects	3(2-1)
14.	ENT-714	Insecticide Toxicology	3(2-1)
15.	ENT-715	Insect Nutrition	3(2-1)
16.	ENT-716	Insecticides and Public Health	3(2-1)
17.	ENT-717	Advances in Biological Control of Insect	3(2-1)
18.	ENT-718	Advances in Insect Behaviour	3(2-1)
19.	ENT-719	Special Problem	1(1-0)
20.	ENT-720	Seminar	1(1-0)
21.	ENT-721	Pesticides Application Equipments	3(1-2)
22.	ENT-722	Advances in Pest Management Research	3(2-1)
23.	ENT-723	Insect Cytogenetics and Cytotaxonomy	3(2-1)
24.	ENT-724	Insect Pathology	3(2-1)
25.	ENT-725	Insect Biochemistry	3(2-1)
26.	ENT-726	Chemical Ecology of insects	3(3-0)
27.	ENT-727	Forensic Entomology	3(2-1)
28.	ENT-728	Insect Neurobiology	3(2-1)
29.	ENT-729	Insect Rearing Techniques	3(2-1)
30.	Thesis	MSc (Hons.) thesis	
31.	Thesis	PhD, thesis	

**Note:** *Courses taken for MSc (Hons) will not be taken again in PhD degree program as per HEC rules*

## DETAIL OF COURSES

**ENT-701 RESEARCH METHODS IN ENTOMOLOGY 3(2-1)**

### **LEARNING OUTCOMES:**

To enable students get familiarized with modern equipments used in Entomological Research and provide concept of software in data analysis.

### **THEORY:**

Introduction; techniques and apparatus for entomological research: temporary and permanent mounts, microtomy, use of ocular grid, micrometry and scientific photography; bio-assay techniques; atomic absorption spectrophotometer, gas chromatography, high performance liquid chromatography, UV-visual spectrophotometer, amino acid analyzer, electrophoresis, PCR, recombinant DNA techniques, ultra-centrifugation, scanning and transmission, electron microscopy and computer software/ bioinformatics in entomology; methods of sampling, analysis of data and report writing; lab/ field experimental techniques.

### **PRACTICAL:**

Insect sampling, collection and preservation techniques; rearing devices; exercises in microtomy, preparation of permanent slides, soft wares for morphometrics and data analysis; scientific photography; electron microscopy; maintenance and measurement of microclimate; bioassay; demonstration of insect DNA amplification through PCR methods. Us

e of different equipment in entomological experiments, tabulation, analysis and interpretation of data.

### **RECOMMENDED BOOKS:**

1. Bancroft, J.D. and Stevens, A. 1990. Theory and Practice of Histological Techniques. Chaschill Livingstone, London.
2. Binns, M.R. 2000. Sampling and Monitoring in Crop Protection. CABI Publishing Company
3. Cappiello, A. 2007. Advance in LC-MS Instrumentation. Elsevier Publishers, USA.
4. Erlich, H. 1992. PCR Technology: Principles and Applications for Amplification. W.H. Freeman & Company, New York.
5. Singh, P. and Moore, R.F. 1985. Handbook of Insect Rearing. Vol, I & II, Elsevier, U.S.A.
6. Dent, D., Walton, M. P. 1997. Methods in ecological and agricultural entomology, Published by CAB International, University of Michigan, USA
7. Drake, V. A., Reynolds, D. R. 2012. Radar Entomology: Observing Insect Flight and Migration. Published by C.A.B. International, University

**LEARNING OUTCOMES:**

To provide the basic concept of insect origin in the time dimension.

**THEORY:**

Introduction; evolutionary groups of insects; geological time table in relation to origin; evolutionary history of insects; theories of origin of insects; mechanisms of evolution: cytological, cytotaxonomic and embryological evidences; phylogenetic theories; origin of species and higher categories; phylogenetic arrangement of orders and families; variation; fossil history of insects.

**RECOMMENDED BOOKS:**

1. Dodson, E.C. and Dodson, I. 1986. Evolution, Process and Product. 4<sup>th</sup> Ed. I.W.S. Publishers.
2. Grimaldi, D. and Engel, M.S. 2005. Evolution of Insects. Cambridge University Press.
3. Hennig, W, 1981. Insect Phylogeny. Wiley Intersciences, London.
4. Kapoor, V.C. 1987. Origin and Evolution of Insects. Kalyani Publishers, New Delhi.
5. Triplehorn, C.A. and Johnson, N.F. 2005. Borror and DeLong's Introduction to the Study of Insects. Books Cole. 7th Ed.
6. Wiley, E.C. 1981. Phylogenetics. The Theory and Practice of Phylogenetic Systematics. John Wiley and Sons Inc., New York.

**ENT-703 ENVIRONMENTAL ENTOMOLOGY 2(2-0)**

**LEARNING OUTCOMES:**

To provide the basic concept of impact of environment on insects, and insects as indices of environmental changes.

**THEORY:**

Introduction; environment and its spheres, diversity of insects in different ecosystems; interactions of various groups of insects with biological, chemical and physical constituents of the environment; physical and chemical characterization of environmental contaminants, impact of pollutants on insects and non-target organisms at different levels; biological responses to pollutants and biogeochemical cycles; insects as indicators of levels of pollution. GIS in relation to insects.

## **RECOMMENDED BOOKS:**

1. Cbiran, D.D. 2010. Environmental Science. 8<sup>th</sup> Edition Jones and Bartlett Publishers, London
2. Gregory, K.J. Simmons, I.G. Brazel, A.J. Day, W.J. Keller, E.A. Sylverter, A.G. and Yanez. A,A. 2009. Environmental Science: a Students companion. SAGE London.
3. Huffaker, C.B. 1999. Ecological Entomology. John Wiley Sons.
4. McEwen, F.L. and Stephenson, G.I. 1979. The Use and Significance of Pesticides in the Environment. John Wiley and Sons Inc., N.Y.
5. Perry, A.S. 1998. Insecticides in Agriculture and Environment: Retrospects and Prospects. Elsevier, New York.
6. Ashfaq, M. and Saleem, M.A. 2010. Environmental Pollution and Agriculture. Pak Book Empire, Lahore, Pakistan.
7. Yazdani, S.S. and Agarwal, M. I. 1997. Elements of Insect Ecology. Narosa Publishing House, New Delhi.
8. Ananthakrishnan, T. N. and Sivaramakrishnan K. G. 2008, Ecological Entomology : Insect life in odd Environment, Scientific Publication 142 pp

## **ENT-704    ADVANCED INSECT MORPHOLOGY            3(2-1)**

### **LEARNING OUTCOMES:**

To provide the concept of structure and function of various organs and organ systems of insects.

### **THEORY:**

Introduction; comparative morphology, structure of integument, sclerites and processes (setae, spines, spurs, scales, etc.); structure of insect head and its endo-skeleton; appendages and modifications of insects mouth-parts; segmentation of head, thorax and their appendages; endo-thorax, modification of wings, wing coupling apparatus, wing development, modification of insect leg, abdomen and its appendages, insect genitalia, development in various insect orders and families; proctiger and caudal appendages, morphology of digestive, circulatory, respiratory, excretory, nervous, muscular and reproductive organs, scent, sound and light producing apparatus; tricho-bothria in adult and immature insects; thermoregulatory, visual, auditory and glandular organs in insects.

