ENTOMOLOGY
Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
ENT 501*	INSECT MORPHOLOGY	1+1
ENT 502*	INSECT ANATOMY, PHYSIOLOGY AND NUTRITION	2+1
ENT 503	PRINCIPLES OF TAXONOMY	2+0
ENT 504*	CLASSIFICATION OF INSECTS	2+1
ENT 505*	INSECT ECOLOGY	1+1
ENT 506	INSECT PATHOLOGY	1+1
ENT 507*	BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS	1+1
ENT 508*	TOXICOLOGY OF INSECTICIDES	2+1
ENT 509	PLANT RESISTANCE TO INSECTS	1+1
ENT 510*	PRINCIPLES OF INTEGRATED PEST MANAGEMENT	1+1
ENT 511*#	PESTS OF FIELD CROPS	1+1
ENT 512*#	PESTS OF HORTICULTURAL AND PLANTATION CROPS	1+1
ENT 513	STORAGE ENTOMOLOGY	1+1
ENT 514	INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS	1+1
ENT 515	GENERAL ACAROLOGY	1+1
ENT 516	SOIL ARTHROPODS AND THEIR MANAGEMENT	1+1
ENT 517	VERTEBRATE PEST MANAGEMENT	1+1
ENT 518*	TECHNIQUES IN PLANT PROTECTION	0+1
ENT 519	COMMERCIAL ENTOMOLOGY	1+1
ENT 520	PLANT QUARANTINE	2+0
ENT 591	MASTER'S SEMINAR	1+0
ENT 599	MASTER'S RESEARCH	20
ENT 601	ADVANCED INSECT SYSTEMATICS	1+2
ENT 602	IMMATURE STAGES OF INSECTS	1+1
ENT 603	ADVANCED INSECT PHYSIOLOGY	2+0
ENT 604	ADVANCED INSECT ECOLOGY	1+1
ENT 605	INSECT BEHAVIOUR	1+1
ENT 606	RECENT TRENDS IN BIOLOGICAL CONTROL	1+1
ENT 607	ADVANCED INSECTICIDE TOXICOLOGY	2+1
ENT 608	ADVANCED HOST PLANT RESISTANCE	1+1
ENT 609	ADVANCED ACAROLOGY	1+1

CODE	COURSE TITLE	CREDITS
ENT 610	AGRICULTURAL ORNITHOLOGY	1+1
ENT 611**	MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH	1+1
ENT 612**	ADVANCED INTEGRATED PEST MANAGEMENT	2+0
ENT 613/ PL. PATH 606$	PL PATH PLANT BIOSECURITY AND BIOSAFETY	2+0
ENT 691	DOCTORAL SEMINAR 1	1+0
ENT 692	DOCTORAL SEMINAR II	1+0
ENT 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme

** Compulsory for Ph.D. programme

One out of 511 or 512 is compulsory

$ Cross-listed with Plant Pathology

Minor Departments **9**

Plant Pathology

Supporting Departments **5**

Statistics and Mathematics

Biochemistry

Non credit compulsory courses

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1
PGS 503 (e-course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-course)	DISASTER MANAGEMENT	1+0

ENT 501 INSECT MORPHOLOGY 1+1

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

Importance of morphology, evolution of insects; insect body wall- structure, cuticular outgrowths, colouration and special integumentary structures in insects; body tagmata, sclerites and segmentation.

UNIT II

Head- Origin, structure and modifications; 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, auditory - and chemoreceptors).

Practical

Preparation of permanent slides. Measurements of microstructures using micrometry. Camera lucida drawings, Study of structure and types of eggs, larvae and pupae. Study of Structure of Head in Cockroaches, Grasshoppers and Plant bugs. Study of Structure of Head in Lepidoptera and Coleoptera Study of Structure of Head in Diptera and Hymenoptera. Study of mouthparts in Grasshoppers , Moths and Plant bugs, Study of mouthparts in Honeybees and Houseflies. Study of structure of thorax in Grasshoppers and Beetles. Study of modifications of antennae and legs in different insects. Study of modifications of wings and wing coupling organs in insects. Study of the structure of the abdomen in Orthopterans, Coleopterans & Hymenopterans. Study of the structure of female genitalia of insects Study of structure of male genitalia of insects, Evaluation.

Suggested references

Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.

David BV & Ananthkrishnan TN. 2004. *General and Applied Entomology*. Tata-McGraw Hill, New Delhi.

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

Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.

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

Saxena RC & Srivastava RC. 2007. *Entomology: At a Glance*. Agrotech Publ. Academy, Jodhpur.

Snodgross RE. 1993. *Principles of Insect Morphology.* Cornell Univ. Press, Ithaca.

