

Courses for B. Sc. (Hons.) Agriculture

2nd Semester

S.No.	Name of Course	Course No.	Cr. Hr.
1.	Fundamentals of Entomology	ENTO 121	3(2+1)

3rd Semester

S.No.	Name of Course	Course No.	Cr. Hr.
1.	Introductory Nematology	ENTO 211	2(1+1)

4th Semester

S.No.	Name of Course	Course No.	Cr. Hr.
1.	Insect Ecology and integrated Pest Management	ENTO 221	2(1+1)

5th Semester

S.No.	Name of Course	Course No.	Cr. Hr.
1.	Pests of Crops and Stored Grain and their Management	ENTO 311	3(2+1)
2.	Biopesticide & Biofertilizers	ENTO 312	3(2+1)

6th Semester

S.No.	Name of Course	Course No.	Cr. Hr.
1.	Management of Beneficial Insects	ENTO 321	2(1+1)

7th Semester

Modules for Skill Development and Entrepreneurship: A student has to register 20 credits opting for two modules of (0+10) credits each (Total 20 credits) from the package of modules in the VII semester.

S.No.	Activities	Credit Hours
1.	Plant Clinic	10 (0+10)
2.	Beekeeping	10 (0+10)

8th Semester

S.No.	Title of the module	Credits
1.	Orientation (RAWE)	-
2.	Plant Clinic (RAWE)	-

CERTIFICATE COURSE IN BEEKEEPING

- Training Course** : Beekeeping
- Venue of training** : Division of Entomology, SKUAST-J, Chatha, Jammu
- Duration of the course** : 3 months (March to May)
- Target groups** : Unemployed youth, rural people, Private individual and

	would be entrepreneurs
Eligibility	: Minimum qualification of 8 th Pass
Registration fee	: Rs. 2000/- (Rupees Two thousand only)
Course programmer	: Dr. Hafeez Ahmad, Professor and Head, Division of Entomology
Course Coordinator	: Dr. Devinder Sharma, Assistant Professor, Division of Entomology

BAE & BHE COURSES TAUGHT BY ENTOMOLOGY

BAE-05 : INSECT PESTS OF FIELD CROPS AND THEIR MANAGEMENT (1+1)

Theory:

Distribution, biology, nature and symptoms of damage, and management strategies of insect and non insect pests of cereals (rice, sorghum, maize, ragi, wheat), Distribution, biology, nature and symptoms of damage, and management strategies of insect and non insect pests of sugarcane, Distribution, biology, nature and symptoms of damage, and management strategies of insect and non insect pests of cotton, mesta, sunhemp, Distribution, biology, nature and symptoms of damage, and management strategies of insect and non insect pests of pulses, Distribution, biology, nature and symptoms of damage, and management strategies of insect and non insect pests of oilseeds (groundnut, castor, gingelly, safflower, sunflower, mustard), Distribution, biology, nature and symptoms of damage, and management strategies of insect and non insect pests of vegetable crops.

Practicals:

Identification of pests and their damage symptoms of important insect pests of cereals, pulses, oilseeds, fibre crops, Identification of pests and their damage symptoms of important insect pests of vegetable crops, Collection of insect pest and damaged material (Insectarium).

BHE-05 : INSECT PESTS OF FRUIT CROPS AND THEIR MANAGEMENT (1+1)

Theory:

Distribution, biology, nature and symptoms of damage, and management strategies of insect and non insect pests of Apple, pear, peach, litchi, plum, cherry, almond, walnuts, pomegranate, mango, guava, aonla, ber, citrus etc.

Practicals:

Identification and collection of insect pests and damaged material, Identification of pests and their damage symptoms of major pests of important crops.

BAE-08 APICULTURE (1+2)

Theory

History of beekeeping in India and world, Importance and Scope of beekeeping, Honeybee species, Colony organization of honeybees, Bee behaviour (Swarming, Absconding, Robbing), Beekeeping equipments, Seasonal management, Migratory beekeeping, Bee products, Bee pasturage/bee forage, Role of honeybee in crop pollination, Diseases and enemies of bees

Practical

Hive inspection, Acquaintance with beekeeping equipments, Field visits

DIVISION OF ENTOMOLOGY
SKUAST-J, CHATHA
PROGRAMME: M.Sc. (Entomology)

COURSE REQUIREMENT:

- Major 20 (12-15 credits should be compulsory rest optional),
- Minor 9
- Supporting 5
- Seminar 1
- Research 20 (as per 9th academic council meeting 2009)

Field of Specialization: Economic Entomology, IPM, Toxicology, Apiculture, Nematology

COURSE NO.	COURSE TITLE	CREDITS	SEMESTER
Compulsory Courses			
ENTO 501	Insect Morphology	1+1	I
ENTO 502	Insect Anatomy, Physiology And Nutrition	2+1	I
ENTO 503	Classification of Insects	2+1	I
ENTO 504	Insect Ecology	1+1	I
ENTO 505	Toxicology of Insecticides	2+1	II
ENTO 506	Principles of Integrated Pest Management	1+1	II
	Total	9+6 = 15	
Optional Courses			
ENTO 507	Principles of Taxonomy	2+0	I
ENTO 508	Insect Pathology	1+1	
ENTO 509	Biological Control of Crop Pests and Weeds	1+1	II
ENTO 510	Plant Resistance to Insects	1+1	II
ENTO 511	Pests of Field Crops	1+1	II
ENTO 512	Pests of Horticultural and Plantation Crops	1+1	II
ENTO 513	Storage Entomology	1+1	I
ENTO 514	Insect Vectors of Plant Viruses and other Pathogens	1+1	II
ENTO 515	General Acarology	1+1	I
ENTO 516	Soil Arthropods and their Management	1+1	I
ENTO 517	Vertebrate Pest Management	1+1	I
ENTO 518	Techniques in Plant Protection	0+1	I
ENTO 519	Commercial Entomology	1+1	II
ENTO 520	Plant Quarantine	2+0	II
ENTO 521	Principles of Nematology	2+1	I
ENTO 522	Nematode Diseases of Crops	3+1	I
ENTO 523	Nematode Interactions with other Organisms	2+1	II
ENTO 524	Nematode Management	2+1	II
ENTO 525	Beneficial Nematodes	1+1	II
ENTO 591	Master's Seminar	1+0	
ENTO 599	Master's Research	20	

NOTE: The student's advisory committee will decide rest of the courses for Minor and Supporting from the Plant Pathology, Vegetable Sciences & Floriculture, Fruit Science, Agricultural Statistics, Biochemistry and Plant Physiology, Genetics and Plant Breeding.