### **PRACTICAL:**

Comparative structure of insect head, thorax, abdomen and their appendages in different insect orders; preparation of temporary and permanent mounts of different body parts and integument; comparative

structure of genitalia in various insect orders, examination of different types of setae, spines, spurs and scales in insects; dissection of soft-parts and organ systems; study of visual, auditory, thermoregulatory, scent, sound producing and luminous organs.

### **RECOMMENDED BOOKS:**

1. Chapman, R.F. 2002. The Insects: Structure and Function. 3<sup>rd</sup> Ed. Hodder and Stoughton Ltd., U.K.
2. Duporte, E.M. 1977. Manual of Insect Morphology. Reinhold Publishing Corp., N.Y.
3. Kerkut, G.A. and Gilbert, L.I. 1985. Comprehensive Insect Physiology, Biochemistry and Pharmacology. Vols. 1-12, Pergamon Press, Oxford, New York, Toronto, Sydney, Paris, Frankfurt
4. Matsuda, R. 1970-75. Morphology and Evolution of Insect Head, Thorax, Abdomen. Mem. Ent. Soc. Canada.
5. Matsuda, R. 1975. Morphology and Evolution of Abdomen. Pergamon Press.
6. Rockstein, M. (Edit.). 1973-1974. Advances in Insect Physiology. Vols. 1-6 2<sup>nd</sup> Edition. Academic Press, N.Y.
7. Snodgrass, R. 1993. Principles of Insect Morphology. Cornell Uni. Press, U.S.A.
8. Beutel, R. G. and Friedrich, F. 2013. Insect Morphology and Phylogeny. Science. 450 pages.
9. DuPorte, E. M. 1959. Manual in Insect morphology. Reinhold Press. University of Minnesota, USA

## **ENT-705    ADVANCED INSECT ECOLOGY    3(2-1)**

### **LEARNING OUTCOMES:**

To provide the advance concepts of population growth of insects in different environmental parameters and to simulate the population structures in various climatic conditions to software technology.

### **THEORY:**

Population growth, theories, life-tables, key factors, analyses, regression, co-existence, co-habitation, competition and mutual displacement, variation, speciation and diversity. A mathematical approach to the dynamics of single and multi-species populations and communities with analytical and simulation model techniques: mathematical and statistical techniques applied to population systems and community ecologies; critical survey of models of population growth, niche matrices, competition, predation, ecological genetics, species diversity and distribution, and ecological succession.



## **PRACTICAL:**

Use of computer simulations in population of insects: computer modeling used by Ecologists to clarify and interpret large field data by clustering, transforming, matrices and multi-variate analysis.

## **RECOMMENDED BOOKS:**

1. Atwal, A.S. and Bains, S.S. 2005. Applied Animal Ecology. Kalyani Publishers, Ludhiana.
2. Bernstein, R. 2003. Population Ecology: An Introduction to Computer Simulations. Willy, New York.
3. Blackith, R.E. and Rayment, R.A. 1984. Multivariate Morphometrics. Academic Press, London.
4. Price, P.W. 2003. Insect Ecology. 3rd Ed. Wiley Interscience Publishers, N.Y.
5. Rockwood, L.L. 2006. Introduction to Population Ecology. Wiley, John & Sons, Incorporated.
6. Southwood, T.R.E. and Henderson, P.A. 2000. Ecological Methods. 3<sup>rd</sup> Ed. Wiley-Blackwell.
7. Vandermeer, J.H. and Goldberg, D.E. 2003. Population Ecology: First Principles. Princeton University Press.
8. Schowalter, T. D. 2011. Insect Ecology: An Ecosystem Approach. 3rd Ed. Elsevier Inc. Jamestown Road, London.
9. Denno, R. F. and Eubanks, M. D. 2011. Insect Ecology: Behavior, Populations and Communities. Cambridge University Press, New York. USA.

## **ENT-706 NUMERICAL TAXONOMY 3(2-1)**

### **LEARNING OUTCOMES:**

To provide awareness of mathematical modeling of the origin of various insect groups and their relationships.

### **THEORY:**

Introduction; aims and principles of numerical taxonomy; data and its types; taxonomic characters, their selection, coding and weightage; parsimony, handling of data; taxonomic evidence, estimation of taxonomic resemblance, construction of a taxonomic system; theory of ranking; population analysis by different methods; phenetic analysis; comparison of faunal elements and contemporary approach to classification; phenograms / dendrograms /cladogram/phylogram.

## **PRACTICAL:**

Characterization, coding and preparation of matrices, generation of phenograms by applying coefficients of association, correlation and taxonomic distance formulae; parsimony, construction of phenograms/dendrograms/cladogram.

### **RECOMMENDED BOOKS:**

1. Clifford, H.T. and Stephenson, W. 1986. An Introduction to Numerical Classification. Academic Press, New York, London.
2. Dung, G. and Everitt, B.S. 1982. An Introduction to Mathematical Taxonomy. Cambridge Uni. Press, Cambridge.
3. Duncan, T. and Stuessy, T.F. (Eds.) 1985. Cladistics. Theory & Methodology. New York, Van Nostrand Reinhold, Press.
4. Blackith, R.E. and Rayment, R.A. 1984. Multivariate Morphometrics. Academic Press, London.
5. Sneath, P.H.A. and Sokal, R.P. 1973. Numerical Taxonomy. W. R. Freeman & San-Francisco, USA.
6. Wheeler, Q.D. 2008. The New Taxonomy. CRC Press London, New York.

## **ENT-707      ADVANCED INSECT PHYSIOLOGY AND                          EMBRYOLOGY**

**3 (2-1)**

### **LEARNING OUTCOMES:**

To provide concepts of comparative physiology, their functions and origin in different insect orders and families.

### **THEORY:**

Introduction; advances in physiology of integument, growth, development, diapause, digestion, respiration, circulation, excretion, reproduction, reception and perception; neuro-muscular physiology; enzymatic functions, biological clocks; embryonic development and organogenesis in different groups of insects; study of comparative embryology in different groups of insects, physiology of locomotion and resistance; hormones, pheromones, glandular secretion, thermoregulation, sound and light production.

### **PRACTICAL:**

Genetic and hormonal control of insect growth, development and breaking of diapause; digestion in different parts of alimentary canal and salivary glands; oxygen consumption, carbon dioxide production and determination of respiratory quotient; qualitative and quantitative analysis of haemocytes; estimation of blood proteins, uric acid in excreta and water loss; pheromones as sex attractants; determination of visual, gustatory, olfactory, acoustic, thermoregulatory responses and experiment on wing beat frequency.