ENT 502 INSECT ANATOMY, PHYSIOLOGY AND NUTRITION 2+1

Objective

To impart knowledge to the students on basic aspects of anatomy of different insect 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, muscular, 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 grasshoppers/ cockroaches to study the digestive, reproductive systems and other systems – preparation of permanent mounts of internal systems. Estimation of free amino acids in haemolymph – chromatographic analysis, Estimation of chitin in insect cuticle, ,Haemocytes staining and counting, Determination of respiratory quotient , Preparation of various artificial diets and its evaluation, Classification and determination of growth ratios in insects, 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.

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.

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

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

Pant N.C. and Ghai, S .1981.Insect physiology and anatomy, ICAR, New Delhi

Gour, T.B. and Sriramulu, M. 2004. Insect Physiology principles and concepts. Kalyani Publishers, Hyerabad. 187p

ENT 503 PRINCIPLES OF TAXONOMY 2+0

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, methodscharacter 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

Blackwelder RE. 1967. *Taxonomy - A Text and Reference Book.* John Wiley & Sons, New York.

International commission on zoological nomenclature 1999 international code of zoological nomenclature .IV $^{the\ d}$, international trust for zoological nomenclature. London.

Kapoor V C 1998 Theory and practice of animal taxonomy, oxford and IBM publishing co. Pvt. Ltd. New Delhi.

Kapoor VC. 1983. *Theory and Practice in Animal Taxonomy*. Oxford & IBH, New Delhi.

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

Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie, London.

ENT 504 CLASSIFICATION OF INSECTS 2+1

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. Kinds and systems of classification, Importance of taxonomy in applied science, Concepts of species, International Code of Zoological Nomenclature, Binomial nomenclature, Common terms used in taxonomical literature and their definitions

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 Paleoptera –Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Orthoptera, Phasmatodea), Subdivision: Hemipteroid Orders (=Paraneoptera): 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 Panorpoid 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*. 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.

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

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

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.

ENT 505 INSECT ECOLOGY 1+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 indicies. Train students in sampling methodology, calculation of diversity indicies, 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. 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

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. Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Inter and Intra-specific interactions- Basic factors governing the interspecific interactions- Classification of inter and intra- specific interactions - The argument of cost-benefit ratios. Concept of niche ecological homologues, competitive exclusion. Prey-predator interactions- Functional and numerical response. Defense mechanisms against predators/ parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

UNIT IV

Characterization of insect colonization. k and r Strategies. 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

Study of types of distribution of organisms- Measurement of pattern of distribution (dispersion) of a pest species on a crop - case of random distribution). Study of types of distribution of organisms- Measurement of pattern of distribution (dispersion) of a pest species on a crop - case of highly aggregated distribution, Study of methods of sampling insects- Estimation of

densities of population of two pest species on a crop and understanding the distribution parameters for randomly distributed pest species, Study of methods of sampling insects- Estimation of densities of population of two pest species on a crop and understanding the distribution parameters for aggregated distributed pest species, Study of measures of central tendencies, Poisson distribution, negative binomial distribution of certain insect pest species. Determination of optimal sample size – First method of determining sample unit and its size. Determination of optimal sample size –second method of determining sample unit and its size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's disc equation. Assessment prey-predator densities from natural system and working out the correlation between the two. Assessment and description of niche of some insects (two pest species) of a single guild. Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of some diversity indices- Sharnon's, Simpson's and avalanche index and understanding their associations and parameters that affect their values. Problem solving in ecology (Case studies). Field visits to understanding Rice ecosystems and to study insect occurrence , Field visits to understanding Rice ecosystems and to study insect occurrence, Final Practical Exam

Suggested Readings

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

Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics.* Sinauer Associates, Inc., underland, 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 and Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.

Southwood TRE and Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Methuen & Co. Ltd., London.

Speight MR, Hunta MD and Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.

Wilson EO and William H Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.

Wratten SD and Fry GLA.1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

ENT 506 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

Study and familiarization with equipment used in insect pathology laboratory, Identification of different groups of insect pathogens (bacteria, fungi, viruses, protozoa and nematodes) and study of symptoms of their infection, Isolation, culturing, standardization and testing pathogenicity of different groups of pathogens namely bacteria, fungi, viruses, protozoa and nematodes, Testing of Koch's postulates for entomopathogenic facultative pathogens namely bacteria and fungi, Testing of Koch's postulates for entomopathogenic obligate pathogens namely baculoviruses, nematodes and protozoa, Estimation of pathogenic load- Serial dilution and standardization techniques in case of bacteria, fungi, viruses, protozoa and nematodes , Extraction of pathogens from live organisms and soil- bacteria, fungi, viruses and nematodes, Bioassays to determine medilian lethal doses and Mendelian lethal time - Testing of virulence of certain isolates of entomopathogenic bacteria, fungi and viruses, Practical examination

Suggested Readings

Boucias DG & Pendland JC. 1998. *Principles of Insect Pathology.* Kluwer Academic Publisher, Norwel.

