

**CURRICULUM
OF
ENTOMOLOGY**

(Revised 2005)



**HIGHER EDUCATION COMMISSION
ISLAMABAD**

CURRICULUM DIVISION, HEC

Prof. Dr. Altaf Ali G. Shaikh	Adviser (Acad/R&D)
Malik Ghulam Abbas	Deputy Director
Miss Ghayyur Fatima	Deputy Director (Curri)
Mr. M. Tahir Ali Shah	Assistant Director
Mrs. Noshaba Awais	Assistant Director

Composed by Mr. Zulfiqar Ali, HEC Islamabad

CONTENTS

1.	Introduction	7
2.	Scheme of Studies for 4-years B.Sc (Hons) Agriculture.	14
3.	Curriculum for Entomology for B.Sc (Hons)	15
4.	Specialization in Entomology	17
	i) Scheme of Studies	17
	ii) Details of Courses	18
5.	Curriculum for Post-Graduate level	31
	i) Scheme of Studies	31
	ii) Details of Courses	33
6.	Recommendation s	54

PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum one can judge the state of intellectual development and the state of progress of the nation. The world has turned into a global village; new ideas and information are pouring in like a stream. It is, therefore, imperative to update our curricula regularly by introducing the recent developments in the relevant fields of knowledge.

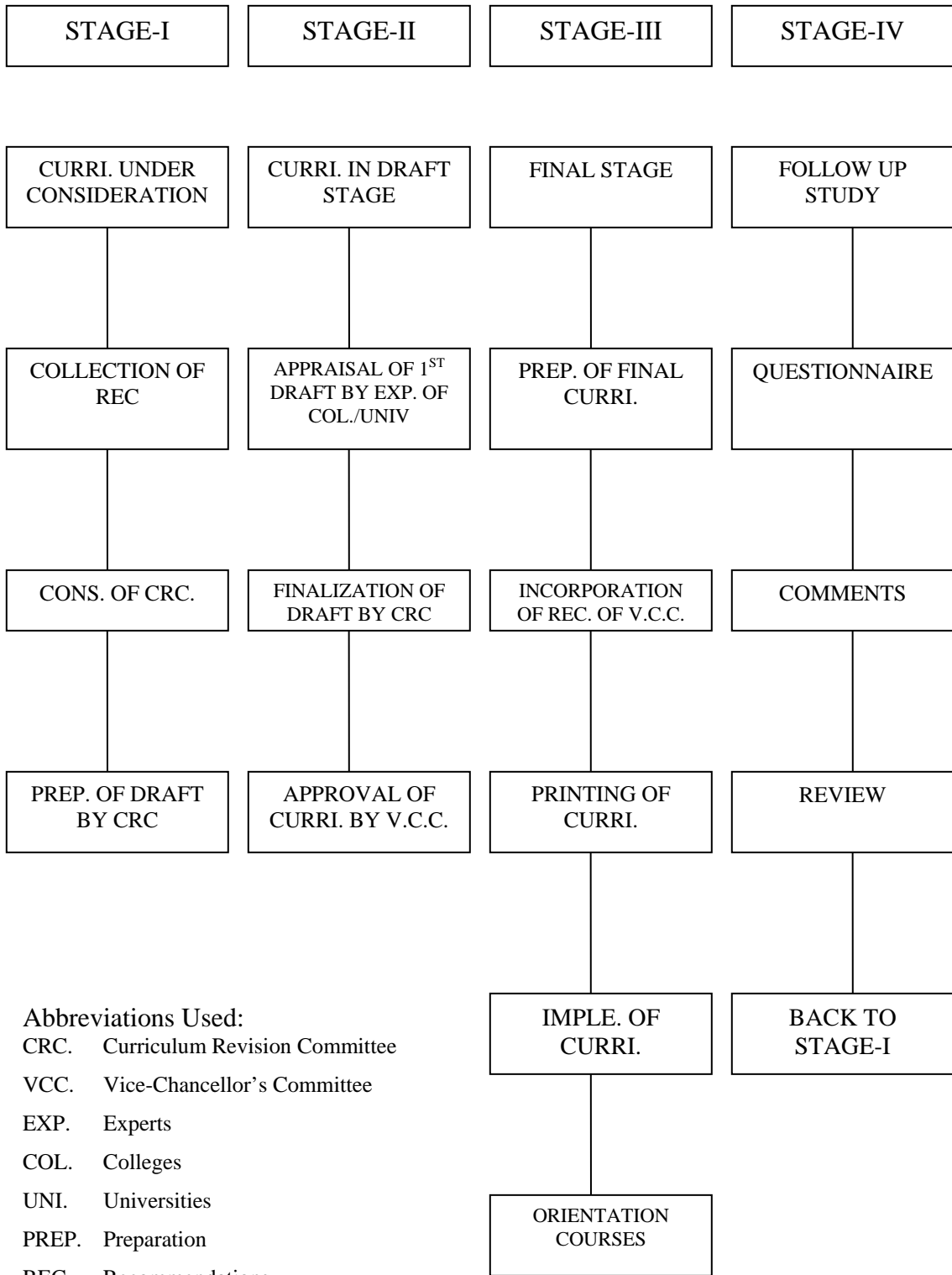
In exercise of the powers conferred by sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide notification no. D773/76-JEA (Cur.), dated December 4, 1976, appointed University Grants Commission as the competent authority to look after the curriculum revision work beyond class XII at bachelor level and onwards to all degrees, certificates and diplomas awarded by degree colleges, universities and other institutions of higher education.

In pursuance of the above decisions and directives, the Higher Education Commission (HEC) is continually performing curriculum revision in collaboration with universities. According to the decision of the special meeting of Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various committees are constituted at the national level comprising senior teachers nominated by universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these committees. The National Curriculum Revision Committee for Entomology in its meeting held in July 14-16, 2005 at the HEC Regional Centre, Karachi revised the curriculum after due consideration of the comments and suggestions received from universities and colleges where the subject under consideration is taught. The final draft prepared by the National Curriculum Revision Committee duly approved by the Competent Authority is being circulated for implementation by architectural institutions.

(PROF. DR. ALTAF ALI G. SHAIKH)
Adviser (Acad/R&D)

August 2005

CURRICULUM DEVELOPMENT



INTRODUCTION

The meeting of National Curriculum Revision Committee for BS (4 years) / MS (2 years) courses of Agriculture in Entomology was held on 14-16 July, 2005 at HEC Regional Centre, Karachi to review / revise existing curriculum at Graduate (4 years Programme) and Post-Graduate (MS and Ph.D. Programmes). Following attended the meeting:

1. Prof. Dr. Imtiaz Ahmad, Convener
Entomologist,
Deptt. of Zoology,
University of Karachi, Karachi
2. Dr. Imtiaz Ali Khan, Member
Associate Professor,
Deptt. of Entomology,
NWFP Agricultural University, Peshawar
3. Prof. Dr. Ghulam Hussain Abro, Member
Professor,
Deptt. of Entomology,
Sindh Agriculture University, Tandojam
4. Prof. Dr. Abdul Khaliq, Member
Professor,
Deptt. of Entomology,
University of Arid Agriculture,
Rawalpindi
5. Prof. Dr. Mushtaq Ahmad Saleem, Member
Principal/Professor Agriculture Entomology,
University College of Agriculture,
Bahauddin Zakria University, Multan
6. Dr. Nikhat Yasmeen Siddiqui, Member
Chairperson,
Deptt. of Zoology,
University of Karachi, Karachi
7. Dr. Syed Anser Rizvi, Member
Deptt. of Zoology,
University of Karachi, Karachi

- | | | |
|-----|--|--------|
| 8. | Dr. Farkhanda Manzoor,
Assistant Professor of Entomology,
Deptt. of Zoology,
Lahore College for Women University,
Lahore | Member |
| 9. | Dr. Ishrat Waheed,
Foreign Faculty Member,
Centre of Excellence in Molecular Biology,
Lahore | Member |
| 10. | Prof. Dr. Mohammad Rafique Khan,
Chairman,
Deptt. of Entomology,
Faculty of Agriculture,
Rawalakot, AJK | Member |
| 11. | Dr. S. Azhar Hasan,
Director,
Pakistan Museum of Natural History,
Garden Avenue, Shakarparian,
Islamabad | Member |
| 12. | Dr. Said Mir Khan,
Deptt. of Entomology,
Faculty of Agriculture,
Gomal University, D.I.Khan | Member |
| 13. | Dr. Anjum Suhail,
Chairman & Associate Professor,
Deptt. of Agricultural Entomology,
University of Agriculture, Faisalabad | Member |
| 14. | Dr. Abdul Latif,
Entomologist,
Agriculture Research Institute,
D.I.Khan | Member |
| 15. | Mr. Muhammad Waseem,
Chairman,
Deptt. of Entomology,
Balochistan Agriculture College, Quetta | Member |

16. Mr. Shawkat Ali, Member
Lecturer,
Deptt. of Biotechnology,
University of Malakand, Chakdara
17. Prof. Dr. Mian Inayatullah, Member / Secretary
Chairman,
Deptt. of Entomology,
NWFP Agriculture University,
Peshawar

MINUTES

The meeting started with recitation of the Holy Quran by Mr. Muhammad Waseem. Prof. Dr. Altaf Ali G. Shaikh, Adviser (Acad/R&I) HEC in his inaugural speech highlighted the aims and objectives of the National Curriculum Revision Committee. He emphasized that the main purpose of revising and devising the curriculum is to bring it at par with the international standard and to facilitate colleges / Institutes for the teaching of Entomology according to the requirements of the Agricultural Departments/Universities of Pakistan. The house unanimously nominated Prof. Dr. Imtiaz Ahmad, Department of Zoology-Entomology, University of Karachi as Convener and Dr. Mian Inayatullah, Chairman, Department of Entomology, NWFP Agricultural University, Peshawar as Secretary.

Prof. Dr. Imtiaz Ahmad thanked the members for nominating him as Convener and pledged that in drafting the courses the opinion of each and every member would be given utmost importance. It was unanimously decided that the committee members would focus their entire attention only on the courses of Entomology (major courses in Agriculture) and these courses alongwith minor/elective courses of Agriculture would be viewed at the collective/cumulative level of B.S (4 years) courses of Agriculture. It was also unanimously decided that minor shift in the courses (Major/Minor/Elective) not only in the credit hours but also in placing/giving the course in a particular semester would be allowed to department/institute as per requirements/ facilities of that institution.

