



UNIVERSITY OF CALICUT

**Abstract**

Faculty of Science- M.Phil. in Zoology- Syllabus revised w.e.f from 2017 admission onwards - implemented- Approved- Orders issued.

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**G & A - IV - J**

U.O.No. 10445/2017/Admn

Dated, Calicut University.P.O, 21.08.2017

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- Read:-*1. Minutes of the Board of Studies in Zoology P.G held on 05.07.2017 item No.2.  
2. Minutes of the Faculty of Science held on 10.07.2017 item No.9 (b).  
3. Extract of the item No.II.H of the minutes of the meeting of the LXXVI meeting of the Academic Council held on 17.07.2017.  
4. Orders of the Vice Chancellor in the file of 191466/GA IV/J1/2013/CU dated 27.07.2017

**ORDER**

Vide paper read first above, the Board of Studies in Zoology P.G has resolved to approve the revised syllabi of M.Phil in Zoology.

Vide paper read second above, the Faculty of Science has resolved to approve the Minutes of the Board of Studies in Zoology P.G held on 05.07.2017.

Vide paper read third above, the LXXVI meeting of the Academic Council has approved the minutes of the Faculty of Science held on 10-07-2017 and the minutes of the meetings of various Boards of Studies coming under the Faculty.

Vide paper read fourth above, the Vice Chancellor has accorded sanction to implement the resolutions of the Academic Council.

Accordingly orders are issued to implement the revised M.Phil in Zoology with effect from 2017 admission onwards.

The revised syllabi of M.Phil in Zoology is attached.

Ajitha P.P

Joint Registrar

To

HoD Department of Zoology, Director DoR, Controller of Examinations, EX Branch.

Forwarded / By Order

Section Officer



**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**  
**M.Phil (Zoology). Syllabus**

**Paper I-RESEARCH METHODOLOGY**

**Unit – 1. Research**

- 1.1 Meaning, objectives, types and significance
- 1.2 Identifying gap areas by literature review
- 1.3 Selection of problem, defining the problem
- 1.4 Ethics in Research

**Unit – 2. Research design**

- 2.1 Principles of experimentation
- 2.2 Formulation of research problem
- 2.3 Design of experiments and testing of hypothesis

**Unit – 3. Data collection and analysis**

- 3.1 Sources of data – primary, secondary and tertiary
- 3.2 Methods of data collection- sampling methods, sample size, sample error
- 3.3 Data processing and analysis
- 3.4 Statistical analysis: Softwares – SPSS, R- program.

**Unit – 4. Scientific documentation**

- 4.1 Types of report – technical reports and thesis
- 4.2 Literature collection and documentation
- 4.3 Layout – introduction, review of literature, methods, results, discussion, conclusion, references.
- 4.4 Oral presentation – planning, presentation, technical considerations, power point presentation

**Unit – 5. Intellectual property and ethical issues**

- 5.1 Intellectual property right and patent law, copy right, royalty
- 5.2 Reproduction of published documents: pattern of citation, style manual for citation, citation index, impact factor, acknowledgement
- 5.3 Plagiarism- softwares for checking plagiarism
- 5.4 Ethical issues: ethical committee in animal experiment and clinical trials

## Unit – 6. Computer applications

6.1 Using excel for data entry and analysis-data entry, analysis, graphical representation

6.2 Reference Management Tools -End note, Zotero.

### References:

1. Daniel, W. W., 2006. Biostatistics: A foundation for analysis in the Health Sciences (7<sup>th</sup> edition). John Wiley & Sons, New York.
2. Duncary, P., 2003. Authorizing a Ph.D thesis: How to plan, draft, write and finish a doctoral dissertation. Palgrave Macmillan.
3. Garg, B. L. Karadla, R., Agarwal, F and Agarwal, G. K., 2002. An introduction to Research methodology, RBSA publishers.
4. Kothari, C. R., 2014. Research methodology: Methods and techniques, Third edition. New age International.418P.
5. Leedy, P. D and Ormrod, J. E., 2004 Practical Research: Planning and Design, Prentice Hall.
6. Online:  
[https://www.pfizer.com/.../research/research\\_clinical\\_trials/ethics\\_committee\\_guide.pdf](https://www.pfizer.com/.../research/research_clinical_trials/ethics_committee_guide.pdf))
7. Reviewing Clinical Trials: A Guide for the Ethics Committee - Pfizer
8. Satarkar, S.V., 2000. Intellectual property rights and copy right.ESS ESS publications.
9. Sinha, S. C and Dhiman, A. K., 2002. Research Methodology,ESS ESS publications, 2 volumes.
10. The Excel® Analyst's Guide to Access® (2010) by Michael Alexander Publisher: John Wiley & Sons ISBN: 9780470567012
11. Trochim, W. M. K 2006. Research methods: the concise knowledge base, Atomic Dog publishing, 270P.
12. Wadehra, B. I. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. University law publishing.
13. Zar Jerrold, H. 2008. Bio-statistical Analysis. Third edition. Pearson education Inc., New Delhi.
14. Ranjit Kumar, 2011. Research Methodology a step-by-step guide for beginners, SAGE Publications Ltd. 1 Oliver's Yard 55, City Road London. EC1Y 1SP
15. Prabhat Pandey., Meenu Mishra Pandey, 2015. Research methodology: tools and techniques. Bridge center Romania, European Union.