## **RECOMMENDED BOOKS:**

1. Berridge, M.J. and Treherne, J.E. 1982. Advances in Insect Physiology. Vol 16, Academic Press Inc.
2. Blum, M.S. 1985. Fundamentals of Insect Physiology. John Wiley and Sons, N.Y.
3. Chapman, R.F. 1998. The Insects; Structure and Function. 4<sup>th</sup> Ed. American Elsevier Publishing Co., Inc. N.Y.
4. Howse, P. Stevens, I. and Jones, O. 1998. Insect Pheromones and their Use in Pest Management. Chapman and Hall, London.
5. Kerkut, G.A. and Gilbert, L.I. 1985. Comprehensive Insect Physiology, Biochemistry and Pharmacology. Vols. 1-12, Pergamon Press, Oxford, New York, Toronto, Sydney, Paris, Frankfurt.
6. Rockstein, M. (Edit.). 1973-1974. Advances in Insect Physiology Vols. 1-6 2<sup>nd</sup> Ed. Academic Press, N.Y.
7. Wigglesworth, V.B. 1984. Insect Physiology, Springer.

## **ENT-708 MOLECULAR ENTOMOLOGY 3(2-1)**

### **LEARNING OUTCOMES:**

To provide the modern concepts of molecular Entomology and its applications..

### **THEORY:**

Introduction; Insects as a model for molecular study (Drosophila, Red flour beetle, Mosquitoes, Honeybee). insect genomes; nucleus, chromosomes, DNA and RNA; Gene structure and function; gene transcription and translation; concept of introns and exons; central dogma of molecular biology; Primer Design and polymerase chain reaction (PCR), gene cloning and sequencing; restriction analysis, gene libraries; mitochondrial and genomic DNA for insect species identifications and insect population diversity/biotyping; Use of molecular markers in insects, DNA for phylogenetic analysis and construction of phylogenies; RAPD, RFLP, PCR-RFLP, microsatellites and SNPs; linkage and chromosomal mapping, genes regulatory processes, mutagenesis; molecular basis of insect functions (insect behavior, insecticidal resistance), gene knock-ins and knock-outs by RNA interference, barcoding, DNA and protein sequence alignments and use of bioinformatics tools.

### **PRACTICAL:**

Demonstration of insect DNA extractions, PCR amplification, gel electrophoresis, gene cloning and plasmid DNA extractions, DNA hybridization (Southern and northern blots); RAPD, RFLP analysis techniques, use of Bio-

Informatics software tools.

### **RECOMMENDED BOOKS:**

1. Gilbert, L. 2005. Comprehensive Molecular Insect Science. 1-7 Vol.
2. Glick, B.R. and Pasternek, J..J. 1998. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press. Washington D.C.
3. Hall, B.G. 2007. Phylogenetic Trees Made Easy: A How to Manual. 3<sup>rd</sup> Ed. Sinauer Associates.
4. Handler, A. M. James, A.A. (Eds.).2004. Insect Transgenesis: Methods and Applications, Comprehensive review of insect gene transfer, its methodologies, applications and risk assessment and regulatory issues. CRC Press.
5. Alfred M. Handler, Anthony A. James. 2000. Insect Transgenesis: Methods and Application. CRC Press.
6. Hoy, M.A. 2013. Insect Molecular Genetics. An Introduction to Principles and Applications, Academic Press. 3<sup>rd</sup> Edition
7. Glick, B.R. Pasternak, J.J. and Patten C.L. 2009, Molecular Biotechnology: Principles and Applications of recombinant DNA. ASM Press Publishers. 4<sup>th</sup> Edition.
8. Walker, J.M. and Rapley, R. 2009. Molecular Biology and Biotechnology Royal Society of Chemistry Publishers. 5<sup>th</sup> Edition.
9. Smith, J.E. 2009. Biotechnology. Cambridge University Press; 5<sup>th</sup> Edition
10. Acquaah, G. 2003. Understanding Biotechnology: An Integrated and Cyber-Based Approach. Prentice Hall; 1 edition.
11. Blomquist, G.J. and Richard, G.V. 2003. Insect pheromone biochemistry and molecular biology, Elsevier Academic.

## **ENT-709 INSECTICIDE RESISTANCE AND MANAGEMENT**

**3(2-1)**

### **LEARNING OUTCOMES:**

To provide the modern concepts of insecticide resistance in various insect populations.

### **THEORY:**

Introduction; development and types of resistance; mechanism of resistance: physiological, behavioural, biochemical and genetic; metabolism of insecticides; detoxification mechanism in insects: phase-I reactions such as oxidation, hydrolysis, reduction and dehydrochlorination; phase-II reaction such as conjugation; multiple pathways, induction of detoxification enzymes; management of resistance; case histories of insecticide resistance management (IRM).

## **PRACTICAL:**

Determination of resistance, monitoring, development of resistant and susceptible strains, collection of potentially resistant strains of insects from the insecticide sprayed fields; biochemical basis of resistance; demonstration of resistance breaking techniques.

## **RECOMMENDED BOOKS:**

1. Denholm, I. 1999. Insecticide Resistance from Mechanism to Management. Prentice Hall. London.
2. Green, M.B. LeBaron, H.M. and Moberg, W.K. (Eds.). 1990. Managing Resistance to Agrochemicals. American Chemical Society. Washington.
3. Gupta, H.C.L. 1999. Insecticides: Toxicology and Uses. Agrotech Publishing Academy, Udaipur.
4. Onstand, D.W. 2007. Insect Resistance Management. Academic Press.
5. Pedigo, L.P. and Marlin, E. R. 2009. Entomology and Pest Management, 6th Edition, Person Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
6. Peshin, R. 2009. Evaluation of Insecticide Resistance Management Program: Theory and Practice.
7. Roush, R.T. and Tabashnik, B.E. (Eds.). 1990. Pesticide Resistance in Arthropodes. Chapman & Hall. New York.
8. Saleem, M. A. 2005. Insecticides Resistance and Management. B.Z. University Press, Multan.
9. Tlo, D. and Webbler, B. 1992. Insecticides Mechanism of Action of Resistance. Intercept Ltd. UK.
10. US National Academy of Sciences. 1986. Pesticide Resistance: Strategies and Tactics for Management. National Academy Press. Washington.
11. Walia, S. and Parmar, B.S. 1995. Pesticide, Crop Protection and Environment. Oxford & IBH Publishing Co. New Delhi, Calcutta.
12. Watson, D.L. and Brown, A.W. 1997. Pesticide Management and Insecticide Resistance. Academic Press Inc. USA.
13. Wilkinson, C.F. 1976. Insecticides Biochemistry and Physiology. Heyden, London, New York, Rheine.
14. Onstad D. W. 2008. Insect Resistance Management: Biology, Economics, and Prediction. Academic Press, Elsevier Ltd. Jamestown Road, London UK.

**ENT-710      INSECTS IN RELATION TO PLANT      3(2-1)**  
**DISEASES**

**LEARNING OUTCOMES:**

To provide the broad overview of insects in relation to plant diseases with special emphasis on their vector status.

**THEORY:**

Introduction; identification, biology of insect and mite vectors of plant diseases; mode of transmission of plant pathogens by insects and mites; insect adaptation for pathogen transmission, interrelationship of insect, plant and microorganism, horizontal and vertical transmission, beneficial microorganisms in insect control, study of causal organisms, etiology, symptoms and control of important fungal, bacterial and viral diseases of crop plants transmitted by insects and mites.

