

## DEPARTMENT OF ENTOMOLOGY

### PROGRAMMES

1. M. Sc.
2. Ph.D.

### COURSE REQUIREMENTS

#### M. Sc.

Field of specialization	Insect Pests Management, Morphology and Anatomy, Physiology and Nutrition, Taxonomy, Toxicology, Ecology, Biological Control and Storage
Core courses	ENT. 511, ENT. 512, ENT. 513, ENT. 531
Optional courses	ENT. 521, ENT. 522, ENT. 523, ENT. 524, ENT. 525, ENT. 532, ENT.533, ENT. 534, ENT.535, ENT. 591, ENT. 599 (Research)
Minor & supporting courses	
Non credit compulsory courses	ENT. 541
Deficiency courses	Nil or as deemed suitable by advisory committee

#### Ph. D.

Field of specialization	Insect Pests Management, Morphology and Anatomy, Physiology and Nutrition, Taxonomy, Toxicology, Ecology, Biological Control and Storage
Core courses	ENT. 611, ENT. 612, ENT. 613
Optional courses	ENT. 614, ENT. 622, ENT. 623, ENT. 624, ENT. 691, ENT. 692, ENT. 699 (Research)
Minor & supporting courses	
Non credit compulsory courses	ENT. 621, ENT. 641
Deficiency courses	Nil or as deemed suitable by advisory committee

### Course Structure – at a Glance

S. No.	Course Numbers	Course Titles	Credit Load
<b>MASTER'S PROGRAMME:</b>			
1.	ENT. 511**	INSECT MORPHOLOGY AND ANATOMY	3 (2 + 1)
2.	ENT. 512**	INSECT PHYSIOLOGY AND NUTRITION	3 (2 + 1)
3.	ENT. 513**	INSECT TAXONOMY AND CLASSIFICATION	3 (2 + 1)
4.	ENT. 521	INSECT ECOLOGY	3 (2 + 1)
5.	ENT. 522	BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS	3 (2 + 1)
6.	ENT. 523	TOXICOLOGY OF INSECTICIDES	3 (2 + 1)
7.	ENT. 524	ACAROLOGY AND SOIL ARTHROPODS	3 (2 + 1)
8.	ENT. 528#	PLANT QUARANTINE	2 (2 + 0)
9.	ENT. 525	INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS	2 (1 + 1)
10.	ENT. 531**	PRINCIPLES OF INTEGRATED PEST MANAGEMENT	3 (3 + 0)
11.	ENT. 532	PESTS OF FIELD CROPS AND THEIR MANAGEMENT	3 (2 + 1)
12.	ENT. 533	PESTS OF HORTICULTURAL AND PLANTATION CROPS	3 (2 + 1)
13.	ENT. 534	STORAGE PESTS AND THEIR MANAGEMENT	3 (2 + 1)
14.	ENT. 535	COMMERCIAL ENTOMOLOGY	3 (2 + 1)
15.	ENT. 541	COMPREHENSIVE	Non-credit
16.	ENT. 591	CREDIT SEMINAR	01
17.	ENT. 599	RESEARCH	20
<b>DOCTORAL PROGRAMME:</b>			
1.	ENT. 611*	ADVANCED INTEGRATED PEST MANAGEMENT	2 (2 + 0)
2.	ENT. 612**	ADVANCED INSECT SYSTEMATICS	3 (1 + 2)
3.	ENT. 613**	ADVANCED INSECT PHYSIOLOGY AND BEHAVIOUR	3 (2 + 1)
4.	ENT. 614	ADVANCED INSECT ECOLOGY	2 (2 + 0)
5.	ENT. 621*	MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH	2 (1 + 1)
6.	ENT. 622	RECENT TRENDS IN BIOLOGICAL CONTROL	3 (2 + 1)

7.	ENT. 623	ADVANCED INSECT TOXICOLOGY	3 (2 + 1)
8.	ENT. 624	ADVANCED ACAROLOGY	2 (1 + 1)
9.	ENT. 641	COMPREHENSIVE	Non-credit
10.	ENT. 691	CREDIT SEMINAR	02
11.	ENT. 699	RESEARCH	45
COMPULSORY NON-CREDIT COURSES (Across Departments)			
1.	PGS 501	TECHNICAL WRITING AND COMMUNICATION SKILLS	1 (0 + 1)
2.	PGS 503	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1 (1 + 0)
3.	PGS 506	DISASTER MANAGEMENT	1 (1 + 0)

