

(20hrs)

Unit 2 Anatomy

- 2.1. Integument : Histology of the basic components, Chemical composition of cuticle, sclerotization, physical properties of cuticle, coloration, permeability, characteristics, molting and external integumentary processes.
- 2.2. Head- General morphology of head (Opisthognathus, Prognathus, Hypognathus). Head segmentation, Head skeleton, Tentorium, Modifications in head capsule, Mouth parts, modifications based on feeding mechanisms. Antennae- Structure, functions and types.
- 2.3. Thorax- Segmentation- Structure and modifications.
- 2.4. Abdomen- Segmentation- Structure and characteristics.
- 2.5. Wings- Origin and evolution of wings, venation- structure, wing modifications.
- 2.6. Appendages- Segmentation- structure- Adaptive radiation of legs.

(20hrs)

Unit 3. Embryogenesis

- 3.1. Types of eggs, Formation of blastoderm and germ layers, formation of germ band and extra embryonic membranes.
- 3.2. Differentiation of germ layers.
- 3.3. Segmentation, Appendage formation and blastokinesis, organogenesis, polyembryony, control of embryogenesis, Oviparity, Viviparity, Oviposition, eclosion, post embryonic morphogenesis.
- 3.4. Growth, metamorphosis, endocrine mechanism in metamorphosis.

(15hrs)

Unit 4. Insect Classification

- 4.1. Biology and habits of the different orders of the insects- classification upto families.
- 4.2. Biology and habits gall forming and leaf mining insects.
- 4.3. Aquatic insects- Aquatic adaptations including respiratory adaptations.
- 4.4. Adaptation of parasitic and predatory insects.
- 4.5. Seasonal adaptations- Dormancy- Diapause.

Unit 5. Insect Physiology

(30hrs)

- 5.1. Insect nutrition: Anatomy and histology of foregut, mid and hind gut, Modification of gizzard (filter chamber) processes of secretion of enzymes, microbiota, and digestion of wood, keratin, wax and silk.
- 5.2. Respiratory system: Trachea, Tracheoles, Air sacs, spiracles. Types of ventilation process- passive ventilation bulk flow and active ventilation. Passive suction ventilation and elimination of CO₂. Ventilation in aquatic insects and endoparasitic insects during molting. Central nervous control of ventilation.
- 5.3. Circulatory system: the dorsal vessel and accessory pumping sinuses. Cardiac regulation and circulation- general characteristics and chemical composition of hemolymph, hemocytes, origin number and function. Other tissue associated with circulatory system.
- 5.4. Excretory system: Malpighian tubules- anatomy and histology. Orthopteran, Hemipteran, Coleopteran and Lepidopteran types. Salt and water balance, control of diuresis and gut mobility, nitrogenous excretion, insect urine.
- 5.5. Nervous system, Glandular and Muscular systems. Structure and function of nervous system, nervous integration.

- Exocrine and endocrine glands and their functions.
Skeletal muscle, visceral muscle, muscle development and maintenance.
- 5.6. Sense organs: Morphology of sense organs, sensory mechanisms, light and sound production.
 - 5.6.1 Mechanoreception- the tactile sense, proprioceptive sense, sound perception.
 - 5.6.2 Chemoreception- sensory coding phagostimulants and phagodeterrents.
 - 5.6.3 Thermoreceptors- Hygroreceptors.
 - 5.6.4. Photoreception- Compound eyes, dorsal ocelli etc.
 - 5.6.5 Light production and sound production- different types of sound producing organs.
 - 5.7. Reproduction and morphogenesis.
 - 5.7.1 Reproductive system and gametogenesis in male and female
 - 5.7.2 Fertilization, Sex determination, parthenogenesis.
 - 5.7.3 Different types of insect larvae and pupae.

Unit 6. Insect communication

(10hrs)

- 6.1. Acoustic, visual, tactile and chemical methods.
- 6.2. Role of hormone in communication.
 - 6.2.1 Pheromones
 - 6.2.2 Kairomones
 - 6.2.3 Allomones
- 6.3. Social organization, communication and behavior with reference to Termites, Ants and Honey bees.
- 6.4. Insect Immunity

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10. Insect hormones, V.J.A. Novak.
11. Modern Entomology, DB Tembhare.
12. Pheromones, M.C. Birch.
13. Biology of insect midgut, MJ Lehane.
14. Recent advances in insect physiology and toxicology, GT Gujar.
15. General & Applied Entomology, KK Nayar et al.
16. Ananthakrishnan TN (1998). Dimensions of insect plant interactions. Oxford and IBH Pub. Co. Pvt. Ltd. N.Delhi.