DIVISION OF ENTOMOLOGY
SKUAST-J, CHATHA
PROGRAMME: Ph. D. (Entomology)

COURSE REQUIREMENT:

- Major 15 (9-12 core rest optional),
- Minor 8,
- Supporting 5,
- Seminar 2,
- Research 45 (as per 9th academic council meeting 2009)

Field of Specialization: Economic Entomology, IPM, Toxicology, Apiculture, Nematology

COURSE NO.	COURSE TITLE	CREDITS	SEMESTER
Compulsory Courses			
ENTO 601	Advanced Insect Ecology	1+1	I
ENTO 602	Recent Trends in Biological Control	1+1	I
ENTO 603	Advanced Integrated Pest Management	2+0	I
ENTO 608	Advanced Insecticide Toxicology	2+1	II
ENTO 606	Advanced Insect Physiology	2+0	I
	Total	8+3 = 11	
Optional Courses			
ENTO 604	Advanced Insect Systematics	1+2	I
ENTO 605	Immature Stages of Insects	1+1	I
ENTO 607	Insect Behaviour	1+1	II
ENTO 609	Advanced Host Plant Resistance	1+1	II
ENTO 610	Advanced Acarology	1+1	II
ENTO 611	Agricultural Ornithology	1+1	I
ENTO 612	Molecular Approaches in Entomological Research	1+1	II
ENTO 613	Current Topics in Nematode Disease Development and Host Resistance	2+1	II
ENTO 614	Advances in Nematode Management	2+1	I
ENTO 691	Doctoral Seminar 1	1+0	
ENTO 692	Doctoral Seminar II	1+0	
ENTO 699	Doctoral Research	45	

NOTE: The student's advisory committee will decide rest of the courses for Minor and Supporting from the Plant Pathology, Vegetable Sciences & Floriculture, Fruit Science, Agricultural Statistics, Biochemistry and Plant Physiology, Genetics and Plant Breeding.

ENTOMOLOGY
M. Sc. Course Contents

ENTO 501	INSECT MORPHOLOGY	1+1	Sem- I
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Objective

To acquaint the students with external morphology of the insect's body i.e., head, thorax and abdomen, their appendages and functions.

Theory

UNIT I

Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

UNIT II

Head- Origin, structure and modification; types of mouthparts and antennae, tentorium and neck sclerites.

UNIT III

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications.

UNIT IV

Abdomen- Segmentation and appendages; Genitalia and their modifications; Embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs (mechano-, photo- and chemoreceptors).

Practical

Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia. Sense organs.

Suggested Readings

1. Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.
2. David BV & Ananthkrishnan TN. 2004. *General and Applied Entomology*. Tata-McGraw Hill, New Delhi.
3. Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.
4. Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.
5. Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.
6. Saxena RC & Srivastava RC. 2007. *Entomology: At a Glance*. Agrotech Publ. Academy, Jodhpur.
7. Snodgrass RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.

ENTO 502	INSECT ANATOMY, PHYSIOLOGY AND NUTRITION	2+1	Sem- I
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Objective

To impart knowledge to the students on basic aspects of anatomy of different systems, elementary physiology, nutritional physiology and their application in entomology.

Theory

UNIT I

Scope and importance of insect anatomy and physiology.

UNIT II

Structure, modification and physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands.

UNIT III

Thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapause.

UNIT IV

Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

Practical

Dissection of different insects to study comparative anatomical details of different systems; preparation of permanent mounts of internal systems; chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

Suggested Readings

1. Chapman RF. 1998. *Insects: Structure and Function*. ELBS Ed., London.
2. Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.
3. Kerkut GA & Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, New York.
4. Patnaik BD. 2002. *Physiology of Insects*. Dominant, New Delhi.
5. Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Vol. 1. *Structure, Physiology and Development*. Chapman & Hall, New York.
6. Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.
7. Wigglesworth VB. 1984. *Insect Physiology*. 8th Ed. Chapman & Hall, New York.

ENTO 503	CLASSIFICATION OF INSECTS	2+1	Sem- I
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Objective

To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects.

Theory

UNIT I

Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- Orders contained.

UNIT II

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

UNIT III

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid-Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

Study of Orders of insects and their identification using taxonomic keys. Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Field visits to collect insects of different orders.

Suggested Readings

1. CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.
2. Freeman S & Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.
3. Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.

4. Ross HH.1974. *Biological Systematics*. Addison Wesley Publ. Co. Triplehorn CA & Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects*. 7th Ed. Thomson/ Brooks/ Cole, USA/Australia.

ENTO 504	INSECT ECOLOGY	1+1	Sem- I
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Objective

To teach the students the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, organization of communities, diversity indices. Train students in sampling methodology, calculation of diversity indices, constructing life tables, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

UNIT I

History and Definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

UNIT II

Basic concepts of abundance- Model vs Real world. Population growth basic models – Exponential vs Logistic models. Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation.

UNIT III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of nicheecological homologues, competitive exclusion. Prey-predator interactions- Basic model- Lotka-Volterra Model, Volterra's principle. Functional and numerical response. Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

UNIT IV

Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's d/w , Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology.

Practical

Types of distributions of organisms. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's Disc equation, Assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild. Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of some diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Suggested Readings

1. Chapman JL & Reiss MJ. 2006. *Ecology: Principles & Applications*. 2nd Ed. Cambridge Univ. Press, Cambridge.

2. Gotelli NJ & Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc., Sunderland, MA.
3. Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA
4. Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.
5. Krebs CJ. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
6. Krebs CJ. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance*. 5th Ed. Benjamin-Cummings Publ. Co., New York.
7. Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton Univ. Press, Princeton.
8. Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.
9. Real LA & Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.
10. Southwood TRE & Henderson PA. 2000. *Ecological Methods*. 3rd Ed. Methuen & Co. Ltd., London.
11. Speight MR, Hunta MD & Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.
12. Wilson EO & William H Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.
13. Wratten SD & Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

ENTO 505	TOXICOLOGY OF INSECTICIDES	2+1	Sem- II
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Objective

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

UNIT I

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

UNIT II

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature. Structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrazoles, insect growth regulators, microbials, botanicals, new promising compounds, etc.

UNIT III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides- synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity.

UNIT IV

Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

UNIT V

Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

Insecticide formulations and mixtures; quality control of pesticide formulations; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides; visit to toxicology laboratories. Good laboratory practices.

Suggested Readings

1. Chattopadhyay SB. 1985. *Principles and Procedures of Plant Protection*. Oxford & IBH, New Delhi.
2. Gupta HCL. 1999. *Insecticides: Toxicology and Uses*. Agrotech Publ., Udaipur.

- Ishaaya I & Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action*. Narosa Publ. House, New Delhi.
- Matsumura F. 1985. *Toxicology of Insecticides*. Plenum Press, New York.
- Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. *Insecticides in Agriculture and Environment*. Narosa Publ. House, New Delhi.
- Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture*. Lewis Publ., New York.