**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**  
**M.Phil (Zoology). Paper II-Syllabus**

**RECENT ADVANCES IN BIOLOGY**

1. Systematics: Chemotaxonomy, Serotaxonomy, Molecular systematics- techniques, advantages and limitations.
2. Cell culture and Tissue culture: Techniques and applications.
3. Stem Cells – properties, culture and applications.
4. Applications of Molecular biology in Diagnosis and treatment of diseases: Diagnostic tools, DNA vaccines, Personalized medicine, Gene therapy , Genome editing- CRISPR/Cas System
5. Proteomics and Genomics: Techniques and applications
6. Animal cloning: Techniques and applications
7. Genetically modified organisms: techniques, applications and challenges.
8. Bioinformatics: Data bases, data base search and applications
9. Ecology: Environmental Impact assessment (EIA), Restoration ecology.
10. Biodiversity: Measurements of biodiversity- Simpson, Shannon-Weiner index.
11. Environmental Biology: Advanced waste management strategies- Biofilters, Upflow anaerobic sludge blanket (UASB), Use of microbes for pollution abatement, Waste to Energy.
12. Bioinstrumentation: Principle, brief method of working and applications:
  - Electron Microscopy (SEM, SEM-EDAX, TEM, STEM)
  - Atomic Force Microscopy (AFM)
  - Confocal Microscopy
  - Micrometry-Software
  - Flow cytometry
  - FPLC
  - MS- MALDI-TOF
  - LC-MS
  - MS/MS
  - NMR

## REFERENCES:

1. Roland W. Herzog, Sergei Zolotukhin. 2010. A Guide to Human Gene Therapy.
2. Colin Ratlidge and Bjorn Kristiansen, 2001. Basic biotechnology. Second edition. The Press syndicate of the University of Cambridge.
3. Jonathen, 2009. Pevsner Bioinformatics and functional genomics. Second edition. A JOHN WILEY & SONS, INC., Publication.
4. David Edwards, Jason Stajich, David Hansen, 2009. Bioinformatics: Tools and Applications. Springer.
5. Ian Freshney, R. 2010. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition. John Wiley & Sons, Inc.
6. Eugene P Odum, and Gary W. Barrett, 2004. Fundamentals of Ecology: 5<sup>th</sup> Edition Thomson Brooks/Cole.
7. Lillian E. Forman,( 2010) Genetically Modified Foods. An imprint of ABDO Publishing Company.
8. Ronald Ross Watson and Victor R. Preedy. 2013. Genetically Modified Organisms in Food Production Safety, Regulation and Public Health ISBN: 978-0-12-802259-7 Humana Press.
9. Pedro R. Cutillas, John F. Timms, 2010. LC-MS/MS in Proteomics: Methods and Applications.
10. Jürgen H Gross. 2017. Mass Spectrometry: A Textbook 3<sup>rd</sup> Edition Springer International Publishing.
11. Timothy M. Cox and John Sinclair. 1997. Molecular Biology in Medicine. 1<sup>st</sup> Edition. ISBN-13: 978-0632027859, ISBN-10: 0632027851.
12. David M. Hills., Craig Moritz and Barbara K. Mable. 1996 Molecular systematics. Sinauer Associates Inc. Publishers, Sunderland, Massachusetts USA.
13. Hewitt, Godfrey M., Johnston, Andrew W.B and Young, J. Peter W. (Eds.) 1991 Molecular Techniques in Taxonomy: Editors: Springer.
14. Carbajo, Rodrigo J, Neira, Jose L. 2013. NMR for Chemists and Biologists Springer.
15. Ian Wilmut, Rudolf Jaenisch, John Gurdon, Robert Lanza, Michael West, Keith Campbell and Jose Cibelli. 2013. Principles of Cloning (Second Edition) eBook ISBN: 9780123865427, Imprint: Academic Press
16. Paul Cutler, 2004. Protein Purification Protocols. Springer Science & Business Media.
17. Satish Totey, and Kaushik D. Deb, 2010. Stem Cell Technologies: Basics and Applications. McGraw-Hill Education. ISBN: 9780071635721
18. Muhammad Jamal, Huazhong, The CRISPR/Cas System: Emerging Technology and Application | Book. Publisher: Caister Academic Press. Agricultural University, Wuhan, Hubei, World Scientific.