**PRACTICAL:**

Identification of insect and mite vectors and pathogens; rearing and handling of insect vectors for plant pathological studies. Study of mode of transmission of plant pathogens by insect and mite vectors.

**RECOMMENDED BOOKS:**

1. Boucias, D.G. 1998. Principles of Insect Pathology. Chapman Hall, London.
2. Jeppson, L.R. Keifer, H.H. and Baker, E. W. 1975. Mites Injurious to Economic Plants. Univ. Calif. Press.
3. Leach, J.B. 2007. Insect Transmission of Plant Diseases. Biotech Books. Delhi, India.
4. Tanada, Y. 1992. Insect Pathology. Academic Press.
5. Cater, W. 1973. Insects in Relation to Plant Disease

**ENT-711      MEDICAL AND VETERINARY ENTOMOLOGY      3(2-1)**

**LEARNING OUTCOMES:**

To provide the knowledge of identification, biology, epidemiology of insects and other arthropods of medical importance.

**THEORY:**

Introduction; epidemiology; identification, biology and management of insects and other arthropods of medical and veterinary importance;

insect and some other arthropods transmitting diseases, their symptoms and diagnosis; venoms, defense secretions and allergens. Economics of livestock and poultry pests with emphasis on different flies, midges, mosquitoes, ticks, mites, beetles and other important insects of medical and veterinary importance.

### **PRACTICAL:**

Surveillance, collection, identification and management of different insects and arthropod pests of medical and veterinary importance in relation to diseases of man and domestic animals.

### **RECOMMENDED BOOKS:**

1. Aldridge, B. 2004. Medical Entomology: Text Book of Public Health and Veterinary. Chapman and Hall, London.
2. Busvine, J.R. 1980. Insects and Hygiene. 3<sup>rd</sup> Ed. Chapman and Hall, London.
3. Harwood, R.F. and James, M.T. 1979. Entomology in Human and Animal Health. 7<sup>th</sup> Ed. Macmillan Publishing Co., Inc., N.Y.
4. James, M.T. and Harwood, R.F. 1969. Herms Medical Entomology. The Macmillan Company Canada.
5. Kettle, D.S. 1995. Medical and Veterinary Entomology. (2<sup>nd</sup> Ed.), CAB International, UK.
6. Mullen, G. 2009. Medical and Veterinary Entomology. 2<sup>nd</sup> Ed. Academic Press.
7. Service, M. 2004. Medical Entomology for Students. Cambridge University Press.
8. Williams, R.E. 2009. Veterinary Entomology: live stock & Companion Animals CRC press, 343 pp.
9. Tyagi, B.K. 2003, Medical Entomology: A Hand book of medically Important Insects & other arthropods Scientific Publisher 262 pp
10. Eldridge, F.B. & Edman, J.D. 2003. Medical Entomology: A textbook on Public Health and Veterinary problems caused by Arthropods. Kluwer Academic Publishers 672 pp

## **ENT-712 ACAROLOGY 3(2-1)**

### **LEARNING OUTCOMES:**

To provide knowledge of the importance of mites and their impacts on crops, vegetables, fruits and stored products.

### **THEORY:**

Introduction; methods of collection, rearing and preservation of different mites and other related organisms; external and internal morphology; physiology, reproduction and development; classification of mites, mites

as pests of important crops, vegetables, fruit trees, stored products and their management; parasitic and predatory mites; losses caused by and management of mite pests; ecology and dispersal; methods of estimation of mite population; mites and plant diseases; resistance mechanism in mites.

### **PRACTICAL:**

Collection, preservation, sampling and rearing techniques and identification of phytophagous, predatory, parasitic and stored grain mites; preparation of permanent slides of mites; estimation of mite population and losses in crops, vegetables, fruit plants and stored grains.

### **RECOMMENDED BOOKS:**

1. Chhillar, B.S. and Gulati, R. 2007. Agricultural Acarology. Daya Publishing House.
2. Evans, G.O. 1992. Principles of Acarology. C.A.B. International Cambridge University Press, Cambridge.
3. Helle, W. and Sabelis, M.W. (Edit.), 1985. Spider Mites, Their Biology, Natural Enemies and Control. Vols. IA. and IB. Elsevier Oxford, U. K.
4. Khuhro, R.D. 1998. Introduction to Acarology. Kashif Publications, Hyderabad (Sindh), Pakistan.
5. Krantz, G.W. 1978. A Manual of Acarology. 2<sup>nd</sup> Ed. Oregon State Univ. Book Store Inc., Corvallis, Oregon, USA.
6. Krantz, G.W. and Walter, D.E. 2009. A Manual of Acarology. Texas Tech. University Press.
7. Rodriguez, J.G. (Edit.), 1979. Recent Advances in Acarology. Vol. I & II. Academic. Press Inc., N.Y.
8. Schuster, R. and Murphey, P.W. 1991. The Acari, Reproduction, Development and Life History Strategies. Chapman & Hall, USA.
9. Woolley, T.A. 1988-01. Acarology, Mites and Human Welfare. JohnWiley & Sons.
10. Zhang, Z.Q. 2003. Mites of Green Houses: Identification Biology and Control. Elsevier, New York.
11. Sabelis, M. W. 2010. Trends in Acarology: Proceedings of the 12th International Congress. Springer Dordrecht Heidelberg London, UK.

## **ENT-713 CLASSIFICATION OF IMMATURE INSECTS 3(2-1)**

### **LEARNING OUTCOMES:**

To impart knowledge about important structure of eggs and immature stages of insects of different orders.

### **THEORY:**

Introduction; eggs and immature stages of insects; types of eggs and chaetotaxi of various immature stages for their identification purposes;



development of keys for identification of eggs and immature stages of economically important orders up to family level, classification and phylogeny of various insect groups through their eggs and immature stages.

### **PRACTICAL:**

Collection, preservation, preparation and identification of immature stages up to family level; study of chaetotaxi; use of keys for identification of eggs, larvae and immature stages and construction of cladograms by using the above characters.

### **RECOMMENDED BOOKS:**

1. Chu, H.F. 1983. How to know the Immature Insects. W.M.C. Brown Co., Publishers, Iowa, USA.
2. Johnson, F.N. and Triplehorn, A.C. 2004. Introduction to The Study of Insects. 7<sup>th</sup> Ed. Books Cole.
3. Lawrence, J.F. Hastings, A.M. Dallintz, M.J. Palmy, T.A. and Zurcher, E.J. 1999. Beetle larvae of the world. CSIRO. Australia.
4. Peterson, A.R. 1960. Larvae of Insects. Part-II, 4<sup>th</sup> Ed. Edwards Brothers Inc., Arbor, Michigan.
5. Peterson, A.R. 1962. Larvae of Insects. Part-I, 4<sup>th</sup> Ed. Edwards Brothers Inc., Arbor, Michigan.
6. Stehr, F. 1991. Immature Insects. Vol. I&II. Kendall - Hunt Publishing, U.S.A.