***The course ENT 621 shall require collaboration with Department of Molecular Biology & Biotechnology***

*# This course shall be conducted jointly with the services of a Plant Pathology Expert*

*\* refers to Compulsory Courses; \*\* refers to Core Courses*

## DESCRIPTION OF COURSES

### Postgraduate courses

**ENT 511                      INSECT MORPHOLOGY AND ANATOMY                      3( 2+1)**

#### **Objective**

To acquaint the students with external morphology and internal systems of the insect's body.

#### **Theory**

##### UNIT I

External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

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

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.

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

##### UNIT II

Internal Systems: Structure and modification of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, and secretory system.

#### **Practical**

Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia. Dissection of digestive, nervous and reproductive systems of different insects.

#### **Suggested Readings**

- Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.
- Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.
- Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.
- Gillott, C. 1995. *Entomology*, 2<sup>nd</sup> Ed. Plenum Press, New York, London.
- Gullan, P.J. and Cranston, P.S. 2000. *The Insects, An Outline of Entomology*, 2<sup>nd</sup> Ed. Blackwell Science, U.K.
- Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10<sup>th</sup> Ed. Chapman & Hall, London.
- Snodgrass RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.
- Tembhore, D.B. 2000. *Modern Entomology*, Himalaya Publishing House, Mumbai.

**ENT 512**                      **INSECT PHYSIOLOGY AND NUTRITION**                      **3 (2+1)**

**Objective**

To impart knowledge to the students about physiology of different systems, nutritional physiology and their application in entomology.

**Theory**

UNIT I

Scope and importance of insect physiology; physiology of integument, moulting; growth, metamorphosis and diapause.

Mechanism of digestion, circulation, respiration, excretion, and impulse transmission in the insects. Physiology of reproductive and secretory systems.

UNIT II

Importance of 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**

Chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

**Suggested Readings**

Chapman RF.1998. *Insects: Structure and Function*. ELBS Ed., London.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.

Gullan, P.J. and Cranston, P.S. 2000. *The Insects: An Outline of Entomology*, 2<sup>nd</sup> Ed. Blackwell Science, U.K.

Kerkut GA & Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, New York.

Patnaik BD. 2002. *Physiology of Insects*. Dominant, New Delhi.

Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Vol. 1. *Structure, Physiology and Development*. Chapman & Hall, New York.

Wigglesworth VB.1984. *Insect Physiology*. 8th Ed. Chapman & Hall, New York.

**ENT 513**                      **INSECT TAXONOMY AND CLASSIFICATION**                      **3 (2+1)**

**Objective**

To sensitize the students on the theory and practice of classifying organisms (with special reference to animals) and the rules governing the same. 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

Introduction to the history and principles of systematics and its importance. Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, its brief explanation and uses.

### 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**

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

Freeman S & Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Mayr, E. 1971. *Principles of Systematic Zoology*. Tata McGraw Hill, New Delhi.

Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10<sup>th</sup> Ed. Chapman & Hall, London.

Ross HH. 1974. *Biological Systematics*. Addison Wesley Publ. Company.

Triplehorn CA & Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects*. 7<sup>th</sup> Ed. Thomson/ Brooks/ Cole, USA/Australia.

**ENT 521**

**INSECT ECOLOGY**

**3 (2+1)**

**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 niche ecological homologues, competitive exclusion. 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 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**

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

**ENT 522      BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS    3 (2+1)**

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

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

### **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 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**

Burges HD & Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, New York.

Dhaliwal GS & Arora R. 2001. *Integrated Pest Management: Concepts and Approaches*. Kalyani Publ., New Delhi.

Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman & Hall, New York.

Huffaker CB & Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

Ignacimuthu SS and Jayaraj S. 2003. *Biological Control of Insect Pests*. Phoenix Publ., New Delhi.

Saxena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.

Van Driesche & Bellows TS. Jr. 1996. *Biological Control*. Chapman & Hall, New York.