17. Pant, NC. And Ghai (Ed) 1981. Insect physiology and anatomy. Indian Council of Agricultural Research, New Delhi.

ZO 242 Applied Insect Science

(100hrs)

Unit 1 Introduction Insect Pests

(5hrs)

- 1.1 Kinds of insect pests. Major pests, minor pests, sporadic pests, endemic pests, exotic pests, seasonal pests, occasional pests, regular pests, persistent pests.

Unit 2 Causes of Pest Outbreak

(8hrs)

- 2.1 Deforestation, Destruction of natural enemies pest resurgence.
2.2 Secondary pest outbreak, Intensive and extensive cultivation, Introduction of new crops, new varieties, hybrid varieties, cultural practices, change in agricultural practices- introduction of new pests.
2.3 Forecasting pest outbreaks and surveillance, short term and long term forecasting- Forecasting based on observations- Climatic and empirical factors.

Unit 3 Biology of pests and control

(20hrs)

- 3.1 Biology, nature of damage and control of major pests of major crops: Paddy, coconut, cotton, mango, vegetables, pulses, coffee, tea, sugarcane, banana, cashew, pepper, turmeric, ginger, cardamom, and stored products.
3.2 Insect pest of domestic animals, biology and control.
3.3 Biology of major arthropod vectors of human diseases belonging to diptera, anoplura, siphonoptera, - control of vectors.
3.4 House hold pest insects - biology and control

Unit 4 Industrial Entomology

(12hrs)

- 4.1 Silkworm technology – Sericulture
4.2 Honeybee- Apiculture
4.3 Lac-Insect-Lac culture
4.4 Insects as human food and as scavengers

Unit 5 Principles and Insect Control

(20hrs)

- 5.1 Basic principles of insect control, prophylactic methods, cultural methods, mechanical methods, physical methods and legal methods.
5.2 Biological control- Brief history, theory behind classical biological control. Agents of Biological control- Parasite and parasitoids, predators and pathogenic microorganisms (bacteria, fungi and virus).
5.3 The practice of biological control- phases conservation, importation and colonization- mass culture and release of natural enemies.
5.4 Important biological control products undertaken in India against insect pest.
5.5 Economic dimensions of biological control- merits and demerits.
5.6 Significance and relevance of biological control in the present regime.

Unit 6 Insect Toxicology

(15hrs)

- 6.1 Chemical control- Insecticide formulations, inorganic and organic pesticides, Classification of insecticides- based on mode of entry, mode of action.
- 6.2 Synthetic organic insecticides. Organochlorine compounds (DDT, BHC, Endosulfan-heptachlor, dieldrin).
- 6.3 Organophosphorous insecticides- monochrotophos, tetra ethyl pyrophosphate, parathion.
- 6.4 Carbamates- Carbaryl, carbofuran
- 6.5 Botanical insecticides- chemical properties, mode of action and toxicity. (nicotine, rotenone, pyrethrum and neem, insect growth regulators).
- 6.6 Synthetic pyrethroids- definition, uses as insecticides, mode of action (pyrethrin, allethrin).
- 6.7 Fumigation and fumigants
- 6.8 Insecticide residues
- 6.9 Pesticide appliances

Unit 7 Pest Management

(15hrs)

- 7.1 Concepts of pest management, definition, characteristics of pest management, pest management strategies and techniques.
- 7.2 Integrated pest management (IPM)- definition, IPM in agro ecosystem, preventive practices, Therapeutic practices, selection of tactics
- 7.3 Principles of behavioural control- pheromonal considerations- communication pheromones, sex pheromones, aggregation, pheromones, orientation theories, use of other chemicals- repellants- plants allomones- Antifeedants, integration of behaviours modification with other tactics.
- 7.4 Autocidal control- (Chemosterilants, sterile male technique and other genetic tactics)
- 7.5 Pest management tactics
 - 7.5.1 Ecological management of crop environment
 - 7.5.2 Reducing average favourability of ecosystem
 - 7.5.3 Disrupting continuity of pest requisites
 - 7.5.4 Diverting pest population away from crop
 - 7.5.5 Reducing the impact of insect injury
- 7.6 Ecological back lash and its management- resistance of population of pest management-tactics, pest population resurgences and replacement- enhanced microbial degradation, upset in community balance.