## **ENT-714                      INSECTICIDE TOXICOLOGY    3(2-1)**

### **LEARNING OUTCOMES:**

To impart knowledge about toxicity of important groups of insecticides in insects and higher animals with reference to their biochemical and genetic basis of mechanism of action.

### **THEORY:**

Introduction; general concepts of insecticide toxicology; theory and principles of bioassay; chemistry and comparative toxicology of some common insecticides; mechanism of action of major groups of insecticides; mammalian and phytotoxicity of insecticides; enzyme activation and inhibition by insecticides at various levels; detoxification mechanisms; joint action of insecticides, (synergism and antagonism); handling and standardization of insects in insecticide tests; methods for testing of formulations of different groups of insecticides under field and laboratory conditions.

### **PRACTICAL:**

Laboratory equipment used in toxicology experiments; gross symptoms produced by representative insecticide groups; relationship between dosages

and responses; use of time-mortality determination in comparing the relative toxicity of insecticides; preparation of spectral transmittance and concentration transmittance curves; bioassay of insecticides.

### **RECOMMENDED BOOKS:**

1. Gupta, H.C.L. 2001. Insecticides: Toxicology and Uses. Agrotech Publishing Academy, Udaipur.
2. Hassal, K.A. 1990. The Biochemistry and Uses of Pesticides: Structure, Metabolism, Mode of Action and Uses in Crop Protection. ELBS/Macmillan, U.K.
3. Ishaaya, I. and Degheele, D. 1998. Insecticides with Novel Modes of Action: Mechanism and Application. Norosa Publishing House, New Delhi, Madras, Bombay, Calcutta, London.
4. Robert. I. and Krieger, W.C. 2001. Handbook of Pesticide Toxicology. 2<sup>nd</sup> Ed. Elsevier Inc.
5. Saleem, M.A.2004. Principles of Insect Toxicology. Izhar sons Printers, Lahore.
6. Sree Ramulu, U.S. 1995. Chemistry of Insecticides and Fungicides. (2<sup>nd</sup> Ed.) Oxford & IBH Publishing Co. Pvt. New Delhi, Bombay, Calcutta.
7. Srivastava, R.P. 1989. A Text Book of Insect Toxicology. Himanshuw Publication.
8. Wilkinson, C.F. 1976. Insecticides Biochemistry and Physiology. Heyden, London, New York, Rheine.
9. Yu, S.J. 2008. The Toxicology and Biochemistry of Insecticides. University of Florida, USA.
10. Krieger, R. I. 2001. Handbook of Pesticide Toxicology. Vol-II. Academic Press. Orlando Florida.

## **ENT-715 INSECT NUTRITION**

**3(2-1)**

### **LEARNING OUTCOMES:**

To impart knowledge on insect synthetic diets for promotion of their natural growth and development.

### **THEORY:**

Introduction; dietary requirements of insects; micro and macro nutrients with their role in insects diet; determination of AD (approximate digestibility), ECI (efficiency of conversion of ingested food in bio mass), ECD (efficiency of conversion of digested food in to bio mass), RCR (relative consumption rate), RGR (relative growth rate), artificial diets for insects rearing; micro-organisms and insect nutrition, co-efficient of digestion, growth and development, metabolism; nutrition and host specificity; phago-stimulation, tritrophic interaction between insect and predator/parasitoids.

## **PRACTICAL:**

Preparation of synthetic diets for different groups of insects; rearing of insects on synthetic, semi-synthetic and natural diets; determination of co-efficient of utilization.

## **RECOMMENDED BOOKS:**

1. Cohen, A.C. 2004. Insect Diets: Science and Technology. CRC Press.
2. Gilmour, D. 1965. The Metabolism of Insects. Oliver and Boyed. Edinburgh and London.
3. Rodrigues, J. G. 1972. Insects and Mite Nutrition. Significance and Implications in Ecology and Pest Management. North Holland Publ. Co., Amsterdam, London.
4. Singh, P. 1977. Artificial Diets for Insects, Mites and Spiders. Plenum Publ. Corporation, N.Y.
5. Fraenkel, G. S. 1947. Bibliography on Insect Nutrition. Cornell University Press, USA
6. Rodriguez, J. G. 1973. Insect and mite nutrition: significance and implications in ecology and pest management, North-Holland Pub. Co.
7. Simpson, S. J. Mordue, A.J. and Hardie, J. 1999. Insect-Plant Relationships, Springer.
8. Taylor, S. 2005. Advances in Food and Nutrition Research, Elsevier Science.
9. Chapman, R.F. 1998. Insects: Structure and Function. 4<sup>th</sup> Ed. American Elsvier. Publ. Co. Inc., New York

## **ENT-716 INSECTICIDES AND PUBLIC HEALTH 3(2-1)**

### **LEARNING OUTCOMES:**

To provide advance concepts of insecticide poisoning, residual effects and their perception on safe use of insecticides.

### **THEORY:**

Insecticides poisoning and its importance to public health; toxic effects of insecticides on indoor inhabitants, farmers, field workers and their domesticated animals; distribution of pesticide residues in soil, ground water, drinking wells and air; symptoms of poisoning due to insecticide residues in blood, fat bodies and the acute diseases they cause; public health and environmental consideration; farmers perception of acute poisoning and safe measures; first aid procedures; laboratory verification; treatment of insecticide poisoning; insecticides monitoring; safe use of insecticides; knowledge of antidotes; transport, storage and disposal of insecticides; insecticide labeling.

## **PRACTICAL:**

Determination of pesticide residues in soil, water, vegetables fruits, milk, cereals, human blood, fat bodies and vital organs; Survey for finding farmers/public perception about pesticide poisoning.

## **RECOMMENDED BOOKS:**

1. Dhaliwal, G.S. and Singh B. 2000. Pesticides and Environment. Commonwealth Publishers. New Delhi. India.
2. Gupta, H.C.L. 2001, Insecticides: Toxicology and Uses. Agrotech Publishing Academy, Udaipur
3. Oudejans J.H.1991. Agropesticides and Functions in Integrated Crop Protection. ESCAP. United Nations. Bangkok, Thailand.
4. Ashfaq, M. and Saleem. M.A. 2010. Environmental Pollution and Agriculture. Pak Book Empire, Lahore, Pakistan.

# ENT-717    **ADVANCES IN BIOLOGICAL CONTROL OF INSECT**

**3(2-1)**

## **LEARNING OUTCOMES:**

To provide latest concepts of the principles of biological control, rearing, screening, introduction, augmentation and conservation of natural enemies, super, multi and hyper parasitism and their problems in biological control.

## **THEORY:**

Introduction; history, development and scope of biological control with special reference to Pakistan; ecological basis of biological control; biological characteristics of natural enemies (predators, parasitoids, microorganism); scope and problems in introduction, rearing, release, augmentation, conservation and establishment of natural enemies; estimating parasitism levels, host-parasitoid and host-predator interaction; numerical and functional response, strategies for rearing high quality of insect bio-control agents integration of chemical and biological control; problems of super, multi and hyper-parasitism and predators; effect of pesticides on natural enemies, effect of natural enemies on non-target organism, Steps in commercialization. Case studies of biological control insect pests, future opportunities and challenges of biological control,

## **PRACTICAL:**

Survey and collection of natural enemies, identification, rearing of parasitoids, predators and micro-organisms of economic importance; study of extent of parasitism / predation of different biocontrol agents, parasitism estimates by host dissection, host-rearing.. Methods for supplying insects and methods of release in the field. Visit to bio-control labs.