ENTO 506	PRINCIPLES OF INTEGRATED PEST MANAGEMENT	1+1	Sem- II
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Objective

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM. Train students in computation of ETL, implementing IPM programmes.

Theory

UNIT I

History and origin, definition and evolution of various related terminologies.

UNIT II

Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

UNIT III

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system.

Suggested Readings

- Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publ., New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
- Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management*. 1st Ed., Springer, New York.
- Horowitz AR & Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.
- Ignacimuthu SS & Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.
- Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management*. John Wiley & Sons, New York.
- Pedigo RL. 2002. *Entomology and Pest Management*. 4th Ed. Prentice Hall, New Delhi.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

ENTO 507	PRINCIPLES OF TAXONOMY	2+0	Sem- I
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Objective

To sensitize the students on the theory and practice of classifying organisms and the rules governing the same.

Theory

UNIT I

Introduction to history and principles of systematics and importance. Levels and functions of systematics. Identification, purpose, methods character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism.

UNIT II

Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.

UNIT III

Nomenclature: Common vs Scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of ICZN. Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes.

Suggested Readings

1. Blackwelder RE. 1967. *Taxonomy - A Text and Reference Book*. John Wiley & Sons, New York.
2. Kapoor VC. 1983. *Theory and Practice in Animal Taxonomy*. Oxford & IBH, New Delhi.
3. Mayr E. 1971. *Principles of Systematic Zoology*. Tata McGraw-Hill, New Delhi.
4. Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie, London.

ENTO 508

INSECT PATHOLOGY

1+1

Objective

To teach the students about various microbes that are pathogenic to insects, factors that affect their virulence; provide hands-on training in identification, isolation, culturing various pathogens and assessing pathogenicity.

Theory

UNIT I

History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

UNIT II

Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

UNIT III

Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens. Safety and registration of microbial pesticides. Use of insect pathogens in integrated management of insect pests.

Practical

Familiarization with equipment used in insect pathology laboratory. Identification of different groups of insect pathogens and symptoms of infection. Isolation, culturing and testing pathogenicity of different groups of pathogens. Testing Koch's postulates. Estimation of pathogen load. Extraction of pathogens from live organisms and soil. Bioassays to determine median lethal doses.

Suggested Readings

1. Boucias DG & Pendland JC. 1998. *Principles of Insect Pathology*. Kluwer Academic Publisher, Norwel.
2. Burges HD & Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
3. Steinhaus EA. 1984. *Principles of Insect Pathology*. Academic Press, London.

ENTO 509

BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS

1+1

Sem- II

Objective

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory

UNIT I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation.

UNIT II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects.

UNIT III

Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation.

UNIT IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Suggested Readings

1. Burges HD & Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
2. De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, New York.
3. Dhaliwal GS & Arora R. 2001. *Integrated Pest Management: Concepts and Approaches*. Kalyani Publ., New Delhi.
4. Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman & Hall, New York.
5. Huffaker CB & Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.
6. Ignacimuthu SS & Jayaraj S. 2003. *Biological Control of Insect Pests*. Phoenix Publ., New Delhi.
7. Saxena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.
8. Van Driesche & Bellows TS. Jr. 1996. *Biological Control*. Chapman & Hall, New York.

ENTO 510 PLANT RESISTANCES TO INSECTS

1+1

Sem- II

Objective

To familiarize the students with types, basis, mechanisms and genetics of resistance in plants to insects and role of plant resistance in pest management.

Theory

UNIT I

History and importance of resistance, principles, classification, components, types and mechanisms of resistance.

UNIT II

Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

UNIT III

Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance - acquired and induced systemic resistance.

UNIT IV

Factors affecting plant resistance including biotypes and measures to combat them.

UNIT V

Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

UNIT VI

Role of biotechnology in plant resistance to insects.

Practical

Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

Suggested Readings

1. Dhaliwal GS & Singh R. (Eds). 2004. *Host Plant Resistance to Insects - Concepts and Applications*. Panima Publ., New Delhi.
2. Maxwell FG & Jennings PR. (Eds). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons, New York.
3. Painter RH. 1951. *Insect Resistance in Crop Plants*. MacMillan, London.
4. Panda N & Khush GS. 1995. *Plant Resistance to Insects*. CABI, London.
5. Smith CM. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches*. Springer, Berlin.

ENTO 511	PESTS OF FIELD CROPS	1+1	Sem- II
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Objective

To familiarize the students about nature of damage and seasonal incidence of insect pests that cause loss to major field crops and their effective management by different methods.

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors.

UNIT I

Insect pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs etc.).

UNIT II

Insect pests of pulses, tobacco, oilseeds and their management.

UNIT III

Insect pests of fibre crops, forages, sugarcane and their management.

Practical

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

Suggested Readings

1. Atwal AS, Dhaliwal GS & David BV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.
2. Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
3. Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publ., New Delhi
4. Evans JW. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.
5. Nair MRGK. 1986. *Insect and Mites of Crops in India*. ICAR, New Delhi.
6. Prakash I & Mathur RP. 1987. *Management of Rodent Pests*. ICAR, New Delhi.
7. Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.

ENTO 512	PESTS OF HORTICULTURAL AND PLANTATION CROPS	1+1	Sem- II
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Objective

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, their integrated management.

Theory

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.

UNIT I

Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

UNIT II

Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, french beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables etc.

UNIT III

Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine etc.

UNIT IV

Ornamental, medicinal and aromatic plants and pests in polyhouses/protected cultivation.

Practical

Collection and identification of important pests and their natural enemies on different crops; study of life history of important insect pests and non-insect pests.

Suggested Readings

1. Atwal AS & Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management*. Kalyani Publ., New Delhi.
2. Butani DK & Jotwani MG. 1984. *Insects and Vegetables*. Periodical Expert Book Agency, New Delhi.
3. Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publ., New Delhi.
4. Srivastava RP. 1997. *Mango Insect Pest Management*. International Book Distr., Dehra Dun.
5. Verma LR, Verma AK & Goutham DC. 2004. *Pest Management in Horticulture Crops : Principles and Practices*. Asiatech Publ., New Delhi.

ENTO 513	STORAGE ENTOMOLOGY	1+1	Sem- I
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Objective

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory

UNIT I

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto visà-vis* total production of food grains in India. Scientific and socio-economic factors responsible for grain losses.

UNIT II

Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

UNIT III

Ecology of insect pests of stored commodities/grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

UNIT IV

Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites

and microorganisms. Preventive measures- Hygiene/sanitation, disinfestations of stores/receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control- prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Integrated approaches to stored grain pest management.