**University of Calicut**  
**M.Phil. Zoology Syllabus-**

**PAPER III**

**GENERAL AND APPLIED ACAROLOGY**

1. Introduction to the Acari-Systematic position and classification of Acari-Origin and phylogeny of Acari-
2. External morphology of Acari- body divisions –taxonomic features of different groups-
3. Detecting, collecting preserving and rearing of Acari-major extraction and collection techniques of Acari from various habitats like soil, air, water, plants and animals.
4. Ecological role of Acari-food and feeding habits-modification of gnathal appendages in relation to feeding-
5. Biology of Acari- reproductive modes of Acari-Culturing and rearing techniques of Acari-patterns of development in different groups of Acari-.
6. Economic status of soil mites –role of oribatid mites in biodegradation, nutrient cycling and enhancement of soil fertility – bioindication – biological control-vector role.
7. Agricultural Acarology- important groups of phytophagous mites – mite –mites injurious to economic plants-diverse types of plant abnormalities –mites as vectors of plant diseases.
8. Mites associated with stored products –common mite pests of stored products-economic loss induced by major mite pests.
9. Acari of medical and veterinary importance-mites and ticks affecting man and domestic animals-common mite and tick borne diseases- dust mites and scabies mites-
10. Role of mites in biological control – important groups of predatory mites- mites as parasites, vectors and agents in weed control.
11. Management of Acari- physical chemical and biological control of Acari-common acaricides used for the control of agricultural, horticultural and stored product mites- integrated management tactics of Acari-

## REFERENCES

- Baker, E.W and G.W. Wharton, 1952. An introduction to Acarology. Mcmillan Co., New York, 465 pp
- Jeppson, L.R, Keifer, H.H and Baker E.W 1975. Mites injurious to economic plants, University of California, 614 pp + 74 pls.
- Hughes, A.M. 1976. The mites of stored food and houses. Ministry of Agriculture, Fisheries and Food, Her Majesty's Stationary Office, London, 400 pp.
- Krantz, G.W. 2. 009 A manual of Acarology. D.S.U Book Stores, Corvallis.
- Haq. M.A and N. Ramani (Eds.) 1992. Man, mites and environment. Anjengo Publications, Calicut, 171 pp.
- James M.T and Harwood R.F 1969. Mites and mite borne diseases. In Herm's medical Entomology. Macmillan Company, London, pp 362-387
- Evans, G.O. 1992 Principles of Acarology. C.A.B International U.K. 563 pp
- Murphy P.W 1962 Progress in Soil Zoology, Butterworths, London, 398 pp
- Wallwork J.A. 1970 Ecology of soil animals Mc Graw Hill, London, 244 p.p
- Kevan, D.K. 1968. Soil Animals. H.F. & G. Witherby Ltd., London, 244 p.p
- Burges, A. and F. Raw, 1967. Soil Biology, Academic Press, London and New York
- Wooley T.A. 1988 Acarology – Mites and human welfare. John Wiley & Sons, New York, 484 pp.
- Balogh, J. 1972. A synopsis of the world oribatid (Acari) genera. Academia Kiado, Budapest.
- Balogh J. and S. Mahunka 1983 Primitive oribatids of the Palaearctic region. Elsevier Science Publishers B.V., Amsterdam, The Netherlands, 226 pp + 133 pls.
- Gupta S.K. 1985. Plant mites of India – Hand boo. Zoological Survey of India, Calcutta, 520 pp.
- Gerson, U. and Smiley, R.L. 1990. Acarine biocontrol agents – An illustrated key and manual. Chapman and Hall, London, New York, Japan.



Marjorie A. Hoy, 2011. Agricultural Acarology: Introduction to mite management, CRC Press, Taylor & Francis group, London and New York.392 pp.

Mary Anithalatha Sadanandan and N. Ramani, 2009. Acarine predators of North Kerala: General Survey, Biosystematics, Biocontrol potential. VDM Verlag Dr.Muller Aktiengesellschaft Co.KG, Germany, 257 pp.ISBN: 978-3-639-20949-5.