## **RECOMMENDED BOOKS:**

1. Gunasekaran, M. and Weber, D. 1996. Molecular Biology of the Biological Control of Pests and Diseases of Plants. ESA Publications, U.S.A.
2. Gunaskaran, M. 1995. Molecular Biology of Biological Control of Pests and Diseases. Fisk University.
3. Hajek, A. 2004. Natural Enemies: An Introduction to Biological Control. Cambridge University Press.
4. Irshad, M. 2008. Biological Control of Insects and Weeds in Pakistan. HEC Islamabad.
5. Lentern, J.C.V. 2003. Quality Control and Production of Biocontrol Agents. Theory and testing procedures.
6. Maramorosch, K. 1991. Biotechnology for Biological Control of Pests and Vectors. CRC Press, U.S.A.
7. Pedigo, L.P. and Marlin, E. R. 2009. Entomology and Pest Management, 6<sup>th</sup> Edition, Person Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.

8. Rehcigl, J.E. Rehcigl, N.A. 1998. Biological and Biotechnological Control of Insects Pests. CRC Press.
9. Upadhyay, R. K. 2003 Advances in Microbial Control of Insect Pests. Kluwer Academic / Plenum Publishers. New York USA

## **ENT-718    ADVANCES IN INSECT BEHAVIOUR**

**3(2-1)**

### **LEARNING OUTCOMES:**

To provide advance knowledge of different patterns of insect behaviour,

### **THEORY:**

Introduction; sensory receptors (mechanoreception, hygromoreception, thermoreception and photoreception); nervous system and behaviour; hormones and behaviour; displacement (causes of migration, classes of migration, adaptive nature of migration); communication (bio-luminescence chemical, acoustic, visual and tactile), circadian rhythms in insects, orientation, navigation and homing; sexual behaviour and reproduction; host selection and feeding behaviour; defense (behavioral, structural, coloration defenses); population behaviour; solitary and social behaviour;

### **PRACTICAL:**

Survey and communication behaviour, migration and its types, host selection, hormones and their role in behaviour, pheromones and their role in tactile behaviour, reproductive behaviour.

### **RECOMMENDED BOOKS:**

1. Dentinger, D.L. Giebultowicz, J. and Sanders, D.S. 2001. Insect Timing: Circadian Rhythmicity to Season Availability. Elsevier.
2. Febre, J.H. 1993. Insect Behaviour. Discovery Publishing House.
3. Fellows, M. and Holloway, G. 2005. Insect Evolutionary Behavior. CABI
4. Greenfield M.D. 2002. Signals and Receivers: Mechanism and Evolution of Arthropod Communication. Oxford University Press.
5. Parihar, R. 2001. Reproductive Behaviour and Biology of Sex. Dominant Publishers and Distributors, Delhi.
6. Prakash, M. 2008. (Encyclopedia of Entomology II) Insect Behaviour. Discovery Publishing House, PVT. LTD. Darya Ganj, New Delhi.
7. Research Journals: Journal of Insect Behavior.
8. Ryan, M.F. 2002. Insect Chemoreception Fundamental and Applied. Kluwer.
9. Vijay, K. 2008. Insect Behaviour. Vista International Publication House.

**ENT-719                      SPECIAL PROBLEMS                      1(1-0)**

**ENT-720                      SEMINAR                      1(1-0)**

## **ENT-721 PESTICIDES APPLICATION EQUIPMENT 3(1-2)**

### **LEARNING OUTCOMES:**

To provide latest knowledge of pesticides application equipments with special reference to recent trends in agriculture.

### **THEORY:**

Introduction; history and scope of development of pesticides application equipment; different systems of application of pesticides; dusting equipment: maintenance and operation of hand dusters, bellow type dusters, rotary hand and power dusters; various types of sprayers; components of a spray machine, maintenance and operation of compression and pump systems, granular applicators; comparative study of ground and aerial application equipments; calibration methods and measurement of droplet size; fog and smoke generators.

### **PRACTICAL:**

Study of different parts, assembling and maintenance of sprayers, dusters and granule applicators; working of different application equipment, study of different types of spray guns, lances, hoses and nozzles; aerosols and aerosol bombs; calibration and measurement of droplet size through different spraying equipments.

### **RECOMMENDED BOOKS:**

1. Dovener, R.A. Mueninghoff, J.C. and Volgar, G.C. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA
2. Mathews, G.A. 1992. Pesticides Application Methods. 4<sup>th</sup> Ed. Longman Inc., N.Y.
3. Matthews, G.A. and Hislop, E.C. 1993. Application Technology for Crop Protection. CAB International. Wallingford Oxon OX10 8DE, UK
4. Mathews, G.A. and Thornhill, E.W. 1995. Pesticide Application Equipments for use in Agriculture. FAO Agriculture Series Bulletin
5. Pedigo, L.P. and Marlin, E. R. 2009. Entomology and Pest Management, 6th Edition, Person Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
6. Pfadt, E.R. 1985. Fundamentals of Applied Entomology. 4<sup>th</sup> Ed. The MacMillan Co., N.Y.
7. Roy, N.K. 2006. Chemistry of Pesticides. Asia Printograph Shahdara Delhi.



**LEARNING OUTCOMES:**

To impart knowledge about the advances in pest management areas with special reference to genetically modified crops, growth regulators and genetic control of pests.

**THEORY:**

Introduction; recent advances in pest scouting, determination of economic thresholds; transgenic and genetically modified crops; organic pest management, microbes/ bio-pesticides, genetic control of insect pests; insect growth regulators; stem injection method, pheromones with reference to capillary evaporation in mating disruption technique; remote sensing of insect pests; use of radiation and radioisotopes, modules of IPM,

**PRACTICAL:**

Determination of pest status through modern scouting techniques for verification of economic threshold, problems of transgenic and genetically modified crops and their insect pests, use of insect growth regulators, stem injection methods, pheromones and mating disruption techniques, use of radiation in male sterilization techniques and their competition with normal males.

**RECOMMENDED BOOKS:**

1. Awasthi, V.B. 2007. Agricultural Insect Pests and their Control. Scientific Publishers (India) Jodhpur.
2. Dent, D. 1996. Integrated Pest Management. Chapman and Hall, London.
3. Flint, M. L. 2012. IPM in Practice: Principles and Methods of Integrated Pest Management. Univ of California Agriculture & Natural Resources; 2nd edition. Pages 292.
4. Gurr, G.M. Wratten, S.D. and Alteri, M.A. 2004. Ecological Engineering for Pest Management: Advances in Halritat Mani Publication for Arthropods. CSIRO, Australia
5. Mayer, C.D. 2004. Biotechnological Approach for the Integrated Management. Wiley Intersciences, London.
6. Maredia, K.M. Dakouo, D. and Mota-Sanclez, D. 2003. Integrated Pest Management in the Global Arena. CABI publishing UK.
7. Metcalf, P.I. 1990 - to date. Advances in Pest Control Research. Vols. I- to date. Inter-sciences Publishers, N.Y.
8. Upadhyay, R.K. Mukerji, K.G. Chawla B.P. and Dubey, O.P. 1998. Integrated Pest and Disease Management. A.P.H. Publishing Corp., New Delhi.