Practical

Collection, identification and familiarization with the stored grains/seed insect pests and nature of damage caused by them; detection of insect infestation in stored food grains; estimation of losses in stored food grains; determination of moisture content in stored food grains; familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques; treatment of packing materials and their effect on seed quality. Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, IGSMRI, Hapur etc. (only where logistically feasible).

Suggesting Readings

1. Hall DW. 1970. *Handling and Storage of Food Grains in Tropical and Subtropical Areas*. FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.
2. Jayas DV, White NDG & Muir WE. 1995. *Stored Grain Ecosystem*. Marcel Dekker, New York.
3. Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publ., New Delhi.
4. Khare BP. 1994. *Stored Grain Pests and Their Management*. Kalyani Publ., New Delhi.
5. Subramanyam B & Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products*. Marcel Dekker, New York.

ENTO 514 INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS 1+1

Sem- II

Objective

To teach the students about the different groups of insects that vector plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

Theory

UNIT I

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

UNIT II

Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

UNIT III

Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

UNIT IV

Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

UNIT V

Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies.

Suggested Readings

1. Basu AN. 1995. *Bemisia tabaci* (Gennadius) - *Crop Pest and Principal Whitefly Vector of Plant Viruses*. Oxford & IBH, New Delhi.
2. Harris KF & Maramorosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.
3. Maramorosh K & Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.

4. Youdeovei A & Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

ENTO 515	GENERAL ACAROLGY	1+1	Sem- I
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Objective

To acquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

Theory

UNIT I

History of Acarology; importance of mites as a group; habitat, collection and preservation of mites.

UNIT II

Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics.

UNIT III

Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens *etc.* Culturing of phytophagous, parasitic and predatory mites.

Practical

Collection of mites from plants, soil and animals; extraction of mites from soil, plants and stored products; preparation of mounting media and slide mounts; external morphology of mites; identification of mites up to family level using keys; studying different rearing techniques for mites.

Suggested Readings

1. Chhillar BS, Gulati R & Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.
2. Gerson U & Smiley RL. 1990. *Acarine Biocontrol Agents - An Illustrated Key and Manual*. Chapman & Hall, New York.
3. Gupta SK. 1985. *Handbook of Plant Mites of India*. Zoological Survey of India, Calcutta.
4. Gwilyn O & Evans GO. 1998. *Principles of Acarology*. CABI, London.
5. Jeppson LR, Keifer HH & Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.
6. Krantz GW. 1970. *A Manual of Acarology*. Oregon State Univ. Book Stores, Corvallis, Oregon.
7. Qiang Zhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control*. CABI, London.
8. Sadana GL. 1997. *False Spider Mites Infesting Crops in India*. Kalyani Publ. House, New Delhi.
9. Walter DE & Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviour*. CABI, London.

ENTO 516	SOIL ARTHROPODS AND THEIR MANAGEMENT	1+1	Sem- I
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Objective

To impart knowledge about the different groups of arthropods found in soil, interaction between the different groups, and role of soil arthropods in humus formation. Hands-on training in sampling and identification of different groups of soil arthropods.

Theory

UNIT I

Soil arthropods and their classification, habitats and their identification.

UNIT II

Estimation of populations; sampling and extraction methods.

UNIT III

Role of soil arthropods in detritus feeding, litter breakdown and humus formation. Soil arthropods as bio-indicators of habitat qualities. Effect of soil arthropod activity on soil properties.

UNIT IV

Harmful and beneficial soil arthropods and their management, interrelationship among arthropods and other soil invertebrates and soil microorganisms. Anthropogenic effects on soil arthropods.

Practical

Sampling, extraction methods and identification of various types of soil fauna; estimation and assessment of soil arthropod population; techniques and culturing soil invertebrates.

Suggested Readings

1. Anderson JM & Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods*. CABI, London.
2. Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley & Sons, New York.
3. Pankhurst C, Dube B & Gupta, V. 1997. *Biological Indicators of Soil Health*. CSIRO, Australia.
4. Veeresh GK & Rajagopal D. 1988. *Applied Soil Biology and Ecology*. Oxford & IBH Publ., New Delhi.

ENTO 517	VERTEBRATE PEST MANAGEMENT	1+1	Sem- I
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Objective

To impart knowledge on vertebrate pests like birds, rodents, mammals etc., of different crops, their biology, damage they cause and management strategies.

Theory

UNIT I

Vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals. Biology of beneficial birds.

UNIT II

Population dynamics and assessment, patterns of pest damage and assessment, roosting and nesting systems in birds.

UNIT III

Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods- Operational practices- baiting, bioassays (LD50 studies), equipments and educative programmes.

Practical

Identification of important rodent and other vertebrate pests of agriculture, food preference and hoarding, social behaviour, damage assessment, field survey, population estimation, control operation and preventive methods.

Suggested Readings

1. Fitzwater WD & Prakash I. 1989. *Handbook of Vertebrate Pest Control*. ICAR, New Delhi.
2. Prakash I & Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.
3. Prakash I & Ghosh RP. 1987. *Management of Rodent Pests*. ICAR, New Delhi.
4. Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay.
5. Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay.

ENTO 518	TECHNIQUES IN PLANT PROTECTION	0+1	Sem- I
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Objective

To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, electrophoresis etc.

Theory

UNIT I

Pest control equipments, principles, operation, maintenance, selection, application of pesticides and biocontrol agents, seed dressing, soaking, root-dip treatment, dusting, spraying, application through irrigation water.

UNIT II

Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers.

UNIT III

Use of light, transmission and scanning electron microscopy.

UNIT IV

Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE.

UNIT V

Use of tissue culture techniques in plant protection. Computer application for predicting/forecasting pest attack and identification.

Suggested Readings

1. Alford DV. 1999. *A Textbook of Agricultural Entomology*. Blackwell Science, London.
2. Crampton JM & Eggleston P. 1992. *Insect Molecular Science*. Academic Press, London.

ENTO 519	COMMERCIAL ENTOMOLOGY	1+1	Sem- II
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Objective

To familiarize the students with entrepreneurial opportunities in entomology, provide information on productive insects and their products, as well as insect pests of public health and veterinary importance and their management.

Theory

UNIT I

Bee keeping- General colony management during different seasons. Seasonal management. Managing colonies for honey production and pollination. Artificial queen rearing. Pests and diseases of honey bees. Bee poisoning. Production and marketing of quality honey and value added honey products. Establishment and maintenance of apiaries.

UNIT II

Study of different species of silkworms, characteristic features, moriculture, silk and its uses, pests and diseases of silkworms, rearing and management of silkworms. Lac insect- natural enemies and their management.

UNIT III

Economic and public health importance of insect pests in human habitation and habitats, biology, damage and control of mosquitoes, houseflies, bed bugs, ants, termites, cockroaches, flies, silverfish, head and body lice, carpet beetles, cloth moths, crickets, wasps, house dust mites, insect pests of cattle, poultry, pet animals and their management.