**ENT 523**                      **TOXICOLOGY OF INSECTICIDES**                      **3 (2+1)**

### **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 pyrozoles, 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; insect-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; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity. Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides.

### **Suggested Readings**

Chattopadhyay SB. 1985. *Principles and Procedures of Plant Protection*. Oxford & IBH, New Delhi.

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.

## **ENT 531 PRINCIPLES OF INTEGRATED PEST MANAGEMENT 3 (3+0)**

### **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. Importance of resistance, principles, classification, components, types and mechanisms of resistance.

#### UNIT II

Concept and philosophy, ecological principles, economic threshold concept, and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

#### 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.

#### UNIT IV

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. 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.

### **Suggested Readings**

Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. 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.

### **ENT 532      PESTS OF FIELD CROPS AND THEIR MANAGEMENT      3 (2+1)**

#### **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**

Atwal AS, Dhaliwal GS & David BV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.

Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.

Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publ., New Delhi

Evans JW. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.

Nair MRGK. 1986. *Insect and Mites of Crops in India*. ICAR, New Delhi.

Prakash I & Mathur RP. 1987. *Management of Rodent Pests*. ICAR, New Delhi.

Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.

### **ENT 533      PESTS OF HORTICULTURAL AND PLANTATION CROPS      3 (2+1)**

#### **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, 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**

Atwal AS & Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management*. Kalyani Publ., New Delhi.

Butani DK & Jotwani MG. 1984. *Insects and Vegetables*. Periodical Expert Book Agency, New Delhi.

Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publ., New Delhi.

Srivastava RP. 1997. *Mango Insect Pest Management*. International Book Distr., Dehra Dun.

Verma LR, Verma AK & Goutham DC. 2004. *Pest Management in Horticulture Crops: Principles and Practices*. Asiatech Publ., New Delhi.

## **ENT 534 STORAGE PESTS AND THEIR MANAGEMENT 3 (2+1)**

### **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**

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.

Jayas DV, White NDG & Muir WE. 1995. *Stored Grain Ecosystem*. Marcel Dekker, New York.  
Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publ., New Delhi.  
Khare BP. 1994. *Stored Grain Pests and Their Management*. Kalyani Publ., New Delhi.  
Subramanyam B & Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products*. Marcel Dekker, New York.

**ENT 524                      ACAROLOGY AND SOIL ARTHROPODS                      3 (2+1)**

**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. 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**

History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.

**UNIT II**

Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

**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. 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.

**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. 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**

- Anderson JM & Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods*. CABI, London.
- Chhillar BS, Gulati R & Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.
- Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley & Sons, New York.
- Gerson U & Smiley RL. 1990. *Acarine Biocontrol Agents - An Illustrated Key and Manual*. Chapman & Hall, New York.
- Gupta SK. 1985. *Handbook of Plant Mites of India*. Zoological Survey of India, Calcutta.
- Gwilyn O & Evans GO. 1998. *Principles of Acarology*. CABI, London.
- Jeppson LR, Keifer HH & Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.
- Krantz GW. 1970. *A Manual of Acarology*. Oregon State Univ. Book Stores, Corvallis, Oregon.
- Pankhurst C, Dube B & Gupta, V. 1997. *Biological Indicators of Soil Health*. CSIRO, Australia.
- Qiang Zhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control*. CABI, London.
- Sadana GL. 1997. *False Spider Mites Infesting Crops in India*. Kalyani Publ. House, New Delhi.
- Walter DE & Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviour*. CABI, London.
- Veeresh GK & Rajagopal D. 1988. *Applied Soil Biology and Ecology*. Oxford & IBH Publ., New Delhi.

## **ENT 525 INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS 3(2+1)**

### **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**

- Basu AN. 1995. *Bemisia tabaci* (Gennadius) - *Crop Pest and Principal Whitefly Vector of Plant Viruses*. Oxford & IBH, New Delhi.
- Harris KF & Maramarosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.
- Maramorosch K & Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.
- Youdeovei A & Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

**ENT 528**

**PLANT QUARANTINE**

**2 (2+0)**

### **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**

- Rajeev K & Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

**ENT 535**

**COMMERCIAL ENTOMOLOGY**

**3 (2+1)**

**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**

Aruga H. 1994. *Principles of Sericulture*. Oxford & IBH, New Delhi.