**LEARNING OUTCOMES:**

To impart modern knowledge in chromosomal morphology and chromosomal deficiencies in solving the problems of cytotaxonomy

**THEORY:**

Introduction; cell structure through electron microscopy; chromosomal structure, morphology, number, diversity, types and deficiencies; chromosomes and parthenogenesis; chromosomal mapping, chromosomal ecology; concept of gene; gene-determined characters; environmental effect on gene expression; sex determination in insects; mutations and variations; use of chromosomes and DNA in taxonomy.

**PRACTICAL:**

Study of a typical insect reproductive cell through phase contrast and electron microscopy, types, morphology, number and chromosomal deficiencies in important insects groups for identification / classification; study of insect resistance through gene markers and their loci; study of different types of genetic variations in insects; genetical identification of species and biotypes.

**RECOMMENDED BOOKS:**

1. Blackman, R.L. Hemitt, G.M. and Ashburner, M. 1980. Insect Cytogenetics. Black-Well Scientific Publications, Oxford, London.
2. Dnyansayer, V.R. 1992. Cytology and Genetics. Tata McGraw-Hill Publishing Co. New Delhi.
3. Hajorie, A.H. 1994. Insect Molecular Genetics. Academic Press, USA.
4. Hoy, M.A. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications.
5. Hoy, M. A. 2000. Insect Transgenesis: Methods and Application. CRC Press.
6. Swanson, C.P. Merz, T. and Young, W.J. 1998. Cytogenetics. The Chromosomes in Division, Inheritance and Evolution, 3<sup>rd</sup> Ed. Prentice Hall of India Pvt. Ltd, New Delhi.

**LEARNING OUTCOMES:**

To impart knowledge in the area of insect diseases against pathogens and micro-biota.

**THEORY:**

Introduction; history, scope, types of insect pathogens; transmission, host range, persistence and virulence of insect pathogens; types of injuries and methods of infection by pathogens in insects; pathogenic diseases, their diagnosis and zoonosis; extra-cellular and intracellular micro-biota of healthy insects; resistance and immunity in insects against pathogens management of microbial diseases of useful insects; role of pathogens in IPM.

**PRACTICAL:**

Isolation, purification, culture and identification of insect pathogens from the diseased insects collected from the fields; diagnosis of different pathogenic diseases; managements of microbial diseases of useful insects; determination of extent of pathogenicity.

**RECOMMENDED BOOKS:**

1. Boucias, D.G. 1998. Principles of Insect Pathology. Chapman Hall, London.
2. Burges, H.D. and Hurrey, N.W. 1972. Microbial Control of Insects and Mites. Academic Press London.
3. Poinar, G.O. Jr. and Thomas, G.M. 1978. Diagnosis for the Identification of Insect Pathogens, Press. N.Y.
4. Tanada, Y. and Kaya, H. K. 1993. Insect Pathology. Academic Press, New York.

**LEARNING OUTCOMES:**

To impart knowledge in the area of energy metabolism, nerve impulses and biochemical changes.

**THEORY:**

Introduction; energy metabolism and production in insects; biochemistry of cuticle, muscles, flight, synaptic transmission, light production, biochromes, enzymes, hormones and kairomones; insect growth regulators and diapause; metabolism and role of carbohydrates, proteins and lipids; signaling cascades, insecticidal effect on insect metabolism; biochemical defence in insects.

## **PRACTICAL:**

Characterization of insect species, biotypes, biochemicals, pheromone extraction, its identification and control in insects; hormonal control of insect growth and development; quantitative analysis of amino acids, proteins, uric acids in haemolymph; etc.

## **RECOMMENDED BOOKS:**

1. Candy, D.J. and Kilby, B.A. 1978. Insect Biochemistry and Function. 2<sup>nd</sup> ed. Chapman and Hall London.
2. Chapman, R.F. 1998. Insects: Structure and Function. 4<sup>th</sup> Ed. American Elsevier. Publ. Co. Inc., New York.
3. Gilmour, D. 1961. The Biochemistry of Insects. Academic Press London.
- Blomquit, G. J. and Vogt, R.G. 2003. Insect pheromone biochemistry and molecular biology, Elsevier Academic.
4. Kerkut, G.A. and Gilbert, L.I. 1985. Comprehensive Insect Physiology, Biochemistry and Pharmacology. Vols. 1-12, Pergamon Press, Oxford, New York, Toronto, Sydney, Paris, Frankfurt
5. Morgan, E.D. 2004 Biosynthesis in insects. T.J. Intl. USA.
6. Rockstein, M. 1978. Biochemistry of Insects. Academic Press, New York, U.S.A
7. Turner, R.B. 1977. Analytical Biochemistry of Insects. Elsevier Scientific Publishing Company New York.

**LEARNING OUTCOMES:**

To provide knowledge in the area of insect behavioral chemical and physical interaction, host selection and sexual communication.

**THEORY:**

Introduction, odor dispersion in still air and wind; effect of wind speed and air temperature; chemo- orientation in walking and flying insects; insect-plant interactions; pollinators ecology,; parasitoids, host relationship, sources of parasitoid behavioral chemicals; chemical and physical interactions; warning coloration and mimicry; warning coloration and predator learning; modes of mimetic resemblance; sexual communication with pheromones and use of insect pheromones in plant protection.

**RECOMMENDED BOOKS:**

1. Barbosa, P. and D. Letournean. 1989. Novel Aspects of Insect Plant Interactions. John Wiley & Sons. New York.
2. Bell, W.J and Carde, R.T. 1994. Chemical Ecology of insects. Chapman and Hall. London.
3. Harbone, J.A. 1998. Introduction to Ecological Biochemistry. Academic Press. London.
4. Jutsum, A.R. and Gorgen, R.F.S. 1989. Insect Pheromones in Plant Protection. John Wiley & Sons. UK.

## **ENT-727 FORENSIC ENTOMOLOGY 3(2-1)**

### **LEARNING OUTCOMES:**

To impart knowledge about various insect groups to solve medico-legal cases and different puzzling crimes.

### **THEORY:**

History and scope of Forensic Entomology. Study of various insect groups and other arthropods related to medico-legal investigations like puzzling events of murder, suicide, and trafficking determination of time or post-mortem intervals and location of the death. Review and survey of insect life histories, life cycle and faunal succession of arthropods related to medico-legal cases and survey of the insects involved in forensic science:

Review of classification of ages in decomposition of human and animal remains, uses of insect and arthropods in investigation of death and the duration of PMI. Forensic entomology in public health, arthropods borne disease, litigation and role of forensic entomology in formulation of health policy.