A 4 years B.Sc. (Hons) Agriculture programme has been introduced in all Institutes/Universities by the HEC. This programme offers different fields of specialization in Agriculture, Entomology being one of them which is being dealt with by the present committee.

Entomology as a preliminary subject is introduced in 3rd and 4th semesters, one course in each semester comprising ENT – 401 Introductory Entomology (3rd semester) ENT-402 Applied Entomology (4th semester), while a 2 credit

hours course ENT-609 Agriculture and environmental pollution is offered in the 7th semester as a general course for all students.

Entomology as specialization is introduced in 3rd year, 5th semester. The students are required to study 15 credit hours courses of major Entomology per semester during 5th, 6th and 7th semesters. During the last semester the student has to complete the internship, including report-writing and presentation, of 15 credit hours.

The committee rectified the previous practice of Credit hours used in the Agriculture Universities. It is now recommended to follow the international standards. For instance previously a 3 Credit hours course was written as 3(2-2) which meant 2 Credit hours theory per week while 2 under parenthesis meant one practical of 2 hours per week. This practice is now abandoned and the committee suggested to follow the HEC-recommended rules and accordingly 3 Credit hours course will now be written as (2+1). Under parenthesis meant 2 Credit hours theory while 1 lab per week. 1 lab means two or three theory hours depending upon the individual university.

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 have been made throughout the curriculum which has been updated/expanded.
2. Our objective is to provide broad and balanced courses of Entomology. The intimacy between insect and environment is emphasized to the entomological research in many directions which later proved of immense value in our indigenous control measures so as to provide more food for the ever-growing population of Pakistan.

MODIFICATIONS

UNDER-GRADUATE COURSES:

In total 17 courses were developed for under-graduate study programme out of which three courses ENT-401, ENT-402 and ENT-609 are the general courses for all students of Agriculture while remaining courses are the major courses for those specializing in Entomology. The total credit hours are 73 including 8 credit hours as general while remaining 65 credit hours as of major subjects.

Out of a total of 17 courses, four courses are furnished with modification in credit hours including ENT-401: 3(2+1), ENT-402: 3(2+1); ENT-501: 4(3+1); ENT-609: (2+0). In one course ENT-507 the title is modified as Insect Pests of Household, Man and Animals ENT-607 and ENT-611 would now read as Range and Forest Entomology and Preparation of Research Project and Scientific Writings respectively. ENT-609 would deal with Agriculture and Environmental Pollution. ENT-601 would deal with Pest forecasting and Management.

The course ENT-609 Agriculture and Environmental Pollution is transferred from 5th semester to 7th semester while in the remaining courses the contents and latest books are incorporated in each course according to the future needs.

POST GRADUATE COURSES

In total 26 courses were evolved for post-graduate study programme out of which ENT-701, 705, 708, 713, 714, 716, 719, 720 and 722 would be compulsory courses with a total credit hours of 22 while remaining courses will be optional. The total credit hours will be 35 including minor subjects which should not exceed 1/3 for the award of M.Sc. degree in Entomology with thesis/research carrying 10 credit hours.

Out of a total of 26 courses, 2 courses are developed by merging old courses and named as ENT-707: Advanced Insect Physiology and Embryology in which Embryology courses are logically merged in Insect Physiology while in ENT-714: Insecticides Toxicology old course Techniques for Testing Insecticides is merged in Insect Toxicology.

Four new courses are also developed for the first time according to the future need. These are ENT-708: Insect Molecular Biology, ENT-716: Insecticide and Public Health, ENT-718: Insect Behaviour, ENT-726: Chemical Ecology of Insects and ENT-727: Forensic Entomology.

Remaining courses are developed after some modifications either in the title i.e. ENT-711: Medical and Veterinary Entomology and ENT-717: Biological Control of Insect Pests and Weeds; or change in the credit hours in courses i.e. ENT-704; 3(2+1), ENT-709 3(2+1), ENT-713: 3(2+1) and ENT-722: 3(2+1) or change in the contents and by some addition of some new books in each course. Some old books are retained due to the pre-requisite of that course.

The post graduate courses developed in the previous meeting are reviewed. Some necessary corrections were suggested and books recommended from

different sources are incorporated. These are given as under with their course nos., titles and credit hours in the appendix No.1.

Appendix No.1

1. ENT-701: Techniques and two books are added in this course.
2. ENT-702: Spelling mistakes are corrected and some new editions of the books are given.
3. ENT-703: After some minor changes in the contents some new books are added.
4. ENT-704: This course was O.K. only credit hours are changed that is now it is 3 credit hours course 3(2+1) and some new edition of the books are incorporated.
5. ENT-705: The content of the course appears O.K. Some minor changes are made in topics and some new books are incorporated.
6. ENT-706: Minor changes like convergence and parallelism, population analysis by different methods, phylogenetic relationships are eliminated and phenetic analysis of data is incorporated while in practical construction of cladograms is changed and construction of phenogram/dendrogram and soft ware programming in numerical taxonomy is added.
7. ENT-707: The contents were O.K. One topic i.e. embryogenic development or oranogenesis in insects is added and three more books are incorporated.
8. ENT-708: Some minor changes are made in the course and latest books are added.
9. ENT-709: This course was O.K. whereas the credit hours of this course are changed now these are 3(2+1) while some new books are added.
10. ENT-710: From this course some old books are deleted while new books are incorporated.
11. ENT-711: The name of course is changed that is now it whould read Medical and Veterinary Entomology. The contents were OK and new books are added in this course.
12. ENT-712: The classification of mites is confined only to those of agriculture, medical and veterinary importance and ticks are also included. Some new books are added.
13. ENT-713: The credit hour of this course is changed now i.e. 3(2+1), Some additions are made in the list of books.
14. ENT-714: In the contents enzyme activation is added. Some new books are added at the end.
15. ENT-715: The quality control of artificial diet for insects is incorporated. One book is deleted and one new book is added.
16. ENT-716: Some new contents are incorporated.

17. ENT-717: The title of the course is modified by the addition of weeds; now it is Biological Control of Insect Pests and weeds. Two topics i.e. celebrated examples and successes of biological control in Pakistan and constraints in biological control programmes are added. Some new books are also added at the end.
18. ENT-718: After correction of some spelling mistakes, the contents are OK.
19. ENT-719: New books are added
20. ENT-720: New books are added.
21. ENT-721: The title of the course is now modified i.e. Insecticide Application Equipment. The books with new edition and some new books are added. Use of aircraft as aerial spray is also incorporated.
22. ENT-722: The credit hours of this course, now, is 3(2+1); after some Minor changes and addition of latest books course appears ok.
23. ENT-723: Some topics are shifted to ENT-708 and some topics are from ENT-708 are added and some minor changes and addition of latest books in this course has been approved.
24. ENT-724: Some new books are added in this course.
25. ENT-725: No change in the contents were made; only latest books are added.
26. ENT-726: This course of Chemical Ecology is of 2(2+0) credit hours. It is now made an independent course separate from ENT-705 Advanced Insect Ecology.
27. ENT-727: Forensic Entomology course of 2(2+0) credit hours is developed for the first time.

Scheme of Study for 4-Year B.Sc (Hons) Agriculture

Mathematics / Biology	6 Credits
Statistics 1 & 2	6
Computers / IT	3
Pak Studies	2
Islamiat	2
Communications Skills	3
English	3
Basic Agriculture	3
Sub-Total	28

One subject from each of the following disciplines

Agronomy	3
Plant Breeding & Genetics	3
Entomology	3
Plant Pathology	3
Food Technology	3
Horticulture	3
Soil Sciences	3
Agriculture Economics	3
Sub-Total	24

Additional Courses from disciplines mentioned below and above

Agriculture Extension	
Forestry & Range Management	
Animal Science	
Marketing & Agri Business	
Rural Development	
Human Nutrition	
Agriculture Chemistry	
Agriculture Engineering	
Water Management	
Sub-Total	21-25

Sub-Total during the first four semesters **73 – 77**

Semester 5, 6, 7 19 Credit Hours each **57**
Final Semester **15**

Grand Total **145 – 149**

CURRICULUM OF ENTOMOLOGY

For B.Sc. (Hons) Agriculture

ENT-401 INTRODUCTORY ENTOMOLOGY

3(2+1)

THEORY:

Introduction; phylum Arthropoda and its classification; external and internal morphology and physiology with particular reference to a typical insect, metamorphosis and its types; insect classification, salient characters of insect orders and families of economic importance with examples of each family.

PRACTICAL:

Characters of classes of Arthropoda; Collection and preservation of insects; external and internal morphology of typical insects; temporary mounts of different types of appendages of insects; types of metamorphosis.

BOOKS RECOMMENDED:

1. Ahmad, I. 1970. Hashriat "Insects" National Book Foundation, Lahore
2. Lohar, M.K. 1998. Introductory Entomology, Kashif Publications, Hyderabad, Pakistan.
3. Yousuf, M., 1996. Manual of Introductory Entomology, University of Agriculture, Faisalabad.
4. Tonapi, G. T., 1994. Experimental Entomology, An Aid to Lab. and Field Studies. C.B.S. Publishers and Distributors, Delhi
5. Mani, M.S., 1990. General Entomology 4th ed.. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
6. Gullan, P.I. & P.S. Crauston, 1994. The Insects (An outline of Entomology) Chapman & Hall New York.
7. Richards, O.W. and R. G. Davies, 1984. Imm's General Text-book of Entomology, Vol. I. and II, 10th ed. Chapman & Hall, London, N.Y.
8. Shahid, M. 1984. Lab Mannual of General Entomology. National Book Foundation, Pakistan.
9. Elzinga, R.T. 2003. Fundamentals of Entomology. Prentice Hall. ISBN 0130480304.
10. Jhonson, N.F., Triplehorn, C.A. Borror and Delong's. 2004 Introduction to the study of Insects. Brooks Cole. 7th ed.

THEORY:

Introduction; causes of success and economic importance of insects; principles and methods of insect control i.e. cultural, biological, physical, mechanical, reproductive, legislative and chemical; introduction to IPM; insecticides, their classification, formulations and application equipment; identification, life histories, mode of damage and control of important insect pests of various crops, fruits, vegetables, stored grains, household, termites and locust; entomological industries: apiculture, sericulture and lac-culture.

