ETERNAL UNIVERSITY, BARU SAHIB, RAJGARH, SIRMOUR HIMACHAL PRADESH

Restructured and Revised Syllabi of Ph.D. Entomology as per BSMA Committee Recommendations, Education Division ICAR - New Delhi touching elements of New Education Policy

Syllabi Applicable from Academic Session 2024-25 onwards

Dr. Khem Singh Gill Akal College of Agriculture

Restructured and Revised Syllabi of Ph.D. Entomology as per BSMA Committee Recommendations, Education Division ICAR - New Delhi touching elements of New Education Policy

(i) Course Work	Credits (Minimum requirement)
Major Courses	12
Minor Courses	06
Supporting Courses	05
Common Courses	-
Seminar	02
(ii) Thesis Research	75
Total	100

Note:

As per New Education Policy, the student has the option to exercise his choice for the courses. Hence semester wise syllabus scheme has to be prepared by the Major Advisor / Head of the Department by instructing and guiding the student to fill Programme of Study for Postgraduate Students (PSPS) popularly known as yellow form within two weeks after getting admission / registration

Course Title with Credit Load Ph.D. Entomology

Course Code	Course Title	Credit Hours
ENT 601**	Insect Phylogeny and Systematics	3 (1+2)
ENT 602**	Insect Physiology and Nutrition	3 (2+1)
ENT 603**	Insect Ecology and Diversity	3 (2+1)
ENT 604	Insect Behaviour	2 (1+1)
ENT 605**	Bio-inputs for Pest Management	3 (2+1)
ENT 606**	Insect Toxicology and Residues	3 (2+1)
ENT 607	Plant Resistance to Insects	2 (1+1)
ENT 608	Acarology	2 (1+1)
ENT 609	Molecular Entomology	2 (1+1)
ENT 610	Integrated Pest Management	2 (2+0)
ENT 691	Doctoral Seminar – I	1 (0+1)
ENT 692	Doctoral Seminar – II	1 (0+1)
ENT 699	Doctoral Research	75 (0+75)

**Core courses for Doctoral programme.

Major courses: *Mark course are compulsory to be registered by a student

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

Common Courses: 05 credits

PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communications Skills	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
PGS 504	Basic Concepts in Laboratory Techniques	0+1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

Note:
If a student has not cleared the Common Courses during Master's Degree Programme, then he/she has to study Common Courses during Doctoral Degree Programme

SCHEME OF EXAMINATION
(Continuous Assessment and End-Semester Examination)

MARKS DISTRIBUTION FOR DIFFERENT CREDIT HOUR COURSES

CREDITS	THEORY			PRACTICALS		
T+P	Total	Mid- Session	End Term	Total	Mid- Session	End Term
1+0	100	40 (30+10#)	60	-	-	-
2+0	100	40 (30+10#)	60	-	-	-
3+0	100	40 (30+10#)	60	-	-	-
4+0	100	40 (30+10#)	60	-	-	-
5+0	100	40 (30+10#)	60	-	-	-
6+0	100	40 (30+10#)	60	-	-	-
0+1	0	0	0	100	50	50
1+1	50	20 (15+5#)	30	50	-	50
2+1	65	25 (20+5#)	40	35	-	35
3+1	75	30 (25+5#)	45	25	-	25
4+1	80	35 (30+5#)	45	20		20
0+2	0	0	0	100	50	50
1+2	35	15 (10+5#)	20	65	-	65
2+2	50	20 (15+5#)	30	50		50
3+2	60	25 (20+5#)	35	40		40
0+3	0	0	0	100	50	50

#Assignments marks

Course Contents

Ph.D. Entomology

ENT 601
Insect Phylogeny and Systematics

Credits: 1 + 2
Contact hours: 14+56

Mid-Session Exam : 15 (10+5#)
Practical Exam : 65
End-Semester Exam: 20

Aim of the course

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

Theory

Units	Content	Lectures
I	Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.	4
II	Study of different views on the evolution of insects- alternative phylogenies ofinsects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.	2
III	Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.	4
IV	Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular systematics.	4

Practical

1	Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, and construction of taxonomic keys for the selected group;	7
2	Development of descriptions, photographing, writing diagrams, and preparation of specimens for "type like" preservation, Submission of the collections made ofthe group;	7
3	Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms;	7
4	Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.	7

Learning outcome

- Scholars are expected to understand the concepts of taxonomic hierarchy, study taxonomic characters, variations, intra-specific phenotypic plasticity; prepare taxonomic keys for specific groups and write taxonomic papers and reviews.
- Scholars should be able to identify insects of economic importance up to family/ generic levels and specialize in any one group of insects up to species level identification.