### **PRACTICAL:**

Sampling, rearing, and preservation techniques in forensic entomology; Study of the decomposition of corpses and dead bodies; Survey, identification and biology of insects and arthropods of forensic importance; Study and analysis of court room proceedings regarding medico-legal cases; Data processing and preparation of project reports.

### **RECOMMENDED BOOKS:**

1. Byrd, J.H. and Costner, J.L. 2009. Forensic Entomology: The Utility of Arthropods in Legal Investigations, 2nd Edition, CRC Press, New York.
2. Catts, E.P. and Haskell N.H. 1990. Entomology and Death. A Procedural Guide. Joyce's Print Inc. Clemson, SC.
3. Goff, M. L. 2000. A fly for the prosecution: how insect evidence helps solve crimes. Harvard University Press, Cambridge.
4. Greenberg, B. and Kunich, J.C. 2002. Entomology and the Law: Flies as Forensic Indicators, Cambridge University Press, Cambridge.
5. Smith, K.G.V.1986. A Manual of Forensic Entomology, Comstock's Publishing Associates, Cornell University Press, Ithaca, N.Y.

**LEARNING OUTCOMES:**

To provides an introduction to neurobiology in insects with a focus on olfaction.

**THEORY:**

Introduction; General principles of neuroscience; structure and components of the insect nervous system, ionic basis for resting, receptive and active potentials; synaptic transmission; olfactory system circuitry, coding and plasticity, basis of Cognitive Neuroscience, phases, neural circuits, cellular and molecular mechanism/ pathways underlying learning & Memory. Concepts of molecular neurophysiology, Introduction to extracellularly, intracellularly recordings, patch clamp technique, neuron imaging. Role of Neurotransmitters, neuromodulators and neurohormones,

**PRACTICAL:**

Insects as Model Organisms in Neuroscience to understand particular features of the neuronal networks in learning and memory, Plan, perform and analyse experiments in basic neurobiology, Dissection of insect brain, Learning and memory experiments with insects. Olfactory experiments in the lab especially with honeybee and other model insects. Demonstration for different phases of learning and memory with experiments.

**RECOMMENDED BOOKS:**

1. Kandel, E.R. Schwartz, J. And Jessel T. 2000. Principles of Neural Science, 5<sup>th</sup> Edition.
2. Burrows, M. 1996. The Neurobiology of an Insect Brain. Oxford University Press.
3. Christensen, T. A. 2004. Methods in Insect Sensory Neuroscience (Frontiers in Neuroscience). CRC Press
4. Kesner, R. P. and Olton, S. D. 1990. Neurobiology of Comparative Cognition. Psychology Press.
5. Anna Menini, A. 2010. The Neurobiology of Olfaction. CRC Press.
6. Bill S. Hansson. B.S. 2010. Insect Olfaction: 1<sup>st</sup> Edition. Springer Berlin Heidelberg publisher
7. D.R. Papaj D. R. and Lewis, A.C.. 1993. Insect Learning. Ecology and Evolutionary Perspectives. Springer publishers.
8. Menzel, R. and Benjamin, P.R. 2013. Invertebrate Learning and Memory, 1<sup>st</sup> Edition. Academic Press
9. Galizia, G. Eisenhardt, D. and Giurfa, M. 2012. Honeybee Neurobiology and Behaviour. Attribute to Randolph Menzel. Springer Publishers.

**LEARNING OUTCOMES:**

To provide knowledge about insect rearing techniques for natural predators, parasites and other insects of economic importance.

**THEORY**

Introduction; basic concepts and general principles of insect rearing; feeding and reproductive biology of different insects of economic importance; Insect diets (development of diets, components of diets, diet assessment, quality control and microbiology of insect diet); Insectary environments; Packaging technology; Insect rearing management (objectives, colony establishment and maintenance). Mass rearing techniques of insects on artificial diet/natural host. Quality control in mass-rearing systems

**PRACTICAL**

Operation of standard rearing equipment (balances, volumetric equipment, pH meters, microscopes, spectrophotometers, various kinds of diet processing equipment); Diet preparation methodology; practical instructions in the rearing of different important insect on artificial diet and natural host.. Visit to different insect rearing laboratories.

**RECOMMENDED BOOKS:**

1. Cohen, A. C. 2005. Insect Diets, Science And Technology, CRC Press Boca Raton London, New York, Washington, D.C.
2. Bernays, E.A. and Chapman, R.F. 1994. Host-Plant Selection by Phytophagous Insects. Chapman & Hall, New York.
3. Brewer, F.D. and Lindig, O. 1984. Ingredients for insect diets. Quality assurance, sources, and storage and handling, in Advances and Challenges in Insect Rearing, E.G. King and N.C. Leppla, Eds. USDA, ARS, New Orleans.
4. Bartlett, A.C. 1984. Genetic changes during insect domestication, in Advances and Challenges in Insect Rearing,
5. King, E.G. and Leppla, N.C. (Eds.) 1984. Advances and Challenges in Insect Rearing. USDA, New Orleans, L.A. USA.
6. Calkins, C.O., Bloem, K. Bloem, S. and Chambers, D.L. 1994. Advances in measuring quality and assuring good field performance in mass reared fruit flies, and the Sterile Insect Technique, C.O. Calkins, W. Klassen, and P. Liedo, Eds. CRC Press, Boca Raton, FL, 85–96.

**THESIS****MSc (HONS.) THESIS****THESIS****PhD, THESIS**



## RECOMMENDATIONS

1. The revised curricula (2014) for all degree programs in Entomology is desired to be implemented across the universities of Pakistan in true letter and spirit.
2. The universities are desired to ensure the availability of qualified faculty, supporting staff, lab equipments, recommended books, and journals etc. for the efficient outcomes. In this regards, the universities may seek help from HEC for cooperation and collaboration.
3. The universities are required to ensure human resource development for the faculty and staff through national/ international trainings, refresher courses, seminars, workshops, symposiums, etc. in the relevant fields.
4. The Quality Enhancement Cell (QEC) of respective universities can play a vital role to guide the universities for the implementation of the HEC academic rules/regulations/policies in general and to ensure desired student: teacher ratio in particular.
5. Collaboration among the Faculty Members of various universities in the field of Entomology may be encouraged to share the latest research in their specialized areas. In this regard, their collaboration through MoUs is highly required.
6. The universities are required to provide trained supporting staff to the departments for their labs and fields. Thus, the advanced training/ refresher courses etc. are also recommended for them.
7. The higher education commission may play a vital role to ensure the participation of all members in NCRC meetings.

## ***Reading***

1. Roberts, M.M., Reiss and G. Monger. 2000. Advanced Biology, Nelson.
2. Starr, C, and R, Taggart, 2001. Biology: The Unity and Diversity of Life Brooks and Cole.
3. Campbell, N.A., J.B, Reece, L.G. Mitchell, M.R, Taylor. 2001. Biology: Concepts and Connections. Prentice-Hall.

*Note: Universities may make necessary changes in the courses according to the requirement as decided by the Board of Studies.*