PRACTICAL:

Collection, identification and mode of damage of insect pests of various crops, fruits, vegetables, stored grains and household; insecticide formulations, their dilutions and safe handling; use of application equipment, practical instructions in apiculture, sericulture and lac-culture.

BOOKS RECOMMENDED:

1. Atwal, A. S., 2005. Agricultural Pests of Southeast Asia and their Management. Kalyani Publishers, Ludhiana.
2. Pedigo, L.P., 2002. Entomology and Pest Management 4th ed. Prentice and Hall Intl. Limited, London.
3. Shah, H.A. and M.A.Saleem, 2002, Applied Entomology, 2nd ed. Izhar Sons Printers, Lahore
4. Hashmi, A. A., 1994. Insect Pest Management. Vols. I, II, III. Pak. Agri. Res. Council, Islamabad.
5. Mathews, G.A., 1992. Pesticide Application Methods, 2nd. Ed. John Wiley & Sons, Inc. N.Y.
6. Saha, L. R., 1990. Hand book of Plant Protection. Kalyani Publishers New Delhi.
7. Pfadt, E. R., 1985. Fundamentals of Applied Entomology, 4th Ed. The Macmillan Co., N. Y.

B. SPECIALIZATION IN ENTOMOLOGY

The Committee has proposed the following "TITLES" with credit hours for specialization in Entomology during III year (5th and 6th semesters) and 4th year (7th and 8th semesters). These are the "CORE" courses, comprising 55 credit hours. To fulfill minimum requirements for the completion of the degree, each university may incorporate more courses according to their needs into their scheme of studies (Curricula).

The semester wise split of CORE courses is as under:-

3RD YEAR SCHEME OF STUDIES

5TH SEMESTER

<u>Course No.</u>	<u>Title</u>	<u>Credit Hours</u>
ENT-501	Insect Morphology	4(3+1)
ENT-503	Principles of Insect Taxonomy	4(3+1)
ENT- 505	Insect Ecology and Behaviour	4(3+1)
ENT- 507	Insect Pests of Household, Man and Animals	3(2+1)

6TH SEMESTER

<u>Course No.</u>	<u>Title</u>	<u>Credit Hours</u>
ENT-502	Insect Physiology	3(2+1)
ENT-504	Insect Biodiversity and Evolution	3(2+1)
ENT-506	Agricultural Pests Management	3(2+1)
ENT-508	Stored Products Pest Management	3(2+1)
ENT-510	Beneficial Insects	3(2+1)

4TH YEAR

7TH SEMESTER

<u>Course No.</u>	<u>Title</u>	<u>Credit Hours</u>
ENT-601	Pest Forecasting and Management	4(3+1)
ENT-603	Plant Resistance to Insect Pests	2(1+1)
ENT-605	Insecticides and their Application	4(3+1)
ENT-607	Range and Forest Entomology	3(2+1)
ENT-609	Agricultural and Environmental Pollution	2(1+1)
ENT-611	Preparation of Research Project and Scientific Writing	2(1+1)

8TH SEMESTER

ENT-610	Internship, including Report Writing and Presentation	15
---------	---	----

DETAILS OF COURSES

5TH SEMESTER

ENT-501 INSECT MORPHOLOGY

4(3+1)

THEORY:

Introduction; integument and its derivatives; body regions; segmentation, sclerites, sulci and appendages of head, thorax and abdomen in different insect orders; endoskeleton and internal organ systems; exocrine and endocrine organs.

PRACTICAL:

Structure of integument and its derivatives; comparative external and internal morphology of different insect orders. Preparation for illustrations.

BOOKS RECOMMENDED:

1. Romoser, W.S. 2001. The Science of Entomology. 3rd ed. WCB Inc.
2. Chapman, R. F., 2000. The insects: Structure and function (4th ed.). Hodder and Stoughton Education Ltd., U.K.
3. Tonapi, G. T., 1994. Experimental Entomology. An Aid to Laboratory and Field Studies. CBS Publishers and Distributors, New Delhi, India.
4. Richard, O.W. and R.G. Davies. 1984. Imm's General Textbook of Entomology, Vol. I, revised. 10th ed. (Structure, Physiology & Development). Chapman and Hall, London, N.Y.
5. Snodgrass, R., 1935. Principles of Insect Morphology. Cornell Univ. Press., U.S.A.
6. Zombori, L. , Strawmann, H. 1999. Dictionary of Insect Morphology. De Gruyter.
7. Romoser, W.S. 2001. The Science of Entomology, 3rd Ed. WCB Inc.

ENT-503 PRINCIPLES OF INSECT TAXONOMY

4(3+1)

THEORY:

Introduction; history, functions and concepts; tasks of a taxonomist; taxonomic categories; taxonomic procedures: collection, samples and methods of sampling, identification, taxonomic discrimination, taxonomic characters, variations in population; descriptions, taxonomic keys, speciation and phylogenies, preparation of taxonomic paper; code of zoological nomenclature; introduction to numerical taxonomy and cladistics.

PRACTICAL:

Methods of collection, preservation and labelling of insects; preparation of taxonomic keys; identification of insects with taxonomic keys; cataloguing and writing descriptions of identified insects; preparation of phenograms and phylogenetic trees.

BOOKS RECOMMENDED:

1. Mayer, E. & P. D. Ashlock, 1991. Principles of Systematic Zoology, 2nd. Ed. McGraw Hill Inc. New York.
2. Kapoor, V.C. 1988. Theory and Practice of Animal Taxonomy, 2nd, Ed. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India.
3. Henning, W., 1981. Insect Pylogenetics. Willy Inter Sciences. U.K.
4. Chamberlin, W. J. 1962. Entomological Nomenclature. Bubaque, U.S.A.
5. The International Commission on Zoological Nomenclature, 1985. International Code of Zoological Nomenclature, adopted by XX General Assembly of the Int. Union of Biological Sciences. Uni. Calif. Press. Los Angles.
6. Daly, H.V. , Doyen J.T. Purcell A.H. Daly, B.B. 1998. Introduction to Insect Biology and Diversity. Oxford University Press.

ENT-505 INSECT ECOLOGY AND BEHAVIOUR

4(3+1)

THEORY:

Introduction; divisions of ecology; habitat and niche; intra and interspecific interactions; natural and agro-ecosystems; flow of energy in ecosystem; trophic relations: Food chain, food web and food mesh concepts; ecological succession; population and its characteristics; introduction to life tables. Types of behaviour: reflexes, kineses and taxes; learning; periodicity; patterns of behaviour; communications; visual; auditory; tactile; chemical. Territoriality; control of behaviour; nervous; endocrine and genetic; biological functions of behaviour, host finding, feeding and reproductive, escape, defence, offence and predation; dispersal and migration; dormancy. Diversity indices.

PRACTICAL:

Maintenance and measurement of temperature, humidity and light with different instruments; population estimation and construction of life tables.

BOOKS RECOMMENDED:

1. Goulson, D. 2003. Bumble bees, Behaviour and Ecology. Oxford University Press.
2. Bourtzis, K. and T.Miller. 2003. Insects Symbiosis. CRC Press
3. Parihar, R. 2001. Reproductive behaviour and biology of sex. Dominant Publishers and Distributors, Delhi.
4. Southwood, T.R.E. and P.A. Henderson. 2000. Ecological Methods. 3rd ed. Blackwell Science.
5. Yazdani, S. S. and M. I. Agarwal, 1997. Elements of Insect Ecology. Narosa Publishing House, New Delhi.
6. Anantakrishn. 1993. Chemical Ecology of Pytophagous Insects. 50448
7. Huffaker, C.B. & Robert L. Rabb. 1984. Ecological Entomology. Wiley Intersciences.
8. Price, P.W. 1984. Insect Ecology. John Wiley and Sons, N.Y.
9. Evans, H. E., 1984. Insect Biology; A Textbook of Entomology. Addison-Wesley Publishing Company.
10. Atwal, A.S. and S.S. Bains. 1974. Applied Animal Ecology, Kalyani Publishers, Ludhiana.
11. Daly, H.V., Doyen J.T. Purcell A.H. and B.B., Daly, 1998. Introduction to Insect Biology and Diversity. Oxford University Press.
12. Baldwin, 2004. Insects and Ecosystem function codeno.62232.

ENT-507 INSECT PESTS OF HOUSHOLD, MAN AND ANIMALS 3(2+1)

THEORY:

Introduction; identification, biology and control of different insect pests like ants, termites, cockroaches, silver-fish, cricket, powder-post and carpet beetles, cloth-moths, psocids, lice, bed-bugs, fleas, mosquitoes, house flies, sand flies, stable flies, flesh flies, blow flies, tse tse flies, black flies, midges etc.

PRATICAL:

Collection, identification, and demonstration of control of different insect pests.

BOOKS RECOMMENDED:

1. Atwal, A.S. 2005. Agricultural Pests of Southeast Asia and their Management. Kalyani Publishers, Ludhiana.

7. Saxena, S. C., 1992. Biology of Insects. Oxford and IBH Publishing Co., New Delhi.
8. Cummins, K.W., Lee. D. Miller, Ned A. Smith and Richard M. Fox. 1985. Experimental Entomology. Reinhold Publishing Corporation, Chapman & Hall Ltd., London.
9. Rockstein, M. (Edit.) 1973-74. The Physiology of Insects. Vol. 1-6, 2nd ed. Academic Press, N.Y.
10. Wigglesworth, V.B. 1972. Principles of Insect Physiology, 7th Ed. Meltron & Co. Ltd. U.K.

ENT-504 INSECT BIODIVERSITY AND EVOLUTION 3(2+1)

THEORY:

Introduction; schemes of classification; phylogenetic affinities of different orders; insect adaptation in various geographical regions; insect adaptive radiation and diversity classification of insect orders up to family level with particular reference to insect fauna of Pakistan; progress and extinction. Gene library.

PRACTICAL:

Assessment of existing phylogenetic arrangement of insect orders; collection and identification of insects up to family level with the help of taxonomic keys.