UNIT IV

Principles and methods of pest management in residential places and public buildings, insecticides for domestic use and their safety, pre- and post construction termite proofing of buildings, appliances for domestic pest control. Rodent control methods. Organic methods of domestic pest management.

Practical

Assessing pest status in dwellings (labs, canteen or hostel), implementation of pest control against flies, mosquitoes, bed bugs, cockroaches and rodents. Pre- and post-construction termite proofing methods, control of silverfishes in the library. Visit to poultry units and assessing pest status in poultries. Evaluation of commercially available domestic insect pest control products through bioassays. Identification of honey bee species, bee castes and special adaptations, identification and handling of bee-keeping equipments. Handling of honey bees-hive and frame inspection. Honey extraction and processing methods of hive products extraction. Preparation of bee-keeping projects for funding. Visit to bee nursery and commercial apiaries. Silkworm rearing and management. Lac host and crop management technology and processing of lac. Products and bye-products of lac.

Suggested Readings

1. Aruga H. 1994. *Principles of Sericulture*. Oxford & IBH, New Delhi.
2. Atwal AS. 2006. *The World of the Honey Bee*. Kalyani Publ., New Delhi.
3. Ganga G. 2003. *Comprehensive Sericulture*. Vol. II. *Silkworm Rearing and Silk Reeling*. Oxford & IBH, New Delhi.

4. Partiban S & David BV. 2007. *Management of Household Pests and Public Health Pests*. Namratha Publ., Chennai.
5. Singh S. 1975. *Beekeeping in India*. ICAR, New Delhi.

ENTO 520	PLANT QUARANTINE	2+0	Sem- II
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Objective

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

UNIT III

Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfection/salvaging of infected material.

UNIT IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

1. Rajeev K & Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.
2. Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

ENTO 521	PRINCIPLES OF NEMATOLOGY	2+1	Sem- I
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Objective

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

Theory

UNIT I

History and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

UNIT II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

UNIT III

Types of parasitism; nature of damage and general symptomatology; interaction of plant parasitic nematodes with other organisms.

UNIT IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

UNIT V

Principles and practices of nematode management; integrated nematode management.

Practical

Studies on kinds of nematodes- free-living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining for sedentary endoparasites; examination of

different life stages of important plant parasitic nematodes, their symptoms and histopathology.

Suggested Readings

1. Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.
2. Perry RN & Moens M. 2006. *Plant Nematology*. CABI, London.
3. Singh RS & Sitaramaiah K. 1994. *Plant Pathogens – Nematodes*. Oxford & IBH, New Delhi.
4. Thorne G. 1961. *Principles of Nematology*. McGraw Hill, New Delhi.
5. Walia RK & Bajaj HK. 2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.

ENTO 522 NEMATODE DISEASES OF CROPS 3+1 Sem- I

Objective

To impart basic knowledge about the causal organism, nature of damage, symptoms and control of nematode diseases of agricultural and horticultural crops.

Theory

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops.

UNIT I

Cereal crops- Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum.

UNIT II

Pulses, Sugar, Fibre, Fodder and Oilseed crops- Pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugarbeet cyst and soybean cyst nematode problems.

UNIT III

Vegetable crops- root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. Nematode problems of protected cultivation.

UNIT IV

Fruit crops- root-knot disease, reniform nematode, slow decline of citrus. Mushroom- nematode problems.

UNIT V

Plantation, medicinal and aromatic crops- burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems of coffee and tea, red ring disease of coconut. Forests- Pine wilt disease.

Practical

1. Diagnosis of causal organisms; identification of different life cycle stages; study of symptoms and histopathology of nematode damage in different crops, study tours for field diagnosis of nematode problems.
2. **Suggested Readings**
3. Bhatti DS & Walia RK. 1992. *Nematode Pests of Crops*. CBS, New Delhi.
4. Evans AAF, Trudgill DL & Webster JM. 1994. *Plant Parasitic Nematodes in Temperate Agriculture*. CABI, Wallingford.
5. Luc M, Sikora RA & Bridge J. 2005. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*. CABI, Wallingford.
6. Nickle WR. 1991. *Manual of Agricultural Nematology*. Marcel Dekker, New York.
7. Perry RN & Moens M. 2006. *Plant Nematology*. CABI, Wallingford.

ENTO 523 NEMATODE INTERACTIONS WITH OTHER ORGANISMS 2+1 Sem- II

Objective

To understand the role of nematodes in disease complexes involving fungal, bacterial, viral and other organisms.

Theory

UNIT I

Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms.

UNIT II

Interaction of plant parasitic nematodes with wilt causing fungal pathogens.

UNIT III

Interaction of plant parasitic nematodes with root rot and other fungal pathogens.

UNIT IV

Interaction of plant parasitic nematodes with bacterial pathogens, other nematode species and arthropods.

UNIT V

Virus transmission by nematodes.

Practical

Green-house experiments to study the role of plant parasitic nematodes in wilt/rot causing fungal and bacterial pathogens.

Suggested Readings

1. Khan MW. 1993. *Nemic Interactions*. Chapman & Hall, New York.
2. Lamberti F, Taylor CE & Seinhorst JW. 1975. *Nematode Vectors of Plant Viruses*. Plenum Press, London.
3. Sasser JN & Jenkins WR. 1960. *Nematology: Fundamentals and Recent Advances with Emphasis on Plant Parasitic and Soil Forms*. Eurasia Publ. House, New Delhi.

ENTO 524	NEMATODE MANAGEMENT	2+1	Sem- II
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Objective

To impart comprehensive knowledge about the principles and practices of nematode management.

Theory

UNIT I

Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.

UNIT II

Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.

UNIT III

Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil, biofumigation, antagonistic and trap crops, sanitation etc.

Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material.

UNIT IV

Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods – use of antagonistic plants and antinemic plant products.

UNIT V

Genetic methods- plant resistance; legal methods- quarantine regulations; integrated nematode management- concepts and applications.

Practical

In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods; methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on biocontrol potential of fungal, bacterial parasites, and predacious fungi and nematodes.

Suggested Readings

1. Bhatti DS & Walia RK. 1994. *Nematode Pest Management in Crops*. CBS, New Delhi.
2. Brown GL. 1977. *The Nematode Destroying Fungi*. CBP, Guelph.
3. Brown RH & Kerry BR. 1987. *Principles and Practice of Nematode Control in Crops*. Academic Press, Sydney.
4. Chen ZX, Chen SY & Dickson DW. 2004. *Nematology: Advances and Perspectives. Vol. II: Nematode Management and Utilization*. CABI, Wallingford.