Uri Gersonl, Robert L. Smiley and Ronald Ochoa, 2003. Acari (Mites) for pest control, Blackwell Science Ltd., USA, UK,539 pp.

Vincenzo Vacante, 2016. The handbook of mites of economic plants:identification, bio-ecology and control-CABI, 2016, London, UK, 872 pp.

Walter, D.E. and H.C. Proctor, 2013. Mites: Ecology, Evolution & Behaviour: Life at a Microscale (Second Edition), Springer, New York, London, 494 pp.

Yadav P.R., Chauhan, R., Putatunda, B.N and B.S. Chhillar, 2002 Mites, their identification and management. ICAR Centre of Advanced studies, Dept. of Entomology, C.C.S Haryana Agricultural University, Hisar, 215 pp.

D<sub>2</sub>. N. Ramani

**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**  
**M. Phil (Zoology)- Syllabus**

**Paper III – AVIAN BIOLOGY**

**1. Origin and evolution of birds**

- Origin of Birds
- Birds in the evolutionary tree of animals
- Avian phylogenetics

**2. Taxonomy, Morphology and Anatomy of Birds**

- Classical taxonomy and systematics
- General bird morphology, morphological adaptations
- Anatomy of birds with emphasis on adaptations to terrestrial, aquatic and arboreal life.

**3. Bird Behaviour**

- Activities, time budget, inter-specific and intra-specific interactions
- Breeding biology: Mating systems, courtship, nest building, clutch size, incubation, parental care, fledging period, brood parasitism, factors deciding breeding in birds
- Visual and vocal communication
- Predator avoidance and optimal foraging
- Food and feeding behaviour
- Sociobiology of birds

**4. Population ecology and Community ecology**

- Population structure and dynamics
- Intrinsic and extrinsic factors affecting bird populations
- Natality, mortality, predation, competition
- Community ecology of birds
- Life strategy, Guilds, stratification
- Resource use and resource partitioning

**5. Physiology of birds**

- Circulation and excretion
- Thermoregulation and metabolism
- Physiological adaptation of birds
- Extrinsic and intrinsic factors effecting bird physiology

**6. Bird Migration**

- Migration of birds - local, national, intercontinental
- Flyways
- Factors driving / affecting migration
- Orientation and navigation
- Migratory birds of India.

**7. Birds & humans**

- Economic importance of birds, Ecosystem goods and services from birds

- Birds as environmental engineers
- Hazards of birds to aviation
- Birds and disease vectors / pathogens
- Conservation of birds, threats to wild birds, threat classification as per IUCN, effects of anthropogenic activity on birds.
- Passports, ID chips, bird banding, CITES

## **8. Raptors in India**

- Habitat and captive management of raptors
- Conservation and breeding methods
- Mismanagement and mortality rate, use of pesticides

## **9. Advanced Methods in Avian Biology**

- Methods in Molecular Biology
- Karyotyping of avian fauna
- Genetic Engineering methods
- Forensic Ornithology

## **References:**

- 1) A Field Guide to the Birds of the Indian Sub Continent, Krys Kazmie
- 2) A Pictorial Guide to the Birds of the Indian Sub Continent, Salim Ali, 1983
- 3) Alan Feduccia (1999), The Origin and Evolution of Birds, Yale University Press
- 4) Birds of the Prey of the Indian Sub Continent, Rishad Navroji
- 5) Cade TJ (1980), Population Ecology of Raptors by Iwan Newton.
- 6) Christopher Perrins, and C.J.O. Harrison - Birds: Their Life, Their Ways, Their World, published by Reader's Digest,
- 7) David Allen Sibley (2001) The Sibley Guide to Bird Life and Behavior, Published by Alfred A. Knopf
- 8) Gupta PK (2011) Elements of Biotechnology, Rastogi Publications, Meerut.
- 9) Ian Newton, William J. Sutherland (2004) Bird Ecology and Conservation: A Handbook of Techniques, Techniques in Ecology and conservation series
- 10) Joel Carl Welty The Life of Birds
- 11) Joseph Forshaw, Steve Howell, Terence Lindsey, and Rich Stallcup - The Nature Company Guide to Birding
- 12) Noble S. Proctor, Patrick J. Lynch- Manual of Ornithology: Avian Structure and Function, Yale University Press (1998)
- 13) Norman Elkins (1990) Weather and Bird Behaviour, Second Edition, Academic Press
- 14) Sankar Chatterjee (2015) The Rise of Birds - 225 Million Years of Evolution, second edition, John Hopkins University Press
- 15) The Book of Indian Birds, Salim Ali 1941
- 16) The Fall of a Sparrow, Salim Ali, 1985
- 17) Tim Birkhead (2012) Bird Sense - What It's Like to Be a Bird, Bloomsbury publishing.