Unit 8. Insecticide Resistance

(5hrs)

- 8.1 Genetic, phisysiological and biochemical mechanisms.
- 8.2 Insecticide metabolism- microsomal and extra microsomal
- 8.3 Dynamics of environmental pollution by insecticides, its impact in biosphere.

8.4 Pest residues, insecticide poisoning, biological magnification, health hazards, silent spring (Racheal Carson).

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Semester IV

Special Subject : Insect Science

Practical I

Zoo 243 (Taxonomy, Anatomy, Histology and Physiology)

Taxonomy

1. Identification and preparation of taxonomic key of 10 insects belonging to 10 families and 4 orders
2. Collection, preservation and presentation of insects belonging to 30 families.
3. Mounting, sketching and labeling of taxonomic features of the following.
 - a) Wings in insect of 5 orders.
 - b) Antennae in insects of 5 orders.
 - c) Mouth parts in insects- 4 types
 - d) Leg-4 types.
 - e) Whole mount of 5 insects/ life stages of taxonomic importance.

Anatomy and Histology

1. Dissection
 - 1.1 Alimentary canal and associated glands of 4 groups of insects with different feeding habits.
 - 1.2 Reproductive system of any 2 female insects.
 - 1.3 Nervous system in any two groups.
 - 1.4 Stomatogastric nervous system (Oesophageal, sympathetic, single recurrent nerve and paired recurrent nervous).
 - 1.5 Endocrine system
 - 1.6 Identification of sensilla employing a suitable technique.

2. Histology

- 2.1 Preparation of paraffin sections of insect midgut epithelium and ovary using Haematoxylin-eosin staining technique to demonstrate histological details.
- 2.2 Whole mount staining preparation of insect brain to demonstrate neurosecretory cells by PAVB technique.

3. Physiology

1. Quantification of proteins in fat/haemolymph
2. Quantification of glycogen in fat body.
3. Estimation of any one transaminase in insect fat body/ haemolymph.
4. Identification of atleast two free amino acids in haemolymph by paper chromatography.

5. Quantitative estimation of any two digestive enzymes (protease, amylase/ invertase).
6. Haemolymph protein profile employing PAGE (Demonstration).
7. Identification of haemocytes using Giemsa/Wright's/ BPS stain.

NOTE: Candidates shall submit a collection consisting of 30 families of insect from different orders (It shall include dry collection, wet collection and slides including life stages). The collection shall be submitted at the time of practical examination along with practical record.

Practical II

Zo244 (Ecology, Economic Entomology and Experimental Entomology)

Ecology

1. Methods of collection and identification of soil insects (any 10 numbers)
2. Field work: A field study shall be conducted to observe the insects in their natural habitat. A detailed field report shall be submitted by each student which includes observation of insects in area such as forests, grass land, aquatic insects, sandy areas etc. the field report duly certified shall be submitted at the time of practical exam along with practical record.
3. Estimation of LC50 value and LD50 value of any two brands of insecticides for some aquatic/terrestrial organisms.

Economic Entomology

1. Collection, preservation, identification and presentation of following categories of pests.
 - 1.1. Agricultural pests of different crops 10 numbers.
 - 1.2. Stored- product pests- 3 numbers.
 - 1.3. Vectors and veterinary pests-4 numbers.
 - 1.4. House-hold pests- 5 numbers.
 - 1.5. Beneficial insects – 6 numbers.
2. Collected and identified insect specimens and pests of crops shall be submitted at the time of practical examination. Candidates shall submit a minimum of 15 wet collections.
3. Field study to collect/observe insect species of pollinators, parasitoids, predators, scavengers and weed killers.
4. Field study of various methods of pest management.
 - Pesticide formulation.
 - Pesticide application.
 - Safety, hazards and first aid.

Experimental Entomology

1. Malpighian tubule activity using suitable dyes.
2. Rearing of any two insects in the laboratory.

3. Identification of larval instars using Dyar's rule.
4. Sexing of insects- larva pupa and adult.
5. Effect of starvation on glycogen/ protein on insect fat body/haemolymph.
6. Effect of starvation on transaminase activity in insects.

NOTE: Candidates shall submit a minimum of 15 numbers of different categories of pests at the time of practical examination along with the practical record. A duly certified field report also shall be submitted at the time of practical examination.