5. Perry RN & Moens M. 2006. *Plant Nematology*. CABI, Wallingford.
6. Starr JL, Cook R & Bridge J. 2002. *Plant Resistance to Parasitic Nematodes*. CABI, Wallingford.
7. Whitehead AG. 1997. *Plant Nematode Control*. CABI, Wallingford.

ENTO 525	BENEFICIAL NEMATODES	1+1	Sem- II
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Objective

To sensitize about the use of nematodes for the biological control of insect pests of crops, and application of some nematodes as biological models and as indicators of environmental pollution.

Theory

UNIT I

Beneficial nematode fauna- predators, parasites of insects, molluscs and other pests; Entomophilic nematodes- important groups, types of nematode insect associations; taxonomic characteristics of nematode parasites of insects.

UNIT II

Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids.

UNIT III

Entomopathogenic nematodes- *Steinernema* and *Heterorhabditis*, their morphological characteristics, taxonomic status, biology and mode of action.

UNIT IV

Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.

UNIT V

Nematodes as biological models, nematodes as indicators of pollution, role of nematodes in organic matter recycling.

Practical

Isolation, identification, mass rearing and application methods of entomopathogenic nematodes.

Suggested Readings

1. Gaugler R & Kaya HK. 1990. *Entomopathogenic Nematodes in Biological Control*. CRC Press, Boca Raton, Florida.
2. Gaugler R. 2002. *Entomophilic Nematology*. CABI, Wallingford.
3. Grewal PS, Ehlers RU & Shapiro DI. 2005. *Nematodes as Biocontrol Agents*. CABI, Wallingford.
4. Jairajpuri MS & Khan MS. 1982. *Predatory Nematodes (Mononchida)*. Associated Publ. Co., New Delhi.
5. Wood WB. 1998. *The Nematode Caenorhabditis elegans*. Cold Spring Harbor Press.
6. Woodring JL & Kaya HK. 1988. *Steinernematid and Heterorhabditid Nematodes: A Handbook of Techniques*. Southern Coop. Bull., Ark. Ag. Ext. Sta.
7. Zuckerman BM. (Ed.). 1980. *Nematodes as Biological Models*. Vols. I, II. Academic Press, New York.

Ph. D Course Contents

ENTO 601	ADVANCED INSECT ECOLOGY	1+1	Sem- I
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Objective

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics.

Theory

UNIT I

Characterisation of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

UNIT II

Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of Associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of Insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites.

Host seeking behaviour of parasitoids. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses.

UNIT III

Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

UNIT IV

Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies - timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

Practical

Methods of data collection under field conditions. Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc. Calculation of sample sizes by different methods. Fitting Poisson and Negative Binomial distributions and working out the data transformation methods. Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies - Calculation of changes under selection, Demonstration of genetic drift. Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/*Goniozus*/Female Bruchids etc.- A test of reproductive effort and fitness. Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution. Exercises in development of Algorithms for crop modeling.

Suggested Readings

1. Barbosa P & Letourneau DK. (Eds.). 1988. *Novel Aspects of Insect-Plant Interactions*. Wiley, London.
2. Elizabeth BA & Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman & Hall, New York.
3. Freeman S & Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.
4. Gotelli NJ & Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Sunderland, MA.
5. Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.
6. Krebs C. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
7. Krebs CJ. 2001 *Ecology: The Experimental Analysis of Distribution and Abundance*. 5th Ed. Benjamin-Cummings Publ. Co., New York.
8. Magurran AE. 1988. *Ecological Diversity and its Measurement*. Princeton University Press, Princeton.
9. Real LA & Brown JH. (Eds.). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, USA.
10. Southwood TRE & Henderson PA. 2000. *Ecological Methods*. 3rd Ed. Wiley Blackwell, London.
11. Strong DR, Lawton JH & Southwood R. 1984. *Insects on Plants: Community Patterns and Mechanism*. Harvard University Press, Harvard.
12. Wratten SD & Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold Publ., London.

ENTO 602 RECENT TRENDS IN BIOLOGICAL CONTROL 1+1 Sem- I

Objective

To appraise the students with advanced techniques in handling of different bioagents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.

Theory

UNIT I

Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents *vis-à-vis* target pest populations.

UNIT II

Mass culturing techniques, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

UNIT III

Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of biocontrol agents, bankable project preparation.

UNIT IV

Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of biocontrol agents.

Practical

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various biocontrol agents, performance of efficiency analyses on target pests; project document preparation for establishing a viable mass-production unit /insectary.

Suggested Readings

1. Burges HD & Hussey NW. (Eds.). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
2. Coppel HC & James WM. 1977. *Biological Insect Pest Suppression*. Springer Verlag, Berlin.
3. De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, London.
4. Dhaliwal, GS & Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publ., New Delhi.
5. Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman & Hall, New York.
6. Huffaker CB & Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

ENTO 603	ADVANCED INTEGRATED PEST MANAGEMENT	2+0	Sem- I
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Objective

To acquaint the students with recent concepts of integrated pest management. Surveillance and data base management. Successful national and international case histories of integrated pest management, non conventional tools in pest management.

Theory

UNIT I

Principles of sampling and surveillance; database management and computer programming, simulation techniques and system analysis and modeling.

UNIT II

Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests.

UNIT III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes. Application of IPM to farmers' realtime situations.

UNIT IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

Suggested Readings

1. Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publ., New Delhi.
2. Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
3. Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management*. Springer, Berlin.
4. Koul O & Cuperus GW. 2007. *Ecologically Based Integrated Pest Management*. CABI, London.
5. Koul O, Dhaliwal GS & Curperus GW. 2004. *Integrated Pest Management -Potential, Constraints and Challenges*. CABI, London.
6. Maredia KM, Dakouo D & Mota-Sanchez D. 2003. *Integrated Pest Management in the Global Arena*. CABI, London.
7. Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management*. John Wiley & Sons, New York.
8. Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concept in Integrated Pest Management*. Prentice Hall, New Delhi.
9. Pedigo RL. 1996. *Entomology and Pest Management*. Prentice Hall, New Delhi.
10. Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

ENTO 604	ADVANCED INSECT SYSTEMATICS	1+2	Sem- I
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Objective

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. International Code of Zoological Nomenclature. Ethics and procedure for taxonomic publications.

Theory

UNIT I

Detailed study of three schools of classification- numerical, evolutionary and cladistics. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts and speciation processes and evidences. Zoogeography.

UNIT II

Study of different views on the evolution of insects- alternative phylogenies of insects: Kukulova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

UNIT III

Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN- Ethics.

UNIT IV

Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, revisionary works, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular Taxonomy, barcoding species.

Practical

Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, construction of taxonomic keys for the selected group. Development of descriptions, photographing, writing diagrams, and preparation of specimens for “type like” preservation. Submission of the collections made of the group. Multivariate Analysis techniques for clustering specimens into different taxa, and development of phenograms. Rooting and character polarisation for developing cladograms and use of computer programmes to develop cladograms.