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

Steinhaus EA. 1984. *Principles of Insect Pathology.* Academic Press, London.

ENT 507 BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS 1+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.

UNIT II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc. and 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. Natural enemies on artificial diet. Commercial insectaries and their maintenance.

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

Basic insectary facilities and equipment to promote biological control. Characters of important orders and families of parasitoids, Characters of important orders and families of predators, Description of the principal groups of infectious organisms. Identification of important microbial insecticides, Identification of important 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 – (2), Collection, preservation, shipment of biotic agents and storage of natural enemies. Field trip for collection of natural enemies.(2), Collection of diseased insects and mites from field and Study of symptoms, Production of NPV of *Helicoverpa armigera* and *Spodoptera litura*–extraction and purification, standardization and storage(2), Counting of PIB and larval equivalents, Formulation of microbial insecticides, Measuring various quality parameters of biopesticides and registration of biopesticides

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 & 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 508 TOXICOLOGY OF INSECTICIDES 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. Neurobiology and its relation to toxicology. Structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, neonicotinoids, oxadiazines, phenyl pyrazoles, insect growth regulators, 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; Pest resurgence and secondary outbreaks, Insecticide formulations.

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

Dilution of technical grade insecticide following serial dilution technique, Preparation of E.C. formulation of an insecticide, Determination of acidity/alkalinity and specific gravity of EC/SC formulation. Determination of flash point and stability of EC/SC formulation. Study of various bioassay techniques and testing the contact, stomach and fumigant toxicity of an insecticide (2), Testing the toxicity to beneficial insects, Study of probit analysis (sigmoid and dosage mortality curves), Calculation of LC_{50} of an insecticide following probit analysis, Calculation of LD_{50} of an insecticide following probit analysis, Calculation of LT_{50} of an insecticide following probit analysis, Calculation of ED_{50} of an insecticide following probit analysis, Determination of joint action of insecticide and vegetable oil/ non-toxic chemical, Calculation of PT values of insecticides, Visit to toxicology laboratory, Study of Good Laboratory Practices

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.

Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publ., New York.

ENT 509 PLANT RESISTANCE TO INSECTS 1+1

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

Estimation of insect infestation by absolute methods, Estimation of insect infestation by relative methods, Evaluation of clumped, uniform and random spatial distribution of sampling methods, Screening resistance by artificial infestation of plants with laboratory reared insects, Screening resistance by measuring insect responses to excised plant parts, Measurement of plant

characters and working out their correlations with plant resistance, Measuring resistance in important crops against direct pests, Measuring resistance in important crops against indirect pests, Bioassay of plant extracts of susceptible/resistant varieties, Demonstration of antibiosis, tolerance and antixenosis.

Suggested Readings

Dhaliwal GS & Singh R. (Eds). 2004. *Host Plant Resistance to Insects - Concepts and Applications.* Panima Publ., New Delhi.

Maxwell FG & Jennings PR. (Eds). 1980.*Breeding Plants Resistant to Insects.* John Wiley & Sons, New York.

Painter RH.1951. *Insect Resistance in Crop Plants*. MacMillan, London.

Panda N & Khush GS. 1995. *Plant Resistance to Insects.* CABI, London.

Smith CM. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches.* Springer, Berlin.

ENT 510 PRINCIPLES OF INTEGRATED PEST MANAGEMENT 1+1

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, Host Plant Resistance, Biological and Mechanical methods in Tools of pest management and their integration; 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; Bio-rational, Biotechnological and other innovative approaches (Mass trapping, mating disruption technique) in IPM, case studies of successful IPM programmes.

Practical

Characterization of agro-ecosystems – rice, cotton ecosystems. Characterization of agro-ecosystems- sugarcane, mango *etc.,* Sampling methods and factors affecting sampling- practical considerations for insect pests of rice, cotton. Sampling methods and factors affecting sampling-practical considerations for insect pests of pulses, oilseeds. Population estimation methods – absolute and relative methods- estimation based on products and effects of insects for key pests of select crops- rice, cotton. Population estimation methods- key pests of select crops-pulses, oilseeds. Crop loss assessment – direct, indirect and potential losses- avoidable and unavoidable losses- in select field crops. Crop loss assessment- in select- horticultural crops.