BOOKS RECOMMENDED:

1. Fellows, M. and G. Holloway, 2005. Insect Entomology Behaviour. CABI.
2. Gupta, R.K. 2003. Advances in Insect Biodiversity. Agrobios, New Delhi, India.
3. Quicke, D. (1993) Principles and Techniques in Contemporary Taxonomy. Blackie.
4. Kim, K.C. 1993. Evolution of Insect Pests: Pattern of Variation. Pak.
5. Starr, C. and R. Taggart, 1989 Biology - the unity and Diversity of Life. Wadsworth Publishing Co.
6. Kershaw, D. 1988 Animal Diversity (2nd edition). Unwin Hyman.
7. Richards, O.W. and R.G. Davies. 1984. IMM's General Text Book of Entomology, Vol. II. 10th ed. (Revised), Chapman and Hall, London.
8. Ross, H.H., C.A. Ross and J.R.P Ross, 1982. A Textbook of Entomology. 4th ed. John Wiley and Sons. Inc., N.Y.
9. Afzal, M.; S.A. Mufti. Natural History Research. Pakistan Scientific and Technological Information Center, Islamabad.

10. Daly, H.V., Doyen, J.T. Purcell, A.H. and B.B. Daly, 1998. Introduction to Insect Biology and Diversity. Oxford University Press.

**ENT-506 AGRICULTURAL PESTS AND THEIR
MANAGEMENT**

3(2+1)

THEORY:

Introduction; identification, distribution, host plants, biology, damage and control of insect and mite pests of field crops, vegetables and orchards; other important vertebrate and invertebrate pests.

PRACTICAL:

Collection and identification of pests of agricultural importance and their damage; demonstration of control measures.

BOOKS RECOMMENDED:

1. Ignacimut. 2005. Sustainable Insect Pest Management. 96351.
2. Atwal, A.S. 2005. Agricultural Pests of South-east Asia and their Management. 5th ed. Kalyani Publishers, Ludhiana.
3. Emden, H. and M. Service, 2004. Pest and Vector Control.
4. Altieri, M.A. 2004. Biodiversity and Pest Management in Agro-Eco System, 2nd ed.94195
5. Horowitz. 2004. Insect Pest Management; Field and Protected Crops. 99295.
6. Hill, D.S. 2002. Pests of Stored Food Stuff and their Control. Kluwer.
7. Pedigo, L. P., 2002. Entomology and Pest Management (4th ed.). Prentice and Hall, Intl., London.
8. Shah, H.A. and M.A. Saleem. 2000. Applied Entomology. 2nd ed. Izharsons Printers, Lahore
9. Upadhyay, R. K., K.G. Mukerji, B.P. Chamola & O.P. Dubey, 1998. Integrated Pest and Disease Management. A. P. H. Publishing Corp. New Delhi, 695 pp.
10. Hashmi, A.A., 1994. Insect Pest Management. Vols. I, II and III. Pak. Agric. Council, Islamabad - Pakistan.
11. Lohar, M. K., 1994. Handbook of Applied Entomology. Kashif Publications, Hyderabad, Pakistan.
12. Hill, D. S. 1993. Agricultural Insect Pests of the Tropics and their Control (Indian ed.). Cambridge University Press, Cambridge, 746 pp.
13. Pfadt, R.E. 1985. Fundamentals of applied Entomology, 4th ed. Macmillan Publishing Co., N.Y.

14. Sathe, T.V. 2003. Agrochemical and Pest Management Code No.51938.
15. Davidson, R.H. and W.F. Lyon. 1977. Insect Pests of Farm, Garden and Orchards. John Wiley and Sons Inc., New York.
15. Koul, O. and G.S. Phalimal. 2004. Integrated Pest Management Protection, Constraint and Challenges. CABI Publishers.

**ENT-508 STORED PRODUCTS PESTS AND THEIR
MANAGEMENT**

3(2+1)

THEORY:

Introduction; Identification, biology and control of different stored products pests. storage principles; types of storages; Factors affecting grain and other products in storages; stored product losses and their prevention.

PRACTICAL:

Visits to the godowns and demonstration of sampling methods and estimation of losses; collection, identification and control of different stored products pests.

BOOKS RECOMMENDED:

1. Hill, D.S.2002. Pests of Stored Food Stuff and their Control. Kluwer.
2. Ashfaq, M., M.A. Saleem and F. Ahmad 2000. Zari Agnas ki Mahfooz Zakhira Kari (in Urdu). Pak Book Empire, Lahore.
3. Morriel, W.L.1995. Insect Pests of Small Grains. 61492
4. Zaklandvoj, G.A. and V.F. Ratanova. 1987. Stored Grain Pests and their Control. Oxonian Press Pvt. Ltd., London.
5. Anonymous, 1986. Operational Manual for Grain Quality, Inspection and Quality Control Procedure during Procurement and storage, Govt. of Pakistan, Ministry of Food, Agriculture and Co-operatives by R.L. Semple P.A. Hicks, J.V. Losare, and A. Castermans 1992.
6. Anonymous, 1984. Insect and Arachnids of Tropical Stored Products, their Biology and Identification. Storage Department, TAD. R.I., Slough, Berks, U.K.
7. Dichter, D. 1978. Manual on improved Farm and Village level Grain Storag Methods. German Agency for Technical Co-operation (GTZ) W. Germany.
8. Wilbur, D.A. and R.B. Mills and J.R Pedersen. 1977. Manual of Grain and Cereal Product Insects and their Control., Kansas State University, U.S.A.

9. Rees, D. 2004. Insects of Stored Products. Code No.61887.
10. Hall, D.W. 1970. Handling and Storage of Food Grains in Tropical and Sub-tropical areas. F.A.O., U.N. Rome.

ENT-510

BENEFICIAL INSECTS

3(2+1)

THEORY:

Introduction; insects of medicinal, food, aesthetic value; insect pollinators and environmental indicators; scavengers, entomophagous and weed-feeding insects; entomological industries; apiculture, sericulture and lac-culture.

PRACTICAL:

Practical instructions in apiculture, sericulture and lac-culture; collection and identification of pollinators, scavengers, entomophagous, medicinal, food, weed feeding and other beneficial insects.

BOOKS RECOMMENDED

1. Sigh, T. 2004. Principles and Techniques of Silk Worm Seed Production. 60328.
2. Sathe, T.V. 2004. Shoots Feeding and Sericulture Trends. 93191.
3. Ashfaq, M. and A.Suhail. 2001. Magasbani kay Jadeed Treeqay (in Urdu), Deptt. of Entomology. U.A.Faisalabad.
4. Devillers, J. and M. Phame. Delegee. 2002. Honey Bees.
5. Irshad, M. and R.Ahmad. 2000. Insect Pests and their Parasitoids, Predators, Pathogens in Pakistan. PIPS (Pvt.) Ltd. Islamabad.
6. Ashfaq, M. and W. Akram. 2000. Rasum ke Keeray Palna (in Urdu), Deptt. of Entomology. U.A.Faisalabad.
7. Waterhous, D.F., 1998 Biological Control of Insect Pests: Southeast Asian Prospect. Australian Centre for International Agricultural Research, Canberra, 548 pp.
8. Ganga, G., and Chetty, J. S. 1997. An Introduction to Sericulture. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi 302 pp.
9. Hashmi, A. A., 1994. insect Pest Management, Vols. I, II & III. Pak. Agri. Res/ Council, Islamabad.
10. Aruga, H. 1994. Principles of Sericulture (Translated from Japanese). Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi 376 pp.
11. Krishnawami, S., Narasimhanna, M. N., Suryanarayan, S.K. and S. Kumaraj, 1993. Sericultural Mannual II: Slikworm Rearing. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi 133 pp.
12. Hooper, T. 1991. Guide to Bees and honey BAS Printers Ltd. Hampshir, UK 271 pp.

13. Ahmad, R.1979. A Guide to Bee Keeping in Pakistan. Extension Book.

7th SEMSTER

ENT-601 PEST FORECASTING AND MANAGEMENT 4(3+1)

THEORY:

Introduction; population sampling; population fluctuation and its measurement; population models, different methods of insect pest scouting and forecasting; losses caused by insect pests to different crops; methods of control: cultural, physical, mechanical, legislative, chemical, biological, microbial and genetical, alongwith antimetabolites, feeding deterrents, hormones and pheromones; concept of integrated pest management (IPM); economics of pest management.

PRACTICAL:

Demonstration of cultural practices and different methods of pest scouting and forecasting; nature and extent of damage; assessment of crop losses by different methods; determination of economic threshold levels of different crop pests; identification of important bio-control agents; installation of light and pheromone traps; computation, preparation and field application of insecticide formulations; familiarity with irradiation techniques.

BOOKS RECOMMENDED:

1. Atwal, A. S. and S. S. Bains, 2005. Agricultural Pests of South East Asia and their Management. Kalyani Publishers, Ludhiana.
2. Pimental D. 2002. Encyclopedia of Pest management. Maral Dekker Inc. USA.
3. Peterson, R.K.D and L.G. Sigley. 2001. Biotic Stress and Yield Loss.
4. Binns, M.R.2000. Sampling and Monitoring in Crop Protection. CABI Publishing Co.
5. Upadhyay, R. K., K. G. Mukerji, B. P. Chamola and O.P. Dubly, 1998. Integrated Pest and Disease Management. A. P. H. Publ. Co., New Delhi.
6. House, P., I. Stevens and O. Jones, 1998. Insect Pheromones and their use in Pest Management. Chapman and Hall, London.
7. Pedigo, L.P., 1996. Entomology and pest management 2nd ed. Prentice and Hall, Intl. Limited, London.
8. Dent, D., 1996. Integrated Pest Management. Chapman & Hall, London.

9. Metcalf, R.L. & W.H, Luckmann. 1994. Introduction to Insect Pest Management. 3rd ed. Intercept Ltd. U.K.
10. Hill, D. S., 1993. Agricultural Insect Pests of the Tropics and Their Control. Cambridge University Press, Cambridge, 746 pp.
11. Goodenough, J.L. & J.M. Mckineon, 1992. Basics of Insect Modelling. Amer. Soc. Agri. Engineers, USA.
12. Pimental, D., 1991. Handbook of Pest Management I - III. C.R.C. Press Inc. Florida, USA.

ENT-603 PLANT RESISTANCE TO INSECT PESTS 3(2+1)

THEORY:

Introduction; mechanism of resistance: ecological, physiological, asynchrony, induced genetic antixenosis, antibiosis and tolerance; factors of resistance; genetic basis of resistance; effect of environment on resistance; biotypes and resistance; measurement of resistance; development of resistant varieties; role of entomologists in breeding for resistance and transgenic crops.