**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**  
**Syllabus for M.Phil (Zoology)**

**Paper - III INSECT ENDOCRINOLOGY**

1. Historical perspectives of insect endocrinology: General concept of neuroendocrinology.
2. Anatomy of insect endocrine system: General structure of Corpora cardiac, corpora allata, and prothoracic glands.
3. Chemistry and mode of action of insect hormones: Chemistry of Prothoracicotropic hormone, sites of PTTH synthesis and release, titres of PTTH and mode of action, Chemistry of ecdysteroids, sites of ecdysone synthesis, Ecdysteroid receptors and binding proteins, ecdysteroids action at molecular level, chemistry and action of JH.
4. Neuroendocrine regulation of insect moulting and metamorphosis: Endocrine control of moulting, endocrine control of growth and metamorphosis, changes in cuticle and imaginal disc development.
5. Male and female reproductive organs of insects: Structure and origin of male and female reproductive system on a comparative basis.
6. Endocrine control of reproduction in insects: Hormonal control of egg maturation in insects, Endocrine influence of reproduction in male insects.
7. Hormonal control of diapauses in insects: Hormonal basis for embryonic diapauses, hormonal basis for larval, pupal and adult diapauses.
8. Hormones and behaviour: Courtship and mating, Sexual selection in mating of insects, sexual pheromones.
9. Applied potential of insect hormone research: Insect growth regulators, chitin synthesis inhibitors, JH analogues, Ecdysone agonists, anti-JH hormones and miscellaneous growth disruptors. Scope of IGRs in pest management programmes.

**References**

1. Adiyodi K.G and R.G Adiyodi. (1988) Reproductive Biology of Invertebrates, Vol III, Wiley Interscience, New York.
2. Gilbert, L. I. (2011) Insect Endocrinology, Academic Press.
3. Gilbert, L. I., Tata, J. R. and Atkinson, B .G. (1996) Metamorphosis, Academic Press, London.
4. Gupta, A.P. (1991) Morphogenetic Hormones of Arthropods, Vols. 1--3. Rutgers University Press, New Brunswick, New Jersey.
5. Highnam , K . C. and Hill. L. (1977) Comparative Endocrinology of invertebrates.
6. Kerkut.G.A and Gilbert,L.I.(1985) Comprehensive Insect Physiology, Biochemistry and Pharmacology Vol.7 and 8 Pergamon Press.
7. Marc J. Klowden (2007) Physiological system in Insects, Elsevier, Academic Press.

8. Maria Raabe (2011) Recent Development in Insect Hormones, Springer, Plenum Publishing Corporation.
9. Nayar, K.K. (1973) Elements of Insect Endocrinology, Prentice Hall.
10. Nijhout, H. F. (1998) Insect Hormones, Princeton University Press.
11. Novak, V. J. A. (1975) Insect Hormones, Chapman and Hall.

# UNIVERSITY OF CALICUT

DEPARTMENT OF ZOOLOGY

M. Phil SYLLABUS

**M.Phil (Zoology).**

## **Paper III- Biochemistry and Molecular Biology**

1. Solutions: Dissolution of solutes in solvents and colligative property, Normality, Molarity.
2. pH and Buffers : pH, buffer
3. s, buffering systems in organisms, Importance of pH and buffers in biological system,
4. Enzymes: Regulation and inhibition, enzyme assays.
5. Protein purification techniques: Salting out, ion exchange chromatography, gel filtration, PAGE, FPLC and their applications.
6. Drug discovery: steps, lead compounds, clinical trials and ethical considerations in human clinical trials.
7. DNA sequencing: Sanger's sequencing, Next generation sequencing.
8. PCR: types, principles and methods. Primer designing. Mutating genes by PCR to study their function.
9. Recombinant DNA technology: vectors-cloning vectors, expression vectors, techniques of gene cloning and its applications.
10. Recombinant protein expression: Recombinant protein expression in bacteria, insect and mammalian cell lines.
11. Data base and search tools: BLAST, Multiple sequence alignment, sequence analysis, restriction enzyme site digestion (web cutter 2.0)
12. Animal Cell culture: Culture media and techniques.
13. Cellular transformation: transformation of bacteria with vectors, transformation of insect cells using viruses and transformation of mammalian cells with mammalian vectors and their applications.