Estimation of losses in storage due to store grain pests. Computation of EIL and ETL for key pests of field crops. Computation of EIL and ETL for key pests of horticultural crops. Crop modeling – in field crops. Crop modeling – in horticultural crops. Designing and implementing IPM system- rice, cotton. Designing and implementing IPM system- apple, mango. Farmers Field school, concept for dissemination of IPM.

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.

ENT 511 PESTS OF FIELD CROPS 1+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

Identification and study of important pests of paddy (2), Identification and study of important pests of millets. Identification and study of important pests of sugarcane , Identification and study of important pests of cotton (2), Identification and study of important pests of pulses, Identification and study of important pests of oilseeds. Identification and study of important pests of forage. Study of mites, birds, rodents, snails & slugs, Detection and estimation of insect damage(2), Estimation of losses in different crops(2), Field Visits (2)

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, Jodhpur.

ENT 512 PESTS OF HORTICULTURAL AND PLANTATION CROPS 1+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, annona, 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

Identification of insects and damage symptoms of pests of Mango, Identification of insects and damage symptoms of pests of.citrus, Identification of insects and damage symptoms of pests of grape vine, pomegranate, guava, Identification of insects and damage symptoms of pests of sapota, ber and banana, Identification of insects and damage symptoms of pests of pine apple, custard apple and papaya, Identification of insects and damage symptoms of pests of tomato, Identification of insects and damage symptoms of pests of moringa and leafy vegetables, Identification of insect pests and damage symptoms of bhendi, Identification of insect pests and damage symptoms of cucurbits, Identification of insect pests and damage symptoms of crucifers, Identification of insect pests and damage symptoms of potato, carrot, raddish French bean, Identification of insects and damage symptoms of pests of coconut, oil palm and cacoa, Identification of insects and damage symptoms of pests of cashew, tea and coffee, Identification of insects pests attacking turmeric, ginger and betel vine, Identification of insects and damage symptoms of pests of aromatic crops, medicinal crops and processed products

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 513 STORAGE ENTOMOLOGY 1+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, disinfestation 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 (Coleopteran) and nature of damage caused by them, Collection, identification and familiarization with the stored grains/seed insect pests (Lepidopteran) and nature of damage caused by them , Collection, identification and familiarization with the stored grains/seed insect pests (Non 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).

References:

Hall DW. 1970. *Handling and Storage of Food Grains in Tropical andSubtropical 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 514 INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS 1+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 development 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 (field trip)- field collection and identification of important vectors- aphids, leafhoppers, plant hoppers, whiteflies, Field trip- field collection and identification of vectors- thrips, beetles, and nematodes, Preservation of vectors for microscopic study, Techniques in culturing and handling of vectors- aphids, leafhoppers, plant hoppers, Techniques in culturing and handling of vectors- whiteflies and thrips, Field trip: collection and identification of symptoms of insect transmitted plant diseases in field crops, Field trip: collection and identification of symptoms of insect transmitted diseases in horticultural crops, Preservation and study of specimens of insect transmitted plant diseases- wet preservation and dry preservation, Study of mouth parts of important vectors and their role in transmission of plant diseases, Demonstration of virus transmission mechanically and through vectors under green house conditions. – sap inoculation of tobacco mosaic virus or cucumber mosaic virus, Demonstration of virus transmission through leafhoppers- Brinjal little leaf virus, Demonstration of development of hopperburn symptoms in cotton/bhendi (phytotoxemia by leafhoppers), Demonstration of virus transmission through whiteflies- YMV in black gram/ green gram, Demonstration of virus transmission through whiteflies- yellow vein mosaic virus in bhendi.

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.

Maramarosh 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 515 GENERAL ACAROLOGY 1+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.

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, Collection of mites from soil , Collection of mites from animals; Extraction of mites from soil, Extraction of mites from plants, Extraction of mites from stored products; Preparation of mounting media, Preparation of mounting slide mounts, External morphology of mites (Tetrranychidae); External morphology of mites (Tarsonemidae); External morphology of mites (Tenuipalpidae); External morphology of mites (Eriophyidae), External morphology of mites (Phytoseidae); Identification of mites up to family level using keys; Studying different rearing techniques for mites.

References:

Chhillar BS, Gulati R & Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.

Gerson U & Smiley RL. 1990. *Acarine Biocontrol Agents - An IllustratedKey and Manual*. Chapman & Hall, NewYork.

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.

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 Behaviou*r. CABI, London.