PRACTICAL:

Testing and measurement of relative plant resistance to insects in different crops and transgenic plants.

BOOKS RECOMMENDED:

1. Sadasaban. 2003. Molecular Host Plant Resistance to Pests. 90423.
2. Pedigo, L.P, 1996, Entomology and Pests Management, 2nd ed. Prentice Hall, Inc, London
3. Panda, N. and G.S.Khush, 1995, Host plant resistance to insects, IRRI, Printed and Bound in UK, Biddles Ltd. Guildford, UK
4. Subba Rao, N.S., C. Balagopalan and S.V. Ramakrishna (Edts) 1992, New Trends in Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi
5. Panda, N. 1980, Principles of Host Plant Resistance to Insect Pests, Allenheld, London.

ENT-605 INSECTICIDES AND THEIR APPLICATION 4(3+1)

THEORY:

Introduction; nomenclature, classification on the basis of mode of entry, chemical nature mode of action and toxicity, formulations, compatibility, physico-chemical properties, mode of action, residues, hazards and safety measures of insecticides; structure and working of various types of hand and power operated equipment for insecticide application.

PRACTICAL:

Computation, preparation and field application of different formulations of insecticides; identification, classification, handling and maintenance of application equipment.

BOOKS RECOMMENDED:

1. Nastic. 2005. Technology of application of pesticides. 98633.
2. Saleem, M.A. 2004. Principles of Insect Toxicology. Vol.-I. Izharsons Printers. Lahore.
3. Mathews G.A., 2000. Pesticide application methods 3rd ed. Intercept. UK.
4. Ishaaya, I. and D. Degheele, 1998. Insecticides with novel modes of action: Mechanism and application. Norosa Publishing House, New Delhi.
5. Otto, D., B. Weber, 1991. Insecticides Mechanism of Action and Resistance. Intercept Ltd., U.K.
6. Brown, A.W.A. 1977. Ecology of Pesticides. John Wiley & Sons.
7. Parmer, 2004. Pesticide Formulation: Theory and Practical Code No.60752
8. Stenersen, 2004, chemical Pesticides: Mode of action and toxicology, Code No.61984.

ENT-607 RANGE AND FOREST ENTOMOLOGY 3(2+1)

THEORY:

Importance of range in forest entomology in range land and forest ecosystem; insect pests on range and forest trees, their identification, distribution, host plants, biology, mode of damage and control. Competition and complementary role of insects with range livestock.

PRACTICAL:

Collection, preservation and identification of insect pests of forest trees.
Practical study of mode of damage and demonstration of control methods.

BOOKS RECOMMENDED:

1. Jha, K. 2003. Forest Entomology. Ashish Publishing House. India.
2. Thakur, M.I., 2000, Forest Entomology (Ecology and Management) S.A.I. Publishing Co.
3. Dajoz, R. 2000. Insects and Forests. Intercept Ltd. UK.
4. Dent, D., 2000, Insect Pest Management, 2nd ed, A.B.I. Publishing Co.
5. Barbose, P. and M.B. Wagner, 1989, Introduction to Forest and Shade Tree Insects, Academic Press, NY, London
6. Knight, F.B. and H.J.Heeiknen, 1980, Principles of Forest Entomology, McGraw Hill, Book Co. NY
7. Anderson, J.F. and M.K. Kaya, 1976, Perspectives in Forest Entomology, Acad Press, NY, San Francisco, London

ENT-609 AGRICULTURE AND ENVIRONMENTAL POLLUTION 2(2+0)

THEORY:

Introduction; general concept of pollutants; sources and nature of pollutants; environmental deterioration, its effect on agriculture; green house effect; types of pollution with reference to agriculture and forest; pesticide and fertilizer pollution; effect of pollution on soil, water, air, plants, living organisms etc; management of pollution.

Books Recommended

1. Gerger, J.J., 1990, Environmental Restoration. Science and Strategies for restoring the health. EBL Publishers, London.
2. Suhai, A & S. Ahmad, 2003. A workbook of Agriculture & Environmental Pollution. Deptt. of Agri. Entomology, University of Agriculture, Faisalabad.
3. Saleem, M.A. and M.Ashfaq, 2004, Environmental Pollution and Agriculture, B.Z. University Press, Multan
4. Misra, S.G. and D. Mani, 1994. Agricultural Pollution, Vols. 1 & 2, Ashih Publishing House, New Delhi.
5. Praksh, R and S.M.Choubey, 1990. Environmental Pollution and Health Hazards. Publication of Society of Biochemistry of India
6. Rizvi, S.M.H. 1994. Fundamentals of Environmental Pollution. CBS Publishers and Distributers. 485, Jain Bhawan, Bhola Nath Nagar, Shahdara, Delhi-32.
7. Racke, K.D.1993. Pesticides in Urban Environments: Fate and Significance 47998

8. Hond, F.D. 2003, Pesticides: Problems, Improvements and Alternatives 42221

**ENT-611 PREPARATION OF RESEARCH PROJECTS
AND SCIENTIFIC WRITING 2(1+1)**

THEORY:

Entomological literature; internet sources and packages of entomological information; layout of experiments; collection, tabulation, analysis and interpretation of research data; instruction in research paper, monograph and catalogue writing.

PRACTICAL:

Library exercises in internet sources of entomological information; collection and analysis of data on field experiments

BOOK RECOMMENDED:

1. Gilbert, I. and C.J. Himalton, 1983, Entomology: A Guide of information sources, Mausell Publishing Co. Ltd.
2. Ghani, M.A. and M. Ashfaq (Edit). 1987, A resume of Post-Graduate Research, 1929-1985. Deptt. of Entomology, University of Agriculture, Faisalabad.
3. Quinn, G.P. and J.K.Michael. 2002. Experimental Design and Data Analysis for Biology. Cambridge University Press.

8TH SEMESTER

ENT-610 INTERNSHIP 15(0+15)

(Including report writing and presentation)

Evaluation Chart

1. 25% 75 marks to the supervisor of host institution.
2. 25% 75 marks for reporting, collection and presentation, evaluated by the proposed committee.
3. 25% 75 marks for written examination conducted by the proposed committee.50% from academics and 50% from internship report.
4. 25% 75 marks for oral examination conducted by proposed internal examiner, external examiner / committee.

CURRICULUM FOR POST-GRADUATE LEVEL

SCHEME OF STUDIES

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.

<u>S. No.</u>	<u>Course No.</u>	<u>Title</u>	<u>Credit Hours</u>
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	Insect Molecular Biology	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	Insects of Man and Animals	3(2+1)
12.	ENT-712	Acarology	4(3+1)
13.	ENT-713	Classification of Immature Insects	3(2+1)
14.	ENT-714	Insecticides Toxicology	3(2+1)
15.	ENT-715	Insect Nutrition	3(2+1)
16.	ENT-716	Insecticide and Public Health	2(2-0)
17.	ENT-717	Biological Control of Insect Pests and Weeds	3(2+1)
18.	ENT-718	Advanced Insect Behaviour	3(2+1)
19.	ENT-719	Special Problem	1(1-0)
20.	ENT-720	Seminar	1(1-0)

21.	ENT-721	Insecticides Application Equipment	2(1+1)
22.	ENT-722	Advances in Pest Management Research	2(2-0)
23.	ENT-723	Insect Cytogenetics and Cytotaxonomy	2(1-2)
24.	ENT-724	Insect Pathology	3(2+1)
25.	ENT-725	Insect Biochemistry	3(2+1)
26.	ENT-726	Chemical Ecology	2(2+0)
27.	ENT-726	Forensic Entomology	2(2+0)

Minimum credit hours should be 35 including minor subjects which shall not exceed one-third.

NOTE: For the award of degree for M.Sc. Agri. Entomology thesis carries a weightage of 10 credit hours.

DETAILS OF COURSES

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

THEORY:

Introduction; techniques and apparatus employed in entomological research: temporary and permanent mounts, microtomy, use of camera lucida, ocular grid, micrometry and scientific photography; bio-assay techniques; use of Potter's tower, atomic absorption spectrophotometer, gas chromatography, high performance liquid chromatography, ultraviolet visual spectrophotometer, amino acid analyzer, electrophoresis, PCR, recombinant DNA techniques ultra centrifugation, scanning and transmission, electron microscopy and computer software in entomology; methods of sampling, analysis of data and report writing.

PRACTICAL:

Insect collection apparatus and preservation techniques; rearing and culturing devices; exercises in microtomy, preparation of permanent slides, micrometry and scientific photography; maintenance and measurement of microclimate; use of different equipment in entomological experiments, sampling, tabulation, analysis and interpretation of data. Bioassay; demonstration of insect DNA amplification through PCR methods.

BOOKS RECOMMENDED:

1. Bancroft, J. D. and A. Stevens, 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. Beatty, B. Mai, S. and J. Squire. 2000. FISH. Oxford University Press.
4. Blaker, A.A. 1977. Handbook for Scientific Photography. W.H. Freeman and Co., San Francisco.
5. Erlich, H., 1992. PCR Technology: Principles and Applications for Amplification. W.H. Freeman & Company, New York.
6. Peterson, A. 1976. Entomological Techniques. Edward Bros. Inc. Ann. Arbor, Michigan, U.S.A
7. Singh, P. & R.F. Moore, 1985. Handbook of Insect Rearing Vol, I & II, Elsevier, U.S.A.
8. Smith, I. 1960. Chromatographic and Electrophoretic Techniques. William Heinemann Medical Books Ltd., London. Vol.I (4th edition) XII.

9. Tonapai, G. T. 1994. Experimental Entomology - An aid to Laboratory and Field Studies. CBS Publishers and Distributors, Delhi, India.

ENT-702 ORIGIN AND PHYLOGENY OF INSECTS 3(3+0)

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.