### **REFERENCES**

Brown T. A. , Gene Cloning and DNA Analysis: An Introduction. 6th Edition

Publisher: John Wiley & Sons (2010) ISBN No.: 9781444334074

Brown, T.A. (2007). Essential Molecular Biology a practical approach Vol.2. II Ed. Oxford University press.

Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter (2002). Molecular Biology of the Cell (4<sup>th</sup> Edition). New York. Garland, NY. ISBN-10: 0-8153-3218-1 ISBN-10: 0-8153-4072-9

David L Nelson and Michale M Cox. 2017 ;Lenhninger Principles of Biochemistry. (7th edn

Elliott, W.H. and C. Elliott. 2003. Biochemistry and Molecular Biology. Oxford University Press, Oxford, UK

Lewin, Benjamin. (2008) Genes IX Ed. Boston, Jones, Bartlett.

Lodish, H., Baltimore, D., Berk, A., Zipursky, S.L., Matsudaira, P. and Darnell, J. (6<sup>th</sup> Edn). Molecular Cell Biology, Scientific American Books, New York.

Plummer, David T (2007) An introduction to Practical Biochemistry, III Ed. Tata Mc Graw-Hill, New Delhi.

Principles and Techniques of Biochemistry and Molecular Biology. (2006) VI Ed. Wilson Keith and Walker John.

Sambrook, M.J. and Russell, D.W. (2006). The condensed Protocols from Molecular cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.

Stayer, L. 2011. Biochemistry. (7th edn). W.H. Freeman & Co. NY

Watson, J.D., M. Gilman, J. Witkowski, M. Zoller. 1992. *Recombinant DNA*. 2d ed. New York: W.H. Freeman and Company, Scientific American Books.



**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**  
**M.PHIL. COURSE WORK SYLLABUS**  
**Special Paper III: INSECT BEHAVIOUR AND ECOLOGY**

**1. Insect behaviour**

- 1.1 Reproductive behaviour: courtship, mating, oviposition, parental care, nesting behaviour.
- 1.2 Chemical communication in insects: Semiochemicals, pheromones, sex pheromones, cast regulating pheromones, aggregation pheromones, alarm pheromones, trail marking pheromones.
- 1.3 Allelochemicals: Kairomones, allomones and synomones.

**2. Collection, preserving and studying insects**

- 2.1 Collecting equipments: Insect net, killing bottles, aspirator, beating umbrella, malaise trap, pit fall trap, light trap, yellow pan trap.
- 2.2 Mounting and preserving insects: Relaxing, cleaning, pinning, spreading and labelling.
- 2.3 Preserving insects in fluids: housing, arranging and caring of the collection, display mounting, packaging and shipping insects.
- 2.4 Keeping live insects in captivity, cage rearing.

**3. Multitrophic interactions**

- 3.1 The trophic level concept
- 3.2 Plant traits that effect enemy-prey interactions
  - 3.2.1 Secondary metabolites
    - 3.2.1.1. Toxins
    - 3.2.1.2. Digestibility reducers
    - 3.2.1.3. Volatiles

**4. Herbivory**

- 4.1 Types and patterns of herbivory
  - 4.1.1 Herbivore functional groups
  - 4.1.2 Measurement of herbivory
  - 4.1.3 Spatial and temporal patterns of herbivory
- 4.2 Effects of herbivory
  - 4.2.1 Plant productivity, survival and growth form

- 5 Biochemical ecology of host-specific and host-non-specific insects
  - 5.1 Breadths of domains of mono-, oligo, and polyphagy in insect feeding.
  - 5.2 Preference versus deterrence in plants for insects.
  - 5.3 Stimulus receptors

## **6. Chemical ecology of insect natural enemies**

- 6.1 Essential elements in parasitoid chemical ecology
- 6.2 Manipulation of the population levels of natural enemies by semiochemicals
- 6.3 Recruitment of predators and parasitoids by herbivore-injured plants
- 6.4 The use of synthetic HIPVs in pest management
- 6.5 Arthropod pest management strategies used in organic farming

## **7. Population Dynamics of insect natural enemies**

- 7.1 Introduction
- 7.2 Demonstrating and quantifying predation and parasitism
- 7.3 The role of natural enemies in insect population dynamics
- 7.4 Selection criteria in classical biological control

## **8. Ecology and evolution of closely associated two unrelated genomes**

- 8.1 Plant-feeding insects and plant competitiveness.
- 8.2 Plant tolerance and compensatory behaviours
- 8.3 Energy movement in communities involving interacting insects and plants.
- 8.4 Geography is a key determinant.