Semester IV

Special Subject: Environmental Physiology

Zo241 : Pollution Biology & Environmental Physiology (100hrs)

Unit 1 Introduction (12hrs)

- 1.1 Environmental pollution – Concepts and definitions
- 1.2 Environmental pollutants
 - 1.2.1 Organic pollutants
 - 1.2.2 Heavy metals, industrial effluents
 - 1.2.3 Pesticides
 - 1.2.4 Radioactive pollutants
 - 1.2.5 Oil, food additives and contaminants

Unit 2 Air Pollution (15hrs)

- 2.1 Chief air pollutants, occurrence, sources and effects
- 2.2 Interaction of air pollutants in the atmosphere – Photochemical reactions- Formation and effects of secondary pollutants and photochemical smog.
- 2.3 Effects of air pollutants on materials, building metals, vegetation and human health; a brief survey of air pollution episodes.
- 2.4 Air pollution abatement technologies- Design and working of bag filters, electrostatic.

Unit 3. Noise pollution (5hrs)

- 3.1 Sources
- 3.2 Effect of noise pollution on materials, animals and humans.
- 3.3 Sonic boom
- 3.4 Abatement strategies

(6hrs)

Unit 4 Water pollution

4.1 Organic pollution

- 4.1.1. Organic and sources of organic pollutants- Biodegradable and non-biodegradable; Domestic, agricultural and industrial sources.
- 4.1.2. Biochemical Oxygen Demand (BOD)
- 4.1.3. Chemical Oxygen Demand (COD)- Importance and method of estimation.
- 4.1.4. Effects of organic pollution on aquatic systems
- 4.1.5. Eutrophication- Sources and effects
- 4.1.6. Biocides, fungicides and herbicides- Sources and effects
- 4.1.7. Biomagnification: Toxic effects on non-target organisms and hazards to man.

4.2. Industrial pollution

- 4.2.1. Heavy metals- Effects of various heavy metals (such as Hg, Pb, Cd, As Cr).
- 4.2.2. Fluoride pollution on human life
- 4.2.3. Thermal pollution – sources, effects and control.
- 4.2.4. Oil spills- sources, effects and control.

4.3. Water pollution abatement technology

(10hrs)

- 4.3.1. Primary, secondary and tertiary treatment systems
- 4.3.2. Design and operations of screens, grit chambers, sedimentation tanks and oxidation ponds.
- 4.3.2. Design and operations of biological treatment systems like aerated lagoons, activated sludge process, trickling filters and sludge digestion.

Unit 5. Radioactive Pollution

(10hrs)

- 5.1. Sources of nuclear radiation.
- 5.2. Biological effects of ionizing radiations and non-ionizing radiations.
- 5.3. Nuclear waste disposal

Unit 6. Terrestrial pollution

(12hrs)

- 6.1 Solid wastes and disposal (garbage, ashes, rubbish, street litter, agricultural waste, mining wastes and industrial wastes.)
- 6.2 Strategies of control of solid waste pollution.

Unit 7 Environmental Physiology

(30hrs)

7.1 Temperature adaptation

- 7.1.1. Morphological and physiological adaptations: Relation between body size and metabolic rate. Temperature and metabolic rate: Thermal acclimation; Enzymatic acclimation;
- 7.1.2. Temperature classification of animals – Homoiotherms and Poikilotherms.

- 7.1.3. Thermal migration.
- 7.1.4. Implications of global warming on animals.

7.2 Pressure adaptations

- 7.2.1. Adaptations to hyperbaric stress with particular reference to deep sea organisms.
- 7.2.2. Biochemical mechanisms of animals to high altitudes (hypoxia and hypoxia).

7.3. Osmoregulation and ionic regulation

- 7.3.1. Osmoregulation in fresh water, marine, estuarine and terrestrial animals.
- 7.3.2. Sodium pump Na^+ and H^+ -ATPase in relation to salinity adaptations.

7.4. Eco-physiological adaptations.

- 7.4.1. Mimicry and coloration
- 7.4.2. Echolocation
- 7.4.3. Bio-luminescence
- 7.4.4. Electric organs

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ZO 242 Environmental Management

(100hrs)

Unit 1 Resources of Earth

(15hrs)

- 1.1 Renewable and non-renewable resources
 - 1.1.1. Forests, wild life, endangered species fisheries.
 - 1.1.2. Fossil fuels, minerals- their over exploitation for domestic, agricultural and industrial purposes.
 - 1.1.3. Water resources- protection of water shed reclamation of sewage and waste and water amangement in India.
- 1.2 Conservation of natural resources
- 1.3 Remote sensing of resource management.