ENT 516 SOIL ARTHROPODS AND THEIR MANAGEMENT 1+1

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

Introduction to soil fauna-arthropods, Importance of soil arthropods, Sampling of different types of harmful soil arthropods, Sampling of different types of beneficial soil arthropods, Extraction of harmful soil arthropods, Identification of soil arthropods, Estimation of population of beneficial soil fauna, Estimation of population harmful soil fauna, Assessment of damage by soil arthropods on plants, Assessment of damage by soil arthropods on plants, Assessment of damage by soil arthropods on plants, Techniques of culturing of soil arthropods, Techniques of culturing of soil arthropods, Testing of effect of soil pesticides on beneficial fauna, Data recording for estimation of damage by soil arthropods.

Suggested Readings

Anderson JM & Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.

Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley & Sons, New York.

Pankhurst C, Dube B & Gupta, V. 1997. *Biological Indicators of Soil Health.* CSIRO, Australia.

Veeresh GK & Rajagopal D.1988. *Applied Soil Biology and Ecology*. Oxford & IBH Publ., New Delhi.

ENT 517 VERTEBRATE PEST MANAGEMENT 1+1

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 Vertebrate Pests in the field based on observation and other physical characteristic features, Methods for estimating population structure of various vertebrate pests in relation to habitats, Nature of damage to different crops by vertebrate pests and their identification, Damage pattern and methods for damage estimation & assessment, Introduction to devices for vertebrate scaring and attraction, Equipments used in vertebrate study, Biostatistics in vertebrate studies, Identification of food , food preference and social behaviour studies in captivity, Field visit to understanding captive breeding in Zoos and visit to a National Park (or) Sanctuary.

Suggested Readings

Fitzwater WD & Prakash I. 1989. *Handbook of Vertebrate Pest Control.* ICAR, New Delhi.

Prakash I & Ghosh *PK.1997. Rodents in Indian Agriculture.* Vol. I. State of Art Scientific Publ., Jodhpur.

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

Prater SH. 1971. *The Book of Indian Animals.* The Bombay Natural History Society, Bombay.

Ali S. 1965. *The Book of Indian Birds.* The Bombay Natural History Society, Bombay

ENT 518 TECHNIQUES IN PLANT PROTECTION 0+1

Objective

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

Practical

UNIT I

Pest control equipments, principles, operation, maintenance, selection, application of pesticides and biocontrol agents, seed dressing, soaking, root-dip treatment, dusting, spraying. Bioassay by Potter's tower. Aerial spraying, HV/LV/ULV sprays, application through irrigation water. Root feeding technique and stem application technique

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

Protein isolation from the pest and host plant and its quantification using spectrophotometer. Use of light transmission and scanning electron microscopy.

UNIT V

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

Suggested Readings

Alford DV. 1999. *A Textbook of Agricultural Entomology.* Blackwell Science, London.

Crampton JM & Eggleston P. 1992. *Insect Molecular Science.* Academic Press, London.

ENT 519 COMMERCIAL ENTOMOLOGY 1+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- Establishment and maintenance of apiaries. 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.

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, house flies, 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

Preparation of planting material and Raising Mulberry nursery and methods of planting of Mulberry under irrigated and rainfed conditions, Study of Insect pests and diseases of Mulberry, Study of Mulberry silk worms and Non- Mulberry silk worms, Study of diseases and pests of silk worms, Visit to sericulture farm and grainage centre, Study of important species of honey bees, castes and special adaptations, Study of bee hives and other equipment and frame inspection, Honey extraction and processing methods of hive products, Study of insect enemies and diseases of honey bees, Visit to commercial Apiaries, Study of lac insect host trees and crop management technology, Study of processing of lac products and bye products of lac., Assessment of pest status in labs or hostels or canteen and implementation of control measures, To evaluate commercially available domestic pest control products through bioassay, Study of pre and post construction termite proofing methods, Visit to the poultry units and assessing the pest status

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

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

ENT 520 PLANT QUARANTINE 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 disinfestation/salvaging of infested 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 and 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 601 ADVANCED INSECT SYSTEMATICS 1+2

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: Kukalova 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

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.* 2ndEd. 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 602 IMMATURE STAGES OF INSECTS 1+1

Objective

To impart knowledge on morphology of immature stages of different groups of insects. Train the 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

Collection and preservation of immature forms of insects, Rearing of Immature stages of insects, Study of different types of keys and practicing them, Comparative morphology and identification of immature forms of order Lepidoptera, Comparative morphology and identification of immature forms of order Coleoptera, Comparative morphology and identification of immature forms of order Hymenoptera, Comparative morphology and identification of immature forms of order Diptera, Comparative morphology and identification of immature forms of order Neuroptera.

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 603 ADVANCED INSECT PHYSIOLOGY 2+0

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.

References :

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

Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Assoc. for Advancement of Entomology, Trivandrum, Kerala.