## **9. Pollination**

- 9.1 Types and Patterns of Pollination
  - 9.2 Pollinator Functional Groups
  - 9.3 Measurement of Pollination
  - 9.4 Spatial and Temporal Patterns of Pollination
  - 9.5 Effects of Pollination
- 

## **References**

1. The Insects: An Outline of Entomology. Gullan P.J. and P.S. Cranston. Blackwell publishing Ltd.
2. Systematics and Biodiversity Conservation. Narendran T.C. and Balakrishnan M. Agrobios, India.
3. Insect Ecology: An Ecosystem Approach. Timothy D. Schowalter. 3<sup>rd</sup> edn. Elsevier

4. Insects As Natural Enemies:A Practical Perspective. Edited by Mark A. Jervis. Springer
5. Borror and DeLong's Introduction to the Study of Insects. Triplehorn C.A., Johnson N.F. Thomson Brooks/Cole

**DEPARTMENT OF ZOOLOGY  
UNIVERSITY OF CALICUT  
SYLLABUS FOR M.PHIL.**

**PAPER 3: INSECTICIDE TOXICOLOGY**

**Unit 1:**

- Introduction to Insecticides and Toxicology
- Physico Chemical Properties of Insecticides
- Classification of Insecticides

**Unit II:**

- Insect Plant Interactions, secondary Metabolites
- Biopesticides- Allelochemicals – Allomones – synomones, IGRs

**Unit III:**

- Toxicity- Acute and Chronic Toxicity
- Exposure and Evaluation of Pesticide Toxicity
- Toxicodynamics

**Unit IV :**

- Introduction to Mode of Action of Insecticides
- Vulnerability of Insects to Control Agents
- Interference of Pesticides with Biological Processes

**Unit V:**

- Insect Neuroendocrine systems and Pheromones
- Insecticide Binding with Protein in Insects
- Action Target – Nerve, Muscle, Growth and Development Targets
- Anatomical, Physiological and biochemical responses of insects to toxicants

**Unit VI :**

- An overview of Insecticide Resistance
- Types of resistance and evolution of Insecticide resistance
- Factors Influencing development of Resistance and Detection Methods

**Unit VII:**

- Hemocytes of Insects- Classification and immunologic functions
- Humoral and cellular immunological responses in insects to Pesticides
- Biochemical, Physiological and Genetic Mechanism of Insecticide Resistance
- Oxidative and Non oxidative Metabolic Pathways of Biotransformation of Pesticides

**Unit VIII :**

- An overview of Environmental Impact of Pesticides
- Pesticides as Environmental and health Hazards

**Unit IX:**

- Translocation and degradation of Pesticides
- Bio magnification
- Analysis of Residues

**Unit X:**

- Environment Impact assessment
- Scope and Importance of Ecofriendly Pesticides

**Reference**

Copping, L.G. and Menn, J.J. (2000) Biopesticides: A Review of Their Action, Applications and Efficacy. *Pest Management Science*, **56**, 651-676. [http://dx.doi.org/10.1002/1526-4998\(200008\)56:8<651::AID-PS201>3.0.CO;2-U](http://dx.doi.org/10.1002/1526-4998(200008)56:8<651::AID-PS201>3.0.CO;2-U)

Brown, A.W.A. 1958. *Insecticide Resistance in Arthropods*. World Health Organization, Geneva

Brown, V. 1988. *Acute and Sub-Acute Toxicology*. Hodder & Stoughton. London. 125 pp

Chambers, J. and Yarbrough, J. 1982. *Effects of Chronic Exposures to Pesticides*. Raven Press, New York. 250 pp.

Gujar G.T. 1994. Recent Advances in Insect Physiology and Toxicology Agricola Publishing Academy, New Delhi 346 pp

**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**  
**M. Phil SYLLABUS**  
**ADVANCE PAPER: PAPER III-TOXICOLOGY**

- 1. Introduction to toxicology (5 Hours)**
  - 1.1 History and scope of toxicology; definitions
  - 1.2 Types of toxicity
  - 1.3 General principles of toxicological evaluation
  
- 2. Mode of action and metabolism (5 Hours)**
  - 2.1 Chronicity of exposure, dose response function, bioassays, tolerance, bioconcentration, biomagnification
  - 2.2 Environmental fate of toxicants - absorption, distribution, excretion
  - 2.3 Xenobiotic biotransformation
  - 2.4 Toxicokinetics, environmental behavior of toxicants - Fugacity modeling
  - 2.5 Animal models as predictors of human toxicity
  - 2.6 Epidemiology and human risk
  - 2.7 Mechanisms of toxicity
  - 2.8 Metabolism of toxicants – Phase I and Phase II reactions, elimination of toxicants.
  