BOOKS RECOMMENDED:

- 1 Borrer, D. J. and D. M. DeLong, 1997. An Introduction To The Study of Insects and Related Invertebrates. 6th Ed. Macmillan, New York.
- 2 Dodson, E. C. and I. Dodson, 1986. Evolution, Process and Product, 4rd Ed. I.W.S. Publishers.
- 3 Hennig, W, 1981. Insect Phylogeny. Wiley Intersciences, London.
- 4 Kapoor, V. C., 1987. Origin and Evolution of Insects. Kalyani Publishers, New Delhi.
- 5 Ross, H. H., C. A. Ross and J.R.P. Ross, 1982. A Textbook of Entomology, 4th ed. John Willey and Sons Inc., N. Y.
- 6 Wiley, E. C. 1981. Phylogenetics. The Theory and Practice of Phylogenetic Systematics. John Wiley and Sons Inc., New York.
- 7 Marjorie, A.H. 1994. Insect Molecular Genetics. Academic Press, USA.
- 8 Hoy, M.A. 2003. Insect Molecular Genetics: An Introduction to Principles and Application. Elsevier.
- 9 Gilbert, L. 2005. Comprehensive Molecular Insect Science. 1-7 Vol.

ENT-703 ENVIRONMENTAL ENTOMOLOGY 2(2-0)

Introduction; 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.

BOOKS RECOMMENDED:

1. Annual Review of Entomology, 1965 to date Palo Alto, California, Ann. Rev. Inc. U.S.A.

2. Anonymous, 1983. Agrochemical Fate in Food and Environment. Published by I.A.E.A., Vienna.
3. McEwen, F.L. and G.I. Stephenson, 1979. The Use and Significance of Pesticides in the Environment. John Wiley and Sons Inc., N.Y.
4. Perry, A.S. 1998. Insecticides in Agriculture and Environment: Retrospects and Prospects. Elsevier, New York.
5. Kookana, R.S., R.Sadler, N. Sethunathan and R. Naidu. Environmental Protection and Risk Assessment of Organic Contaminants. Science Publishers, Inc. Enfield (NH), USA. Plymouth. UK.
6. Huffaker, C. B. 1999. Ecological Entomology. John Wiley Sons.
7. Saleem, M.A. and M. Ashfaq. 2004. Environmental Pollution and Agriculture. B.Z. University Press, Multan.

ENT-704 ADVANCED INSECT MORPHOLOGY

3(2+1)

THEORY:

Introduction; study of structure of integument and its processes (setae, spines, spurs, scales, etc.); modifications of various mouthpart structures, segmentation and structure of head, thorax and abdomen, wing structure in insect orders and families of economic importance; other body appendages in adult and immature insects; comparative study of genitalia in various groups of insects; thermoregulatory, visual, auditory, glandular and luminous organs in insects.

PRACTICAL:

Study of structure of head, thorax, abdomen and their appendages in different insect orders: preparation of permanent mounts of different body parts and integument to study their structure; examination of different types of setae, spines, spurs and scales in insects; study of visual, auditory thermoregulatory and luminous organs.

BOOKS RECOMMENDED:

- 1 Champan, R. F., 2000. The Insects: Structure and Function, 4th ed. Hodder and Stoughton Ltd., U.K.
- 2 Duporte, E. M., 1977. Manual of Insect Morphology. Reinhold Publishing Corp., N.Y.
- 3 Fox, R. M. and J.W. Fox, 1963. Comparative Entomology. Reinhold publishing corp., Chapman and Hall Ltd., London, N.Y.
- 4 Matsuda, R., 1965. Morphology and Evolution of Insect Head. Memr. Amer. Ent. Ist. Ann. Arbor, Michigan, USA.
- 5 Matsuda, R., 1971. Morphology and Evolution of Insect Thorax. Mem. Ent. Soc. Canada., Vol. 76.

- 6 Matsuda, R., 1975. Morphology and Evolution of Abdomen. Pergamon Press.
- 7 Snodgrass, R., 1993. Principles of Insect Morphology. Cornell Uni. Press, U.S.A.
- 8 Tuxen, R. 1956. Structure of Genitalia

ENT-705 ADVANCED INSECT ECOLOGY 3(2+1)

THEORY:

Introduction; environmental requirements of insects; essential elements and limiting factors; trophic spectrum; population sampling, modeling and attributes; fecundity and life tables, "K" factor analysis, regression, co-existence, co-habitation, competition and mutual displacement; variations; growth theories and indices.

PRACTICAL:

Insect ecology instruments for micro-environment measurements; study of optimal conditions for important insect groups, exercises in population studies; innate capacity for increase, stable age distribution, use of logistic curve for growth and regressions; estimation of population density; determination of sampling size; construction of life tables, budget; host-parasite and predator-prey relationships.

BOOKS RECOMMENDED:

1. Atwal, A. S. and S. S. Bains, 2005. Applied Animal Ecology. Kalyani Publishers, Ludhiana.
2. Goodenough, J.L. & J.M. McKnion, 1992. Basics of Insect Modelling. American Soc. Agri. Engineers.U.S.A.
3. Price, P.W., 1984. Insect Ecology, 2nd ed. Wiley Interscience Publishers, N.Y.
4. Southwood, T.R.E., 1978. Ecological Methods With Particular Reference to the Study of Insect Population. Methuen and Co. Ltd., London.
5. Symondson, W. O. C. and J. E. Lidbell, 1996. The Ecology of Agriculture Pests - Biochemical Approach. Chapman & Hall, London.
6. Varley, G.C., G.R. Gradwell and M.P. Hassell, 1973. Insect Population Ecology- An Analytical Approach. Blackwell Scientific Publications, London.

7. Yazdani, S. and M. I. Agarwal, 1997. Elements of Insect Ecology. Narosa Publishing House, New Delhi.
8. Rian, M.F. 2002. Insect Chemoreception: Fundamental and Applied. Pak
9. Barends, S.K. 1998. The Diversity of Living Organisms. Pak.
10. Raman, A. 1997. Ecology and Evolution of Plant Feeding Insects in Nature. Pak.
11. Baldwin, 2004. Insects and Ecosystem Function, Code No.62232.

ENT-706

NUMERICAL TAXONOMY

2(1+1)

THEORY:

Introduction; aims and principles of numerical taxonomy; data and its types; taxonomic characters, their selection, coding and weightage; 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

PRACTICAL:

Characterization, coding and preparation of matrices, generation of phenograms by applying Coefficients of Association, Correlation and Taxonomic Distance formulae. Construction of phenograms/dendrograms; Software programmes in Numerical Taxonomy.

BOOKS RECOMMENDED:

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

ENT-707 ADVANCED INSECT PHYSIOLOGY AND EMBRYOLOGY

3(2+1)

THEORY:

Introduction; advances in physiology of integument, growth, development, diapauses, 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:

Hormonal control of insect growth, development and breaking of diapause; digestion in different parts of alimentary canal; Oxygen consumption, carbon dioxide production and determination of respiratory quotient. Qualitative and quantitative analysis of haemocytes haemolymph; 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.

BOOKS RECOMMENDED:

1. Agarwal, O.P., 1994. Perspectives in Entomological Research. Scientific Publishers, India.
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, 4th ed. American Elsevier Publishing Co., Inc. N.Y.
4. Howse, P., I. Stevens and O. Jones, 1998. Insect Pheromones and Their Use in Pest Management. Chapman and Hall, London.
5. Kerkut, G. A. and L.I. Gilbert, 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 2nd Edition. Academic Press, N.Y.
7. Tonapi, G.T., 1994. Experimental Entomology; An Aid to Laboratory and Field Study. CBS, Publishers, India.
8. Chapman, R.F. 1998. The Insects: Structure and Function (4th ed.) Hodder and Stoughton Educational Ltd., U.K.
9. Cummins, K.W., Lee. D. Miller, Ned A. Smith and Richard M. Fox. 1985. Experimental Entomology. Reinhold Publishing Corporation, Chapman & Hall Ltd., London.

10. Saxena, S. C., 1992. Biology of Insects. Oxford and IBH Publishing Co., New Delhi.
11. Tonapi, G. T., 1994. Experimental Entomology. An Aid to Laboratory and Field Studies. CBS Publishers and Distributors, New Delhi, India.
12. Wigglesworth, V.B. 1972. Principles of Insect Physiology, 7th Ed. Meltron & Co. Ltd. U.K.

ENT-708 INSECT MOLECULAR BIOLOGY (2+1)

THEORY:

Introduction, insect genomes, Linkage and Chromosomal mapping, Linkage maps of *Drosophila* and *Aedes*, *Anopheles* spp etc. Gene libraries, Gene organization and functions in *Drosophila* / *Anopheles* regulatory genes, genes regulatory processes, metamorphosis; mutagenesis, Molecular basis of insect behaviour, Gene knock ins and knockouts.

PRACTICALS:

Demonstration of DNA hybridization and sequencing PCR and RAPD techniques, Gene libraries and cloning techniques.

BOOKS RECOMMENDED:

1. Elsevier,2003, Insect Molecular Genetics: An Introduction to Principles and Applications
2. 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.
3. Richard L. L. Lacey, (Ed.) 2003. Molecular Biology of the Gene, Fifth Edition
4. John Wilson , Tim Hunt, Molecular Biology of the Cell: The Problems Book
5. William Stansfield, 1996. Outline of Molecular and Cell Biology,1996
6. Hoy, M.A. 2003.Insect Molecular Genetics: An Introduction to Principles and Applications. Elsevier.
7. Hoy, M.A.2000. Insect Transgenesis: Methods and Application. CRC Press.
8. Handler, A.M., James. A.A., Blomquist, G., Vogt, R.G. (Eds.). 2003. Insect Pheromone Biochemistry and Molecular Biology: The Biosynthesis and Detection of Pheromones and Plant Volatiles. Elsevier.

- Glick, B.R. and J.J. Pasternek. 1998. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press. Washington D.D.

ENT-709 INSECTICIDE RESISTANCE AND 3(2+1)
MANAGEMENT

THEORY:

Introduction; development and types of resistance; mechanism of resistance: biochemical and genetic; metabolism of insecticides; detoxification mechanism in insects: phase I reactions such as oxidation, hydrolysis, reduction and dehydrochlorination etc.; phase II reaction such as conjugation; multiple pathways, induction of detoxification enzymes; management of resistance; Genotoxicity.

PRACTICAL:

Collection of potentially resistant strains of insects from the pesticide sprayed fields; detection of level of resistance in resistant strains; biochemical basis of resistance; demonstration of resistance breaking techniques.