Suggested Readings

1. CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.

- Dakeshott J & Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer-Verlag, Berlin.
- Freeman S & Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.
- Hennig W. 1960. *Phylogenetic Systematics*. Urbana Univ. Illinois Press, USA.
- Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.
- Mayr E & Ashlock PD. 1991. *Principles of Systematic Zoology*. 2nd Ed. McGraw Hill, New York.
- Mayr E. 1969. *Principles of Systematic Zoology*. McGraw-Hill, New York.
- Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie Academic and Professional, London.
- Ross HH. 1974. *Biological Systematics*. Addison Wesley Publ. Co., London.
- Wiley EO. 1981. *Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists*. Columbia Univ. Press, USA.

ENTO 605	IMMATURE STAGES OF INSECTS	1+1	Sem- I
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Objective

To impart knowledge on morphology of immature stages of different groups of insects. Train students in identification of common pest species during their immature stages.

Theory

UNIT I

Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects

UNIT II

Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

Types of immature stages; their collection, rearing and preservation. Identification of immature insects to orders and families, in endopterygotes orders viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key.

Suggested Readings

- Chu HF. 1992. *How to Know Immature Insects*. William Brown Publ., Iowa.
- Peterson A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.
- Stehr FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publ., Iowa.

ENT 606	ADVANCED INSECT PHYSIOLOGY	2+0	Sem- I
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Objective

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones etc.

Theory

UNIT I

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, types of sclerotization.

UNIT II

Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.

UNIT III

Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

UNIT IV

Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polyphenism and diapause. Energetics of muscle contractions.

Suggested Readings

1. Kerkut GA & Gilbert LI. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.
2. Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Assoc. for Advancement of Entomology, Trivandrum, Kerala.

ENTO 607	INSECT BEHAVIOUR	1+1	Sem- II
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Objective

To acquaint the students with a thorough understanding of how natural selection has led to various survival strategies manifested as behaviour in insects.

Theory

UNIT I

Defining Behaviour- Concept of Umwelt, instinct, fixed action patterns, imprinting, complex behaviour, induced behaviour, learnt behaviour and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism.

UNIT II

Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

UNIT III

Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour- kin selection, parental manipulation and mutualism; Selforganization and insect behaviour.

UNIT IV

Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behaviour, pollination behaviour, coevolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semiochemicals, auditory stimuli and visual signals in pest management.

Practical

Quantitative methods in sampling behaviour; training bees to artificial feeders; sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees. Evaluation of different types of traps against fruit flies with respect to signals; Use of honey bees/*Helicoverpa armigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

Suggested Readings

1. Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford & IBH, New Delhi.
2. Awasthi VB. 2001. *Principles of Insect Behaviour*. Scientific Publ., Jodhpur.
3. Bernays EA & Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman & Hall, London.
4. Brown LB. 1999. *The Experimental Analysis of Insect Behaviour*. Springer, Berlin.
5. Krebs JR & Davies NB. 1993. *An Introduction to Behavioural Ecology*. 3rd Ed. Chapman & Hall, London.

- Manning A & Dawkins MS. 1992. *An Introduction to Animal Behaviour*. Cambridge University Press, USA.
- Mathews RW & Mathews JR. 1978. *Insect Behaviour*. A Wiley- InterScience Publ. John Wiley & Sons, New York.

ENTO 608	ADVANCED INSECTICIDE TOXICOLOGY	2+1	Sem- II
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Objective

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

Theory

UNIT I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides.

UNIT II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

UNIT III

Joint action of insecticides; activation, synergism and potentiation.

UNIT IV

Problems associated with pesticide use in agriculture: pesticide resistance, resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

UNIT V

Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; insecticide laws and standards, and good agricultural practices.

Practical

Sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects.

Suggested Readings

- Busvine JR. 1971. *A Critical Review on the Techniques for Testing Insecticides*. CABI, London.
- Dhaliwal GS & Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publ., New Delhi.
- Hayes WJ & Laws ER. 1991. *Handbook of Pesticide Toxicology*. Academic Press, New York.
- Ishaaya I & Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action*. Narosa Publ. House, New Delhi.
- Matsumura F. 1985. *Toxicology of Insecticides*. Plenum Press, New York.
- O' Brien RD. 1974. *Insecticides Action and Metabolism*. Academic Press, New York.
- Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. *Insecticides in Agriculture and Environment*. Narosa Publ. House, New Delhi.
- Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture*. Lewis Publ., New York.

ENTO 609	ADVANCED HOST PLANT RESISTANCE	1+1	Sem- II
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Objective

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

Theory

UNIT I

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species - gene pool; insect sources – behaviour in relation to host plant factors.

UNIT II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

UNIT III

Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

UNIT IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

Practical

Understanding mechanisms of resistance for orientation, feeding, oviposition *etc.*, allelochemical bases of insect resistance; macroculturing of test insects like aphids, leaf/plant hoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

Suggested Readings

1. Panda N. 1979. *Principles of Host Plant Resistance to Insects*. Allenheld, Osum & Co., New York.
2. Rosenthal GA & Janzen DH. (Eds.). 1979. *Herbivores – their Interactions with Secondary Plant Metabolites*. Vol. I, II. Academic Press, New York.
3. Sadasivam S & Thayumanavan B. 2003. *Molecular Host Plant Resistance to Pests*. Marcel Dekker, New York.
4. Smith CM, Khan ZR & Pathak MD. 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*. CRC Press, Boca Raton, Florida.

ENTO 610	ADVANCED ACAROLOGY	1+1	Sem- II
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Objective

To acquire a good working knowledge of identification of economically important groups of mites up to the species level, a detailed understanding of the newer acaricide molecules and utilization of predators.

Theory

UNIT I

Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

UNIT II

Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

UNIT III

Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

UNIT IV

Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi-identification, isolation and utilization.

Practical

Identification of commonly occurring mites up to species, preparation of keys for identification. Collection of specific groups of mites and preparing their identification keys. Rearing phytoseiid mites and studying their role in suppression of spider mites. Management of mite pests of crops using

acaricides, phytoseiid predators, fungal pathogens *etc.*

Suggested Readings

1. Evans GO. 1992. *Principles of Acarology*. CABI, London.
2. Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents- An Illustrated Key and Manual*. Chapman & Hall, New York.
3. Gupta SK. 1985. *Handbook of Plant Mites of India*. Zoological Survey of India, Calcutta.
4. Krantz GW. 1970. *A Manual of Acarology*. Oregon State University Book Stores, Corvallis, Oregon.
5. Sadana GL. 1997. *False Spider Mites Infesting Crops in India*. Kalyani Publ. House, New Delhi.