Unit 2 Human exploitation of earth's resources

(15hrs)

- 2.1 Human interferences in ecosystems- consequences of over-exploitation

- 2.2. Brief account of weather modifications, desalination, artificial rain making, acid rain, green house effects and its consequences and destruction of ozone umbrella.

Unit 3. Biological conservation and management (20hrs)

- 3.1 Principles of conservation
- 3.2 Conservation and economic use of energy and energy audit.
- 3.3 Ecological problems due to intensive aquaculture- importance of trawling ban
- 3.4 Conservation of wild life- present status and strategies of conservation.
- 3.5 Deforestation and its consequences- need for scientific management and conservation of forests.
- 3.6 Biodiversity in India- Biodiversity conservation – *in situ* and *ex-situ* methods.
- 3.7 Biodiversity registering and patenting of biodiversity.

Unit 4. Environmental policy and Education (15hrs)

- 4.1 Environmental policy- social, economic and legal aspects.
- 4.2 Environmental laws and their enforcement.
- 4.3 Environmental awareness- role of Government, media and voluntary organizations.

Unit 5. Environmental Impact Assessment and Sustainable Development (15hrs)

- 5.1 Environmental Impact Assessment (EIA)
 - 5.1.1. Definition, aim, principles and concepts of EIA.
 - 5.1.2. Elements of environmental impacts.
 - 5.1.3. Methods for preparing EIA- Check list method, Werner- Prestroit study.
 - 5.1.4. EIA Process making inventories, sampling and data processing, impact prediction and stimulation.
- 5.2 Sustainable Development
 - 5.2.1. Concepts and dimensions.
 - 5.2.2. Basic needs
 - 5.2.3. Unavoidable impacts and imperatives relating to sustainable development.
 - 5.2.4. Alternative strategies.

Unit 6. Environmental Biotechnology (20hrs)

- 6.1 Pollution abatement using microbes.
 - 6.1.1. Sewage treatment.
 - 6.1.2. Solid waste disposal.
- 6.2 Soil enrichment by using microbes.
- 6.3 Genetic engineering of nitrogenous gene ('*nif*' genes) and nodulation genes.
- 6.4 Microbial insecticides
 - 6.4.1. Insecticidal toxin of *Bacillus thuringiensis* and genes and nodulation genes.

6.4.2. Baculoviruses as biocontrol agents and their genetic engineering for improved biocontrol.

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Semester IV

Special Subject: Environmental Biology

Practical 1. Zo 243 Pollution Biology & Environmental Physiology

(10 practicals to be carried out)

1. Analysis of soil texture using micrometry.
2. Determination of moisture content of soil.
3. Determination of soil pH (different soil samples)
4. Determination of organic carbon.
5. Determination of porosity/water retaining capacity of soil.
6. Determination of chlorine in water.
7. Determination of H₂S in water.
8. Determination of Ammonia in water.
9. Short term bioassays and determination of LC50 of fish exposed to a given pollutant.
10. Effect of soil pollution on the population on earth works.
11. Study of indicator organisms.
12. Effect of population on the oxygen consumption of fishes.
13. Temperature/pH preferences of fishes.
14. Field work- Students are expected to make a field study on the problem of environmental pollution in their area.

Note: the students should submit the field study report at the time of examination.

Practical II Zo 244 Environmental Management

(10 practicals to be carried out)

1. Determination of pH of water.
2. Determination of electrical conductivity of water.
3. Determination of turbidity of water.

4. Determination of salinity of water.
5. Determination of hardness of water.
6. Determination of BOD and COD of polluted water.
7. Estimation of BOD and COD of polluted water.
8. Instrumentation: Principles, use and working of the following instruments.
 - 8.1 pH meter
 - 8.2 Electrical conductivity meter.
 - 8.3 Flame photometer
 - 8.4 Hygroscopic soil thermometer
9. Estimation of primary productivity (chlorophyll method).
10. Estimation of secondary productivity
11. Construction of pyramids of numbers and biomass from a pond collection.
12. Species diversity estimation with reference to a fresh water pond/soil.