BOOKS RECOMMENDED:

- Gupta, H.C.L., 1999. Insecticides: Toxicology and Uses. Agrotech Publishing Academy, Udaipur.
- Hassall, K. A., 1990. The Biochemistry and uses of Pesticides: Structure, Metabolism, Mode of Action and Uses in Crop Protection. ECBS/Macmillan U.S.A.
- Pedigo, L.P., 1996. Entomology and Pest Management. Macmillan Publishing Co. N. Y., London.
- Walia, S. and B. S. Parmar., 1995. Pesticide, Crop Protection and Environment. Oxford & IBH Publishing Co. New Delhi, Calcutta.
- Wilkinson, C.F., 1976. Insecticides Biochemistry and Physiology. Heyden, London, New York, Rheine.
- Roush, R.T. and B.E.Tabashnik (Eds.). 1990. Pesticide Resistance in Arthropodes. Chapman & Hall. New York.
- US National Academy of Sciences. 1986. Pesticide Resistance: Strategies and Tectics for Management. National Academy Press. Washington.
- Green, M.B., H.M. LeBaron and W.K.Moberg (Eds.). 1990. Managing Resistance to Agrochemicals. American Chemical Society. Washington.
- Denholm, I. 1999. Insecticide Resistance from Mechanism to

ENT-711

**MEDICAL AND VETERINARY
ENTOMOLOGY**

3(2+1)

THEORY:

Introduction; epidemiology; identification, biology and control of insects and other arthropods of medical and veterinary importance; insect and some other arthropod transmitted diseases, their symptoms and diagnosis; venoms, defense secretions and allergens.

PRACTICAL:

Collection, identification and control of different arthropod pests (cockroaches, lice, mosquitoes, flies, fleas, mites and others) in relation to diseases of man and domestic animals.

BOOKS RECOMMENDED:

- 1 Busvine, J.R., 1980. Insects and Hygiene, 3rd ed. Chapman and Hall, London.
Harwood, R. F. and M.T. James, 1979. Entomology in Human and Animal Health, 7th ed. Macmillan Publishing Co., Inc., N.Y.
- 2 Kettle, D.S., 1995. Medical and Veterinary Entomology (2nd ed.), CAB International, UK.
- 3 Service, M. W., 1996. Medical Entomology for Students. Chapman Hall, London.
- 4 Goddard, P. Physician Guide to Arthropods of Medical Importance. 4th Ed. CRC Press
- 5 Aldridge, B. 2004. Medical Entomology: Text Book of Public Health and Veterinary. Chapman and Hall, London.
- 6 Muller, P. and L. Burden. 2002. Medical and Veterinary Entomology. 1st Ed. Academic Press London.
- 7 Lehane, 2005. Biology of Blood Sucking Insects. Printice USA.

ENT-712

ACAROLOGY

4(3+1)

THEORY:

Introduction; methods of collection, rearing and preservation; external and internal morphology; physiology, reproduction and development; mites as pests of important crops, vegetables, fruit trees, stored grains, stored products and their control; parasitic and predatory mites; losses caused by and control of mite pests; ecology and dispersal; methods of estimation of

mite population and losses; classification of mites; mites and plant diseases. Resistance mechanism in mites.

PRACTICAL:

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

BOOKS RECOMMENDED:

1. Evans, G. O., 1992. Principles of Acarology. C. A. B. International Cambridge University Press, Cambridge.
2. Helle, W. and M. W. Sabelis (Edit.), 1985. Spider Mites, Their Biology, Natural Enemies and Control, Vols. IA. and IB. Elsevier Oxford, U. K.
3. Jeppson, L. R., H. M. Keifer and E. W. Baker, 1975. Mites Injurious to Economic Plants. Univ. Calif. Press.
4. Khuro, R. D. 1998. Introduction to Acarology Kashif Publications, Hyderabad (Sindh), Pakistan.
5. Krantz, G. W., 1978. A Manual of Acarology, 2nd ed. Oregon State Univ. Book Store Inc., Corvallis, Oregon, USA.
6. Rodriguez, J. G. (Edit.), 1979. Recent Advances in Acarology, Vol. I & II. Academic 7. Press Inc., N. Y.
7. Schuster, R. and P.W. Murply. 1991. The Acari, Reproduction, Development and Life History Strategies. Champman & Hall, USA.
8. Kropczynska, D., J. Boczek and A. Tomczyk. 1995. The Acari, Psysiological and Ecological Aspects of Acari- Host Relationship. Dabor Publishers. Warsa. Poland
9. Zhang, Z.Q.. 2003 Mites of Green Houses: Identification Biology and Control. Elsevier, New York.

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

THEORY:

Introduction; collection and preservation of immature stages of insects; preparation of immature insects for identification; identification and classification of immature stages of Ephemeroptera, Plecoptera, Odonata, Diptera, Lepidoptera, Trichoptera, Hymenoptera, Neuroptera and Coleoptera up to family level.

PRACTICAL:

Collection, preservation, preparation and identification of immature stages up to family level.

BOOKS RECOMMENDED:

1. Chu, H.F., 1983. How to know the Immature Insects. W.M.C. Brown Co., Publishers, Iowa, USA.
2. Peterson, A., 1962. Larvae of Insects, Part-I, 4th ed. Edwards Brothers Inc.; Arbor, Michigan.
3. Peterson, A.R., 1960. Larvae of Insects, Part-II, 4th ed. Edwards Brothers Inc., Arbor, Michigan.
4. Stehr, F., 1991. Immature Insects. Vol. I&II. Kendall - Hunt Publishing, U.S.A.
5. Lawrence, J.F., A.M. Hastings, M.J. Dallintz, T.A. Palmy and E.J. Zurcher. 1999. Beetle larvae of the world. CSIRO. Australia.

ENT-714

INSECTICIDES TOXICOLOGY

3(2+1)

THEORY:

Introduction; general concepts of insect 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; chemical assay of insecticides.

BOOKS RECOMMENDED:

1. Gupta, H.C.L., 1999. 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 D. Deghecle, 1998. Insecticides With Novel Modes of Action: Mechanism and Application. Norosa Publishing House, New Delhi, Madras, Bombay, Calcutta, London.
4. Kerkut, G.A. and Gilbert, L.I., 1985. Comprehensive Insect Physiology, Biochemistry and Pharmacology. Pergamon Press, Oxford, N.Y., Toronto, Sydney, Paris, Frankfurt.
5. Pedigo, L.P., 1996. Entomology and Pest Management. Macmillan Publishing Co. N. Y., London.
6. Rockstein, M., 1978. Biochemistry of Insects. Academic Press, N.Y., San Francisco, London.
7. Sree Ramulu, U.S., 1995. Chemistry of Insecticides and Fungicides (second edition). Oxford & IBH Publishing Co. Pvt. New Delhi, Bombay, Calcutta.
8. Wilkinson, C.F., 1976. Insecticides Biochemistry and Physiology. Heyden, London, New York, Rheine.
9. Busvine, J.P. 1971. A Critical Review of Testing Insecticides. Soughton. London.
10. Saleem, M.A. 2004. Principles of Insect Toxicology. Izharsons Printers, Lahore.
11. Stenersen, 2004. Chemical Pesticides: Mode of action and toxicology.

ENT-715

INSECT NUTRITION

2(1+1)

THEORY:

Introduction; dietary requirements of insects; micro and macro nutrients with their role in insects diet; artificial diets for insects and their quality control; micro-organisms and insect nutrition, co-efficient of digestion, metabolism and growth; nutrition and host specificity; phago-stimulation.

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.

BOOKS RECOMMENDED:

- 1 Chapman, R.F., 1998. The Insects, Structure and Function, 4th ed. American Elsevier Publ. Co., Inc., N.Y.
- 2 Gilmour, D., 1965. The Metabolism of Insects. Oliver and Boyed. Edinburgh and London.

- 3 Rodrigues, J. G. (Edit.), 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.
- 5 Cohen, A.C.. 2004. Insect Diets: Science and Technology. CRC Press.

ENT-716 INSECTICIDE AND PUBLIC HEALTH 2(2+1)

THEORY:

Agro-medical approach to pesticide management. Epidemiology of pesticides, Prevention, pesticide poisonings, toxicity, residues and mode of action, first aid procedures clinical aspects of acute poisoning. Laboratory verification. Symptoms and treatment of pesticide poisoning. Human pesticide exposure assessment. Pesticide monitoring and human concerns; workers protection. Agriculture, public health and environmental considerations. Safe use of insecticides. Transport, storage and disposal of pesticides; registration and labeling, pollution reduction; Nutrition and pesticide interactions.

BOOKS RECOMMENDED:

1. Gupta, H.C.L.1999, Insecticides: Toxicology and Uses, Agrotech Publishing Academy, Udaipur
2. Davis, J.E., V.H. Freed and F.W. Whittemore (Eds.). 1985. An agromedical approach to pesticide management. Some health & environmental considerations. AID. Consortium for International Crop Protection, University Miami School of Medicine.
3. Oudejans J.H.1991. Agropesticides AND Functions in Integrated Crop Protection. ESCAP. United Nations. Bangkok, Thailand.
4. Habib, N. 1996. Invisible Framers. Pesticide Action Network Asia & the Pacific and khoj-Res. & Publication Centre.
5. Bourke et al (Eds.) 1992. Pesticide Waste Management: Americal Chemical Society, Washington.
6. Dhaliwal, G.S. and B. Singh (Eds.) 2000. Pesticides and Environment. Commonwealth Publishers. New Delhi. India.
7. Pretty, J. 2005. The pesticides Delox. EarthScan. London.
8. Parmar, 2004. Pesticide formulation: Theory and Practice.
9. Sathe, V. 2003. Agrochemical and Pest Manatement. Code No.51938.

ENT-717 BIOLOGICAL CONTROL OF INSECT PESTS AND WEEDS

3(2+1)

THEORY:

Introduction; history, development and scope of biological control with special reference to Pakistan; ecological basis of biological control; biological characteristics of entomophagous insects; introduction, culture, release and establishment of entomophagous insects; conservation and augmentation of natural enemies; role of micro-organisms in biological control; integration of chemical and biological control.

PRACTICAL:

Collection, laboratory rearing, culturing and identification of parasitoids, predators and micro-organisms of economic importance; study of extent of parasitism / predation of different biocontrol agents.