Murray S. Blum 1985 Fundamentals of Insect physiology. John Wiley & Sons, USA

ENT 604 ADVANCED INSECT ECOLOGY 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.* 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 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.* 3rd Ed. Wiley Blackwell, London.

Strong DR, Lawton JH & Southwood R. 1984. *Insects on Plants: Community Patterns and Mechanism*. Harward University Press, Harward.

Wratten SD & Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold Publ., London.

ENT 605 INSECT BEHAVIOUR 1+1

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, inducted behaviour, learnt behaviour and motivation. History of Ethology- development of behaviorism and ethology, contributions 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 taxis 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; Self organization and insect behaviour.

UNIT IV

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

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.

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.

ENT 606 RECENT TRENDS IN BIOLOGICAL CONTROL 1+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 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

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 607 ADVANCED INSECTICIDE TOXICOLOGY 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 mode 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 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

Pesticide residues-Definition, Objectives of analysis and tolerance limits, Preparation of standard pesticide solutions, Sampling techniques in insecticide residue estimation, Methods of insecticide

extraction from different samples, Methods of cleanup in insecticide residue estimation, Analysis of insecticide residues by Spectrophotometry, Analysis of insecticide residues by Chromatography, Analysis of insecticide residues by ELISA, Radioisotopes & Mass Spectrometry, Biochemical techniques for detection of insecticide resistance in insects, Biological techniques for detection of insecticide resistance in insects, Visit to toxicology laboratories.

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.,

ENT 608 ADVANCED HOST PLANT RESISTANCE 1+1

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

Mechanisms of resistance for orientation, feeding, oviposition, Allelochemical base of insect resistance, Macro culturing of test insects such as aphids, Macro culturing of test insects such as leaf/plant hoppers, Macro culturing of test insects such as mites, Macro culturing of test insects such as stored grain insects, Macro culturing of test insects such as lepidopteran insects, Field screening- microplot technique, infester row technique, spreader row technique, Field screening - Plant nursery technique, Determination of antixenosis index, Determination of antibiosis index, Determination of tolerance and plant resistance index

Suggested Readings

Ananthakrishnan, T.N. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford & IBH, New Delhi

Bernays E.A. & Chapman, R.F. 1994. *Host Plant Selection by Phytophagous Insects*. Chapman & Hall, London.

Panda N. 1979. *Principles of Host Plant Resistance to Insects*. Allenheld, Osum & Co., New York.

Rosenthal GA & Janzen DH. (Eds.). 1979. *Herbivores – their Interactions with Secondary Plant Metabolites*. Vol. I, II. Academic Press, New York.

Sadasivam S & Thayumanavan B. 2003. *Molecular Host Plant Resistance to Pests*. Marcel Dekker, New York.

Smith CM, Khan ZR & Pathak MD. 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*. CRC Press, Boca Raton, Florida.

Painter, R.H. 1951. *Insect Resistance in Crop Plants*. MacMillan, NewYork. 520 pp.

ENT 609 ADVANCED ACAROLOGY 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, Orthogalumnidae, 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.

ENT 610 AGRICULTURAL ORNITHOLOGY 1+1

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.

Practicals

Identification of birds in the field based on direct observation and other characteristic features., Study of methods of sampling birds and their population estimation. Mapping of birds in relation to habitats, Identification of damage species, nature and type of damage, Damage pattern and methods to evolve extent of damage, Introduction to devices for bird scaring and attraction,

Equipments used in field Ornithology, Biostatistics in Ornithology, Trapping, banding, types of nests and nest monitoring, Field visit to understanding captive breeding in Zoos, Methods to study food and feeding habits, Exposure the nest box designs.

Suggested Readings

Dhindsa SR and Parasharya BM. 1998. *Birds in Agricultural Ecosystem.* Society for Applied Ornithology, Hyderabad.

Mehrotra KN and Bhatnagar RK. 1979. *Status of Economic Ornithology in* India- Bird Depredents, Depredations and their Management, ICAR, New Delhi.

Vasudeva Rao and Dubey OP. 2006. Grainivorous Pests and their Management. In: *Vertebrate Pests in Agriculture*, *The Indian Scenario* (Ed: Sridhara, S.), Scientific Publ., Jodhpur.

ENT 611 MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH 1+1

Objective

To familiarize the students with DNA recombinant techonology, 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, chitinase, CPTI; lectins and proteases. Peptides and neuropeptides, JH esterase, St toxins and venoms, Bt toxin, CPTI; trypsin inhibitors. 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. Alpha amylase inhibitor, GEAC, Bio-safety considerations

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 Biotehnology*. 1st 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*. 1st 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 612 ADVANCED INTEGRATED PEST MANAGEMENT 2+0

Objective

To acquaint the students with recent concepts of integrated pest management. Surviellance 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, system analysis and modeling.