Atwal AS. 2006. *The World of the Honey Bee*. Kalyani Publ., New Delhi.

Ganga G. 2003. *Comprehensive Sericulture*. Vol. II. *Silkworm Rearing and Silk Reeling*. Oxford & IBH, New Delhi.

Partiban S & David BV. 2007. *Management of Household Pests and Public Health Pests*. Namratha Publ., Chennai.

Singh S. 1975. *Beekeeping in India*. ICAR, New Delhi.

## **ENT 621 MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH 2 (1+1)**

### **(Compulsory Course)**

#### **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. 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**

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

**ENT 611      ADVANCED INTEGRATED PEST MANAGEMENT      2 (2+0)**  
**(Compulsory Course)**

**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' real time 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**

- 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*. Springer, Berlin.
- Koul O & Cuperus GW. 2007. *Ecologically Based Integrated Pest Management*. CABI, London.
- Koul O, Dhaliwal GS & Curperus GW. 2004. *Integrated Pest Management –Potential, Constraints and Challenges*. CABI, London.
- Maredia KM, Dakouo D & Mota-Sanchez D. 2003. *Integrated Pest Management in the Global Arena*. CABI, London.
- Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management*. John Wiley & Sons, New York.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concept in Integrated Pest Management*. Prentice Hall, New Delhi.
- Pedigo RL. 1996. *Entomology and Pest Management*. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

**ENT 612**                      **ADVANCED INSECT SYSTEMATICS**                      **3 (1+2)**  
**(Core Course)**

**Objective**

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

**Theory**

**UNIT I**

Detailed study of three schools of classification- numerical, evolutionary and cladistic. 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, works on revision of taxa, 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, and 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 polarization for developing cladograms and use of computer programmes to develop cladograms.

### **Suggested Readings**

- CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2<sup>nd</sup> 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*. 2<sup>nd</sup> Ed. Academic Press, New York.
- Mayr E & Ashlock PD. 1991. *Principles of Systematic Zoology*. 2<sup>nd</sup> 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.

## **ENT 613      ADVANCED INSECT PHYSIOLOGY AND BEHAVIOUR      3 (2+1)** **(Core Course)**

### **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, hardening of cuticle.

#### **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, polymorphism and diapause. Insect 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**

Demonstration of the use of different techniques – (a). Electrophoretic (b) Chromatography (c) Spectrophotometry (d) Olfactometer

#### **Suggested Readings**

- Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford & IBH, New Delhi.
- Awasthi VB. 2001. *Principles of Insect Behaviour*. Scientific Publ., Jodhpur.
- Bernays EA & Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman & Hall, London.
- Brown LB. 1999. *The Experimental Analysis of Insect Behaviour*. Springer, Berlin.
- Kerkut GA & Gilbert LI. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.
- Krebs JR & Davies NB. 1993. *An Introduction to Behavioural Ecology*. 3<sup>rd</sup> 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-Inter Science Publ. John Wiley & Sons, New York.
- Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Assoc. for Advancement of Entomology, Trivandrum, Kerala.
- Rockstein, M. 1978. *Biochemistry of Insects*, Academic Press

**ENT 614**

**ADVANCED INSECT ECOLOGY**

**2 (1+1)**

#### **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**



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

**ENT 622                      RECENT TRENDS IN BIOLOGICAL CONTROL                      3 (2+1)**

**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 semio-chemicals 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**

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

## **ENT 623                      ADVANCED INSECTICIDE TOXICOLOGY                      3 (2+1)**

### **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.

### **ENT 624**

### **ADVANCED ACAROLOGY**

**2 (1+1)**

#### **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, Orthogalummidae, 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**

Evans GO.1992. *Principles of Acarology*. CABI, London.

Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents- An Illustrated Key and Manual*. Chapman & Hall, New York.

Gupta SK. 1985. *Handbook of Plant Mites of India*. Zoological Survey of India, Calcutta.

Krantz GW. 1970. *A Manual of Acarology*. Oregon State University Book Stores, Corvallis, Oregon.

Sadana GL. 1997. *False Spider Mites Infesting Crops in India*. Kalyani Publ. House, New Delhi.