Suggested Reading

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

Dakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology.* Springer-Verlag, Berlin.

Freeman S and 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 and Ashlock PD. 1991. *Principles of Systematic Zoology.* 2nd Ed. McGraw Hill, New York.

Mayr E.1969. *Principles of Systematic Zoology.* McGraw-Hill, New York.

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

Ross HH. 1974. *Biological Systematics.* Addison Wesley Publ. Co., London.

Wiley EO. 1981. *Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists*. Columbia Univ. Press, USA.

ENT 602

Insect Physiology and Nutrition

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam : 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the course

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

Units	Content	Lectures
I	Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticlde.	7
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.	7
III	Detailed physiology of nervous system, transmission of nerve impulses, neuro-transmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.	7
IV	Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.	7

Practical

1	Preparation of synthetic diets for different groups of insects;	2
2	Rearing of insects on synthetic, semi-synthetic and natural diets;	2
3	Determination of co-efficient of utilization;	2
4	Qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph;	2
5	Zymogram analyses of amylase;	2
6	Determination of chitin in insect cuticle;	2
7	Examination and count of insect haemocytes.	2

Learning outcome

- The scholars are expected to have thorough theoretical and practical knowledge of insect physiology that can be made use of in practical/ applied entomological aspects.
- Understand how physiological systems in insects are integrated to maintain homeostasis.

Suggested Reading

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford and IBH, New Delhi.

Bernays EA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, London.

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

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

Rockstein, M. 1978. *Biochemistry of Insects*, Academic Press.

Simpson, SJ. 2007. *Advances in Insect Physiology*, Vol. 33, Academic Press (Elsevier), London, UK.

ENT 603

Insect Physiology and Nutrition

Credits: 2 + 1 Mid-Session Exam : 25 (20+5#)
Contact hours: 28+28 Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To impart advanced practical knowledge of causal factors governing the distributionand abundance of insects and the evolution of ecological characteristics. Studyinsect-plant interactions; get acquainted with biodiversity and conservation.

Theory

Units	Content	Lectures
I	Characterization 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 andNicholson-Bailey Model. Crop Modeling- an introduction.	7
II	Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of typesof associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of insect diversity and role of phytophagy as an adaptive zonefor 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. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. Host seeking behavior of parasitoids.	9
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.	6
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.	6

Practical

1	Methods of data collection under field conditions;	1
2	Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index,Index of Dispersion, etc.;	2
3	Calculation of sample sizes by different methods;	1
4	Fitting Poisson and Negative Binomial distributions and working out the datatransformation methods;	2
5	Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies –	2

	Calculation of changes under selection, Demonstration of genetic drift;	
6	Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/ *Goniozus*/ Female Bruchids, etc.;	2
7	A test of reproductive effort and fitness;	1
8	Construction of Life tables and application of Leslie Matrix – population projections,Stable age distribution;	2
9	Exercises in development of Algorithms for crop modeling;	1

Learning outcome

- The scholar is expected to develop expertise in methods of data collection for insectpopulation studies, data transformation for analyses, diversity estimates, assessing distribution parameters, study the impact of abiotic and biotic factors on the distribution and abundance of insects.
- Should gain significant knowledge on construction of life tables and their analyses, assessment of resource size by female insects, reproductive effort and fitness.

Suggested Reading

Barbosa P and Letourneau DK. (Eds.). 1988. *Novel Aspects of Insect-Plant Interactions*. Wiley, London.

Elizabeth BA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects.* Chapman and Hall, New York.