UNIT II

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

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. Push and pull technology, area wide pest management, green pest 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 613/ PLANT BIOSECURITY AND BIOSAFETY 2+0
PL PATH 606

Objective

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

Theory

UNIT I

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases.

UNIT II

National Regulatory Mechanism and International Agreements/Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

UNIT III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Suggested Readings

FAO Biosecurity Toolkit 2008.

www.fao.org/docrep/010/a1140e/a1140e00.htm Laboratory Biosecurity Guidance.

http://www.who.int/csr/resources/publications/biosafety/WHO_CD S_EPR_2006.pdf

Grotto Andrew J & Jonathan B Tucker. 2006. *Biosecurity: A* Comprehensive Action Plan.

http://www.americanprogress.org/kf/biosecurity_a_comprehensive_ action_plan.pdf Biosecurity Australia.

www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia *Biosecurity New Zealand*. www.biosecurity.govt.nz

DEFRA.www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm

Randhawa GJ, Khetarpal RK, Tyagi RK & Dhillon. BS (Eds.). 2001.

Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.

Khetarpal RK & Kavita Gupta 2006. *Plant Biosecurity in India - Status and Strategy*. Asian Biotechnology and Development Review 9(2): 39-63. Biosecurity for

Agriculture and Food Production. http://www.fao.org/biosecurity/

CFIA.http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht ml

List of Journals

Agricultural and Forest Entomology- Royal Entomological Society, UK
Annual Review of Entomology- Paloatto, California, USA
Applied Soil Ecology- Elsevier Science, Amsterdam, The Netherlands
Biopesticides International- Koul Research Foundation, Jalandhar
Bulletin of Entomological Research- CAB International, Wallingford, UK
Bulletin of Grain Technology- Food Grain Technologist Res. Association of India, Hapur
Crop Protection- Elsevier's Science, USA
Ecological Entomology -Royal Entomological Society, UK
Entomologia Experimentalis Applicata- Kluwer Academic Publishers, The Netherlands
Entomon- Association for Advancement of Entomology, Kerala
Environmental Entomology- Entomological Society of America, Maryland, USA
Indian Journal of Applied Entomology- Entomological Research Association, Udaipur
Indian Journal of Entomology- Entomological Society of India, New Delhi
Indian Journal of Plant Protection- Plant Protection Society of India, Hyderabad
Indian Journal of Sericulture- Central Silk Board, Bangalore
International Journal of Acarology- Indira Acarology Publishing House, Minessota, USA
International Journal of Pest Management- Taylor and Francis, UK
Journal of Acarology- Acarological Society of India, UAS, Bangalore
Journal of Apiculture Research- IBRA, UK
Journal of Applied Entomology- Blackwell Science Ltd., Oxford, UK

Journal of Biocontrol- Society for Biocontrol Advancement, Bangalore
Journal of Economic Entomology- Entomological Society of America, Maryland, USA
Journal of Entomological Research- Malhotra Publishing House, New Delhi
Journal of Insect Behaviour- Plenum Publishing Corporation, NY, USA
Journal of Insect Physiology- Pergamon Press, UK
Journal of Insect Science- Indian Society for the Advancement of Insect Science, Ludhiana
Journal of Invertebrate Pathology, Elsevier Publ. Corporation, The Netherlands
Journal of Soil Biology and Ecology, Indian Society of Soil Biology and Ecology, UAS, Bangalore
Journal of Stored Products Research- Elsevier's Science, USA
Pesticides Research Journal- Society of Pesticides Science, New Delhi
Pesticide Science – Oxford, London
Pesticide Biochemistry and Physiology- New York, USA
Physiological Entomology- Royal Entomological Society, UK
Review of Applied Entomology- CAB International, Wallingford, UK
Systematic Entomology- Royal Entomological Society, UK

e-Resources

http://www.colostate.edu/Depts/Entomology/
http://www.ent.iastate.edu/list/
http://www.biologybrowser.org/
http://www.teachers.ash.org.au/aussieed/insects.htm
http://entomology.si.edu/
http://www.intute.ac.uk/healthandlifesciences/agriculture/
http://www.agriculture.gov.au/
http://www.gbif.org/
http://www.mosquito.org/
http://www.nysaes.cornell.edu/fst/faculty/acree/pheronet/index.html
http://medent.usyd.edu.au/links/links.htm
http://www.ent.iastate.edu/list/
http://www.ento.csiro.au/index.html
http://www.biocollections.org/lib/listbycat.php?cat=Entomology
http://www.IPMnet.org/DIR/
http://www.nhm.ac.uk/hosted_sites/acarology/
http://www.agnic.org/
http://ars-genome.cornell.edu/
http://www.tulane.edu/~dmsander/garryfavweb.html
http://www.ufsia.ac.be/Arachnology/Arachnology.html
http://www.ippc.orst.edu/IPMdefinitions/home.html
http://www.ent.iastate.edu/list/
http://www.ippc.orst.edu/cicp/pests/vertpest.htm
http://ipmwww.ncsu.edu/cicp/IPMnet_NEWS/archives.html
http://nematode.unl.edu/wormsite.htm