BOOKS RECOMMENDED:

1. Burges, H.D. and N.W. Hussey, 1971. Microbial Control of Insects and Mites. Academic Press, London.
2. De'Bach, 1976. Biological Control of Pests and Weeds. Chapman & Brotes.
3. Gunasekaran, M. and D. Weber, 1996. Molecular Biology of the Biological Control of Pests and Diseases of Plants. ESA Publications, U.S.A.
4. Maramorosch, K., 1991. Biotechnology for Biological Control of Pests and Vectors. CRC Press, U. S. A.
6. Pedigo, L. P., 1996. Entomology and Pest Management, 2nd ed. Prentic Hall Intl., London.
7. Lentern, J.C.V., 2003. Quality Control and Production of Biocontrol Agents. Theory and testing procedures.
8. Hajek, A. 2004. Natural Enemies: An Introduction to Biological Control. Cambridge University Press.
9. Sahayaraj, 2004. Indian Insect Predators in Biological Control.
10. Endem, H. Van; Service, M. Pest and Vector Control.

ENT-718

INSECT BEHAVIOUR

3(2+1)

THEORY:

Introduction; Types of behaviour; Sensory receptors (mechanoreception, hygroreception, thermo-reception, photoreception); Nervous system and behaviour; Hormones and behaviour; Displacement (causes of migration, classes of migration, adaptive nature of migration); Orientation, navigation and homing; Communication (bio-luminescence chemical, acoustic, communication, visual, tactile communications); Sexual behaviour and reproduction; Host selection and feeding behaviour; Defense (behavioral, structural, coloration defenses); Population behaviour; Social behaviour.

PRACTICAL:

Collection of diurnal and nocturnal insects; Laboratory studies of various organs (sensillae); Rearing of social and solitary insects; Insect responses to audio-visual stimuli.

BOOKS RECOMMENDED:

1. Fellows, M. and G. Holloway, 2005, Insect Evolutionary Behavior, CABI
2. Bio-Communication in Insects, 1998, ISBN 1-57808-031-2/112 US\$49.00
3. Ryan, M.F., 2002, Insect Chemoreception Fundamental and Applied, Kluner
4. Dentinger, D.L., Giebultowicz, J. and Sanders, D.S. 2001, Insect timing: Cicadid Rhythmicity to season availability. Text figures.244pp, Elsevier (11752) HB.
5. Greenfield Micheal, D. 2002. Signals and Receivers: Mechanism and Evolution of Arthropod Communication. Oxford University Press.
6. Fellows, M.; Holloway, G (Eds) Insect Evolutionary Behaviour.

ENT-719

SPECIAL PROBLEMS

1(1-0)

ENT-720

SEMINAR

1(1-0)

ENT-721

**EQUIPMENT FOR INSECTICIDES
APPLICATION**

2(1+1)

THEORY:

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

PRACTICAL:

Study of different parts and assembling of sprayers, dusters and granule applicators; assembling and 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.

BOOKS RECOMMENDED:

- 1 Mathews, G.A., 1984. Pest Management. 1st ed. Longman Inc., N.Y.
- 2 Mathews, G.A., 1992. Pesticides Application Methods, 4th ed. Longman Inc., N.Y.
- 3 Pedigo, L., 1996. Entomology and Pest Management. 2nd ed. Prentice and Hall Intl. Ltd. London.
- 4 Pfadt, E. R., 1985. Fundamentals of Applied Entomology, 4th ed. The Macmillan Co., N.Y.
5. Metcalf C.L. and W.P Flint 1978. Destructive and Useful Insects. Their Habits and control 2nd ed. McGraw Hill Book Co. Inc. N.Y.
6. Nastec. 2005. Technology of Application of Pesticides. CRC Press.

ENT-722

**ADVANCES IN PEST MANAGEMENT
RESEARCH**

3(2+1)

THEORY :

Introduction; latest sampling techniques; determination of decision thresholds; transgenic and genetically modified crops; genetic control of insect pests; insect growth regulators; stem injection method, pheromones; remote sensing of insect pests; use of radiation and Radioisotopes in entomology

PRACTICAL:

Visit to different relevant institution.

BOOKS RECOMMENDED:

1. Dent. D., 1996. Integrated Pest Management. Chapman and Hall, London.
2. Metcalf, P.I. (Edit.), 1990 - todate. Advances in Pest Control Research, Vols. I-todate. Inter-sciences Publishers, N.Y.
3. Mittler, E.T., F.J. Radouiy and V.H. Resb, 1984. Annual Review of Entomology. Vol. 1984.
4. Todate. Ann. Review Inc., Palo Alto, California, U.S.A.
5. Sathe, T.V. 2003. Agrochemicals and Pest Management. Code No.51938.
6. Norris, 2003. Concepts in Integrated Pest Management.
7. Upadhyay, R. K., K. G. Mukerji, B. P. Chawola and O. P. Dubey, 1998. Integrated Pest and Disease Management. A.P.H. Publishing Corp., New Delhi.
8. Mayer, C.D. 2004. Biotechnological Approach for the Integrated Management. Wiley Intersciences, London.

ENT-723

INSECT CYTOGENETICS AND CYTOTAXONOMY

2(1+1)

THEORY:

Introduction; cell structure; characteristics and cell division in insects; chromosomes structure, number, diversity and types in insects; chromosomes and parthenogenesis in insects; chromosomes and ecology; modern concept of gene; gene-determined characters; environmental effect on gene expression; sex determination in insects; mutations and variations; use of chromosomes in taxonomy.

PRACTICAL:

Study of a typical insect reproductive cell, cell division, types and number of chromosomes in important insects groups for identification / classification; study of insect resistance; study of different types of genetic variations in insects; genetical identification of species and biotypes in insects.

BOOKS RECOMMENDED:

1. Blackman, R.L., G.M. Hemitt and M. Ashburner, 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. Swanson, C.P., T. Merz and W.J. Young, 1998. Cytogenetics - The Chromosomes in Division, Inheritance and Evolution (3rd ed). Prentice-Hall of India Pvt. Ltd. New Delhi.

ENT-724

INSECT PATHOLOGY

3(2+1)

THEORY:

Introduction; history definition and scope; resistance and immunity in insects against pathogens; 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 and their diagnosis; extra-cellular and intracellular microbiota of healthy insects; control of microbial diseases of useful insects; role of pathogens in IPM.

PRACTICAL:

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

BOOKS RECOMMENDED:

1. Boucias, D.G. 1998. Principles of Insect Pathology. Chapman Hall, London.
2. Burges, H.D. and N.W. Hurrey, 1972. Microbial control of Insects and Mites. Academic Press London.
3. Poinar, G.O. Jr. and G.M. Thomas, 1978. Diagnosis for the Identification of Insect Pathogens, Press. N.Y.
4. Tanada, Y. and H. Kaya, 1992. Insect Pathology. Academic Press, New York. 613 P.

ENT-725

INSECT BIOCHEMISTRY

3(2+1)

THEORY:

Introduction; energy metabolism and production in insects; biochemistry of cuticle, muscles, flight, synaptic transmission, light production, biochromes, hormones and karomonoos; insect growth regulators and diapause in insects; metabolism and role of carbohydrates, proteins and lipids in insects; chemical control of insect behaviour; biochemical defences in insects.

PRACTICAL:

Chemical identification of insect species and biotypes; pheromone extraction, its identification and control in insects; hormonal control of insect growth and development. Quantitaive analysis of Amino acids, proteins, uric acids in haemolymph; amylase etc.

BOOKS RECOMMENDED:

1. Candy, D.J. and B.A. Kilby, 1978. Insect Biochemistry and Function (2nd ed.) Chapman and Hall London. 314 pp.
2. Chapman, R.F., 1998. Insects: Structure and Function. 4th ed. American Elsvier. Publ. Co. Inc., New York.
3. Gilmour, D., 1961. The Biochemistry of Insects. Academic Press London. 343 pp.
4. Turner, R.B., 1977. Analytical Biochemistry of Insects. Elsevier Scientific Publishing Company New York. 315 pp.
5. Rockstein, M., 1978. Biochemistry of Insects. Academic Press, New York, U.S.A., 649 pp.
6. Morgan, E.D. 2004 Biosynthesis in insects. T.J. Intl. USA.

ENT-726

CHEMICAL ECOLOGY OF INSECTS

(2+0)

Introduction, odour dispersion in still air and wind; effect of wind speed and air temperature; Chemo- orientation in walking and flying insects; insect-plant interactions; biochemistry of pollination; Parasitoids, host relationship, sources of parasitoid behavioural chemicals; chemical and physical interactions; Warning colouration and Mimicry; Warning colouration and predator learning; Modes of mimetic resemblance; Sexual communication with pheromones and use of insect pheromones in plant protection.

BOOKS RECOMMENDED

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

ENT 727 **FORENSIC ENTOMOLOGY** (2 + 0)

Introduction ; historical perspective ; Insects and other arthropods on or in corpses/, in carcasses/ carrions ; corpses decomposition in succession and association of different insects and other arthropods with each stage ; importance of nematocerans as necrophages ; importance of some group as Phoridae, Sphaeroceridae, Sarcophagidae, Calliphoridae, some Coleoptera e. g *Dermestes* spp and mite species and their life cycles ; Caspers rule ; authenticity of investigations by human pathologists in medico-legal cases.

1. Byrd, J.H. and J.L. castner 2000
Forensic Entomology. CRC Press.
2. Keh, B. 1985. Scope & applications of Forensic Entomology
Ann. Rev. Entomol: 30 : 137 - 154
3. Erzinclioglu, Z. 1985 Few flies in Forensic entomology : New Scientist.
May issue : 15 – 17

RECOMMENDATIONS

1. It is strongly recommended by the committee members that refresher courses/workshops/training/seminars be arranged and it should be supported financially by HEC.
2. Teachers should be provided opportunities/resources to visit foreign universities to update their knowledge for short courses.
3. There must be adequate numbers of staff available to teach core/major courses at graduate/post-graduate levels.
4. It is highly recommended that HEC should provide funds to equip laboratories with apparatus and chemicals especially to the institutes where these are not available.
5. Adequately trained high-tech technologies/engineers be employed for the processing of samples and maintenance of sophisticated laboratory equipments funded by HEC.
6. HEC should provide funds for the installation of Internet facilities, Internship programmes of the students and visit/tours of the students/Books/Journals/periodicals etc.
7. It is recommended that HEC should encourage and facilitate teachers exchange programme so that expertise in a field present in an institute should be utilized by other institutes.