ENTO 611 AGRICULTURAL ORNITHOLOGY 1+1 Sem- I

Objective

To expose the students to the prevalence of birds in agricultural fields, their habitat associations and the beneficial and harmful role played by birds in crop fields and management of pest situations.

Theory

UNIT I

Status of agricultural ornithology in India, groups of birds associated with agro-ecosystems. Habitat associations of birds in both wet and dry agricultural systems. Association of birds with different cultivation practices and crop stages, their seasonality and succession. Pestiferous and beneficial birds associated with different crops, their general biology and ecology. Food and feeding habits of birds in crop fields.

UNIT II

Nature of damage caused by birds in different crops. Foraging ecology of birds in agricultural fields. Birds affecting stored grains in houses and godowns. Beneficial role of birds in agriculture and attracting them to field. Use of bird excreta in agriculture. Management of bird pests in agriculture: physical, cultural, ecological and chemical methods.

Practical

Study of different groups of birds associated with agriculture, their morphology and field identification. Field visits to different agroecosystems. Study of bird associations with different crop stages. Study of nesting and roosting habits of birds in agricultural habitats. Study of the feeding habits, nature and types of damage caused by birds in selected crops. Visits to godowns. Analysis and study of the use of bird excreta in agriculture at a bird sanctuary. Field visits to paddy growing command areas to study birds in crop fields. Assignments on assessing bird damage, estimation of populations etc.

Suggested Readings

1. Dhindsa SR & Parasharya BM. 1998. *Birds in Agricultural Ecosystem*. Society for Applied Ornithology, Hyderabad.
2. Mehrotra KN & Bhatnagar RK. 1979. *Status of Economic Ornithology in India- Bird Depredents, Depredations and their Management*. ICAR, New Delhi.
3. Vasudeva Rao & Dubey OP. 2006. Grainivorous Pests and their Management. In: *Vertebrate Pests in Agriculture, The Indian Scenario* (Ed: Sridhara, S.), Scientific Publ., Jodhpur.

ENTO 612 MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH 1+1 Sem- II

Objective

To familiarize the students with DNA recombinant technology, marker genes, transgenic plants, biotechnology in sericulture and apiculture.

Theory

UNIT I

Introduction to molecular biology; techniques used in molecular biology.

UNIT II

DNA and RNA analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, *Bt* and entomopathogenic fungi.

UNIT III

Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Bt toxin, CPTI; trypsin inhibitors, lectins and proteases, neuropeptides. Transgenic plants for pest resistance and diseases.

UNIT IV

Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.

UNIT V

DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

Practical

Isolation of DNA/RNA; purity determinations; base pair estimation; agarose gel electrophoresis; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

Suggested Readings

1. Bhattacharya TK, Kumar P & Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publ., New Delhi.
2. Hagedorn HH, Hilderbrand JG, Kidwell MG & Law JH. 1990. *Molecular Insect Science*. Plenum Press, New York.
3. Oakeshott J & Whitten MA.. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.
4. Rechcigl JE & Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests*. Lewis Publ., North Carolina.
5. Roy U & Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publ., New Delhi.
6. Singh BD. 2008. *Biotechnology (Expanding Horizons)*. Kalyani Publ., New Delhi.
7. Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publ., New Delhi.

ENTO 613 CURRENT TOPICS IN NEMATODE DISEASE DEVELOPMENT AND HOST RESISTANCE

2+1

Sem- II

Objective

To update knowledge on the recent research trends in the field of plant nematode relationships at genetic and molecular level.

Theory

UNIT I

Mechanisms of pathogenesis, cytological and biochemical changes induced by nematode feeding.

UNIT II

Plant defense systems, role of phytoalexins etc. against major plant parasitic nematodes.

UNIT III

Genetic basis of plant resistance to nematodes and identification of resistance genes against economically important nematodes.

UNIT IV

Application of biotechnological methods in the development of nematode resistant crop cultivars; resistance markers; incorporation of resistance by conventional breeding and transgenic approaches.

UNIT V

Influence of microorganisms on plant nematode interactions.

Practical

Microtomy for study of histopathological changes induced by important nematodes, screening techniques for assessment of resistance in crop germplasm against nematodes.

Suggested Readings

1. Barker KR, Pederson GA & Windham GL. 1998. *Plant and Nematode Interactions*. CABI, Wallingford.
2. Fenoll C, Grundler FMW & Ohi SA. 1997. *Cellular and Molecular aspects of Plant-Nematode Relationships*. Kluwer Academic Press, Dordrecht.
3. Lamberti F, Giorgi C & Bird D. 1994. *Advances in Molecular Plant Nematology*. Plenum Press.

ENTO 614 ADVANCES IN NEMATODE MANAGEMENT

2+1

Sem- I

Objective

To keep abreast with latest developments and trends in nematode management.

Theory

UNIT I

Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- predacious and parasitic fungi; nematotoxic fungal culture filtrates.

UNIT II

Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- parasitic and nematode antagonistic bacteria; predacious mites and predacious nematodes.

UNIT III

Mass culturing, formulation, quality control, bio-safety and registration protocols of bio-control agents.

UNIT IV

Phytoalexins, allelochemicals, phytotherapeutic substances, novel nematicides, deployment of resistant varieties and non-host crops in nematode suppressive cropping systems, emergence of resistance breaking biotypes, recent regulatory provisions and methods, quarantine and disinfection.

UNIT V

Nematode management modules for integrated pest and disease management in cropping systems. Nematode management options and approaches for organic farming and precision farming. Application of GIS and GPS technology for surveillance and management.

Practical

Green-house experiments on the efficacy of fungal and bacterial bio-control agents, botanicals.

Suggested Readings

1. Chen ZX, Chen SY & Dickson DW. 2004. *Nematology: Advances and Perspectives Vol. II. Nematode Management and Utilization*. CABI, Wallingford.
2. Jana BL. 2008. *Precision Farming*. Reseachco Books & Periodicals Pvt. Ltd., Delhi.
3. Lillesend TW, Kiefer RW & Chipman JW. 1979. *Remote Sensing and Image Interpretation*. John Wiley & Sons, New York.
4. Poinar GO Jr & Jansson H-B. 1988. *Diseases of Nematodes*. Vols. I, II. CRC Press, Boca Raton, Florida.
5. Starr JR, Cook R & Bridge J. 2002. *Plant Resistance to Parasitic Nematodes*. CABI, Wallingford.
6. Tarafdar JC, Priputhi KP & Mahesh Kumar 2007. *Organic Agriculture*. Scientific Publ., Jodhpur.
7. Upadhyaya
8. RK, Walia RK & Dubey OP. 2004. *IPM Systems in Agriculture. Vol. IX. Phytonematology*. Aditya Books, New Delhi.