http://www.bmckay.com/
http://ace.ace.orst.edu/info/extoxnet/pips/pips.html
http://www.ifgb.uni-hannover.de/extern/ppigb/ppigb.htm
http://www.ceris.purdue.edu/npirs/npirs.html
http://www.ces.ncsu.edu/depts/pp/bluemold/
http://www.ipm.ucdavis.edu
http://ippc.orst.edu/pestalert/
http://www.orst.edu/Dept/IPPC/wea/
http://www.barc.usda.gov/psi/bpdl/bpdl.html
http://www.nalusda.gov/bic/BTTOX/bttoxin.htm
http://www.nysaes.cornell.edu/ent/biocontrol/
http://entweb.clemson.edu/cuentres/
http://www.agr.gov.sk.ca/Docs/crops/cropguide00.asp
http://www.caf.wvu.edu/kearneysville/wvufarm6.html
http://www.chebucto.ns.ca/Environment/NHR/lepidoptera.html
http://nt.ars-grin.gov/fungaldatabases/databaseframe.cfm
http://www.orst.edu/dept/infonet/
http://www.attra.org/attra-pub/fruitover.html
http://www.ceris.purdue.edu/napis/pests/index.html
http://danpatch.ecn.purdue.edu/~epados/farmstead/pest/src/
http://ipmwww.ncsu.edu/current_ipm/otimages.html
http://nematode.unl.edu/wormhome.htm
http://www.ipm.ucdavis.edu/
http://hammock.ifas.ufl.edu/en/en.html
http://www.rce.rutgers.edu/weeddocuments/index.htm
http://www.agric.wa.gov.au/ento/allied1.htm
http://biology.anu.edu.au/Groups/MES/vide/refs.htm
http://chrom.tutms.tut.ac.jp/JINNO/PESDATA/00database.html
http://agrolink.moa.my/doa/english/croptech/crop.html
http://nbo.icipe.org/agriculture/stemborers/default.html
http://www.bdt.org.br
http://www.bspp.org.uk/fbpp.htm
http://www.elsevier.com/inca/publications/store/3/5/6/ http://www.hbz-nrw.de/elsevier/00207322/
http://ianrhome.uni.edu/distanceEd/entomology/401_801_insectphysio.shtml
www.entsoc.org
http://aprtc.org/
http://www.ipmnet.org/news.html
http://www.pestnet.org/www.fruitfly.org
www.celera.com
www.hgsc.bcm.tmc.edu/drosophila

http://sdb.bio.purdue.edu/fly/aimain/links
http://flybase.bio.indiana.edu/
http://naasindia.org/journals.htm

Suggested Broad Topics for Master's and Doctoral Research

Strengthening of eco-friendly strategies of integrated insect and mite pest management including:

Biological control

Bio-rational pesticides

Host plant resistance

Transgenic crop protection

Judicious use of pesticides

Molecular biosystematics

Investigations on ecological factors including:

Survey and surveillance of insect and mite pests

Forecasting of insect and mite pest population life-tables and predictive models

Insect and mite biology

Population dynamics as influenced by abiotic and biotic factors

Studies on role of pollination including honeybees in increasing crop yields and production of honey and other allied products and management of honeybee diseases and mites

Pesticide resistance and Insecticide Resistance Management strategies

Biotypes of pests

Below ground biodiversity- Bio-indicator of soil health, role in decomposition of litter, soil physico-chemical properties

Bioprospecting for protocols, peptides, genes, insecticidal proteins and antibiotics

Climate change and pests

IPM in protected cultivation

Location specific IPM strategies in different cropping systems

Genetic improvement of natural enemies

Genetic improvement of silkworms

Refinement of silkworm rearing technology for different regions

Management of silkworm pests and diseases

Crop-pest modeling

Insect biochemistry- pheromones, hormones and neuropeptides

Insect physiology- metabolism and regulatory mechanisms.

Indigenous technology

Plants as sources of insecticides

Molecular systematics – finger printing of species

Insect systematics and phylogeny