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

Gotelli NJ and 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 and Brown JH. (Eds.). 1991. *Foundations of Ecology: Classic Papers with Commentaries.* University of Chicago Press, USA.

Southwood TRE and Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Wiley Blackwell, London. Strong DR, Lawton JH and Southwood R. 1984. *Insects on Plants: Community Patterns and Mechanism*. Harward University Press, Harward.

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

ENT 604
Insect Behaviour

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

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

Theory

Units	Content	Lectures
I	Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behavior, inducted behavior, learnt behavior and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behavior- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behavior and behavioural polymorphism.	4
II	Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.	3
III	Reproductive behavior- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behavior- kin selection, parental manipulation and mutualism; Self organization and insect behavior.	3
IV	Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behavior, pollination behavior, 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.	4

Practical

1	Quantitative methods in sampling behavior;	2
2	Training bees to artificial feeders;	2
3	Sensory adaptation and habituation in a fly or butterfly model, physical cues usedin host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honeybee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees;	4
4	Evaluation of different types of traps against fruit flies with respect to signals;	2
5	Use of honey bees/ *Helicoverpa armigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.	4

Learning outcome

- Scholars are expected to be well versed with the behavior and orientation of insects towards exploitation as a tool in IPM.

Suggested Reading

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. OXford and IBH, New Delhi.

Awasthi VB. 2001. *Principles of Insect Behaviour*. Scientific Publ., Jodhpur.

Bernays EA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman and Hall, London.

Brown LB. 1999. *The Experimental Analysis of Insect Behaviour*. Springer, Berlin.

Krebs JR and Davies NB. 1993. *An Introduction to Behavioural Ecology*. 3rd Ed. Chapman and Hall, London.

Manning A and Dawkins MS. 1992. *An Introduction to Animal Behaviour*. Cambridge University Press, USA.

Mathews RW and Mathews JR. 1978. *Insect Behaviour*. A Wiley-InterScience Publ. John Wiley and Sons, New York.

ENT 605

Bio-inputs for Pest Management

Credits: 2 + 1 Mid-Session Exam : 25 (20+5#)
Contact hours: 28+28 Practical Exam : 35
End-Semester Exam: 40

Aim of the course

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

Theory

Units	Content	Lectures
I	Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents *vis-à-vis* target pest populations.	3
II	Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio- agents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.	3
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 bio-control agents, bankable project preparation.	4
IV	Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in bio-control agents for introgressing and for progeny selections, breeding techniques of bio-control agents.	4

Practical

1	Mass rearing and release of some commonly occurring indigenous natural enemies;	2
2	Assessment of role of natural enemies in reducing pest populations;	2
3	Testing side effects of pesticides on natural enemies;	2
4	Effect of semio-chemicals on natural enemies, breeding of various bio-control agents,performance of efficiency analyses on target pests;	3
5	Project document preparation for establishing a viable mass-production unit/insectary;	3
6	Observation of feeding behavior acts of predatory bugs/ beetles.	2

Learning outcome

- Scholars are expected to learn the mass multiplication techniques of the more common and economically feasible natural enemies to be exploited under IPM programmes.
- They should be able to guide entrepreneurs for establishing a viable mass- production unit/ insectary.

Suggested Reading

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

Coppel HC and James WM. 1977. *Biological Insect Pest Suppression.* Springer Verlag, Berlin. De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman and Hall, London. Dhaliwal, GS and Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publishers, New Delhi.

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

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

ENT 606

Insecticide Toxicology and Residues

Credits: 2 + 1 Mid-Session Exam : 25 (20+5#)
Contact hours: 28+28 Practical Exam : 35
End-Semester Exam: 40

Aim of the course

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

Units	Content	Lectures
I	Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.	6
II	Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.	6
III	Joint action of insecticides; activation, synergism and potentiation.	4
IV	Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.	6
V	Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility; insecticide laws and standards, and good agricultural practices.	6

Practical

1	Mass rearing and release of some commonly occurring indigenous natural enemies;	4
2	Assessment of role of natural enemies in reducing pest populations;	3
3	Testing side effects of pesticides on natural enemies;	3
4	Effect of semio-chemicals on natural enemies, breeding of various bio-control agents, performance of efficiency analyses on target pests;	4

Learning outcome

- Scholars are expected to be well versed with the latest technologies of bioassays, insecticide/ pesticide residue analysis and solving problems associated with insectresistance to insecticides.

Suggested Reading

Busvine JR. 1971. *A Critical Review on the Techniques for Testing Insecticides.* CABI, London. Dhaliwal GS and Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publishers, New Delhi.

Hayes WJ and Laws ER. 1991. *Handbook of Pesticide Toxicology.* Academic Press, New York.

Ishaaya I and 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 and Perry R. 1998. *Insecticides in Agriculture and Environment.* Narosa Publ. House, New Delhi.
Prakash A and Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publ., New York.

ENT 607
Plant Resistance to Insects

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

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

Units	Content	Lectures
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.	3
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.	4
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.	3
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.	4

Practical

1	Understanding mechanisms of resistance for orientation, feeding, oviposition, etc., allelochemical bases of insect resistance;	4
2	Macroculturing of test insects like aphids, leaf/ plant hoppers, mites and stored grain pests;	3
3	Field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries;	3
4	Determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.	4

Learning outcome

- Scholars are expected to identify sources of resistance in different crops and varieties; their utilization in resistance breeding programmes involving screening techniques for specific pests.

Suggested Reading

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

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

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

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

ENT 608
Acarology

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

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

Units	Content	Lectures
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.	5
II	Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.	3
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.	3
IV	Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi- identification, isolation and utilization.	3

Practical

1	Identification of commonly occurring mites up to species, preparation of keys for identification;	4
2	Collection of specific groups of mites and preparing their identification keys;	3
3	Rearing phytoseiid mites and studying their role in suppression of spider mites;	3
4	Management of mite pests of crops using acaricides, phytoseiid predators, fungal pathogens, etc.	4

Learning outcome

- Scholars should be able to identify major mite pests, their management and predatory mites that can be used in biological control.
- They are also expected to learn the rearing techniques of predatory Phytoseiid mites.

Suggested Reading

Evans GO.1992. *Principles of Acarology.* CABI, London.
Gerson H and Smiley RL. 1990. *Acarine Bio-control Agents- An Illustrated Key and Manual*. Chapman and 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 609
Molecular Entomology

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

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

Theory

Units	Content	Lectures
I	Introduction to molecular biology; techniques used in molecular biology.	2
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.	3
III	Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Transgenic plants for pest resistance and diseases.	3
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.	3
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.	3

Practical

1	Isolation of DNA/ RNA;	2
2	Purity determinations, purification of total DNA from animal tissues;	2
3	Base pair estimation;	2
4	Agarose gel electrophoresis;	2
5	Quantitative enzyme profile of alimentary canal;	2
6	Restriction mapping of DNA;	2
7	Demonstration of PCR, RFLP and RAPD techniques.	2

Learning outcome

The scholars are expected to have mastered the molecular techniques applicable in entomological research like isolation of insect DNA, purification, DNA barcoding and utilizing these techniques in molecular systematics and biological control aspects.

Suggested Reading

Bhattacharya TK, Kumar P and Sharma A. 2007. Animal Biotechnology. 1st Ed., Kalyani Publication, New Delhi.

Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. Molecular Insect Science. Plenum Press, New York.

Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
Oakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer Verlag.
Rechcigl JE and Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.
Roy U and Saxena V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publishers, New Delhi.
Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publishers, New Delhi. Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publishers, New Delhi.

ENT 610
Integrated Pest Management

Credits: 2 + 0 Mid-session exam: 40 (30+10#)
Contact hours: 28+0 End-semester exam: 60

Aim of the course

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

Theory

Units	Content	Lectures
I	Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modeling.	5
II	Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.	7
III	Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management-case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.	9
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.	7

Learning outcome

Having gained sufficient experience in advanced studies of IPM the scholars should be able to independently frame IPM schedules for major crops/ cropping ecosystems (cereal/ pulse crop/ oilseed crop based/ vegetable crop based agro-ecosystems).

Suggested Reading

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