- 3. Clinical toxicology (10 Hours)**
  - 3.1 Identification of toxicant; types of poisons
  - 3.2 Diagnosis, principles of therapy
  - 3.3 Drug affecting the central nervous system (CNS) – CNS stimulants and depressants
  - 3.4 Narcotics – opoid analgesics and related compounds
  - 3.5 Recreational and sports medicine drugs
  - 3.6 Drug abuse and dependence
  - 3.7 Local antidotes - Activated Charcoal and others
  - 3.8 Transportation and medical attention; Symptomatic and supportive treatment; Specific antidote available and indicated
  - 3.9 Elimination of toxicants
  
- 4. Environmental toxicology (10 Hours)**
  - 4.1 Environmental and chemical carcinogenesis – cancer biomarkers and susceptibility factors
  - 4.2 Environmental sample collection methods – sampling schemes, environmental matrices
  - 4.3 Analytical techniques – quantification
  - 4.4 Environmental persistence; bioaccumulation
  - 4.5 Environmental risk assessment
  
- 5. Systemic toxicology (5 Hours)**
  - 5.1 Hepatotoxicity
  - 5.2 Nephrotoxicity
  - 5.3 Reproductive and developmental toxicity
  - 5.4 Neurotoxicity

- 5.5 Endocrine disrupters and toxicity
- 5.6 Respiratory toxicology
- 5.7 Dermatotoxicity
- 5.8 Mutagenesis
  
- 6 Immunotoxicology (12 Hours)**
  - 6.1 Immunochemical techniques in toxicology
  - 6.2 Monoclonal and polyclonal antibody production
  - 6.3 Immunotechniques - immunohistochemistry; immune affinity purification; immunoprecipitation, immune blotting, RIA, ELISA, immunochemical flow cytometry
  - 6.4 Classification of immune mediated injury (hypersensitivity)
  - 6.5 Effects of chemicals on allergic disease – allergic contact dermatitis (ACD), respiratory allergens, adjuvants, systemic hypersensitivity
  
- 7 Cellular and Molecular toxicology (8 Hours)**
  - 7.1 Cellular toxicology
  - 7.2 Cellular studies in intact tissues
  - 7.3 Monolayer and other cell culture techniques,
  - 7.4 Proteomics; Metabolomics
  - 7.4 Replacement of animal testing with cell culture models
  - 7.5 Transgenic animal models
  - 7.6 Mechanisms of cell death
  - 7.7 Molecular techniques in toxicology
  
- 8 Genotoxicology (10 Hours)**
  - 8.1 Genotoxicity assays in toxicology studies– DNA damage – Ames mutagenicity test, comet assays, karyotyping, sister chromatid exchange, CBMN assay; Dominant lethal assay and Micronucleus test
  - 8.2 Carcinogens; DNA lesions and genomic instability
  - 8.3 Mechanism of action of genotoxic and non-genotoxic carcinogens
  - 8.4 Management of genetic disorders
  
- 9 Applied toxicology (5 Hours)**
  - 9.1 *In vivo* tests of toxicity – acute, subchronic, chronic, special tests
  - 9.2 *In vitro* tests of toxicity – prokaryotic and eukaryotic mutagenicity
  - 9.3 DNA damage and repair, chromosome aberrations
  - 9.4 Ecological effects – field test, risk analysis
  
- 10 Occupational and industrial toxicology (10 Hours)**
  - 10.1 Occupational toxicants
  - 10.2 Acute toxicity – monitoring, general signs and symptoms in humans
  - 10.3 Occupational epidemiology, Occupational ergonomics
  - 10.4 Occupational health and safety management systems; occupational safety.

## **References:**

1. Essentials of Toxicology. Klaassen CD, Watkins JB III, eds. New York: McGraw-Hill, 2003.
2. Casarett and Doull's Toxicology-The Basic Science of Poisons, 6th Edition. Klaassen CD, ed. New York: McGraw-Hill, 2001.
3. A Textbook of Modern Toxicology, 4<sup>th</sup> edition. Ernest Hodgson,ed. John Wiley & Sons, New Jersey.
4. Essentials of Environmental Toxicology: Environmentally Hazardous Substances & Human Health. W. William Hughes; Taylor and Francis, USA.
5. Lu's Basic Toxicology, Fourth Edition: Fundamentals, Target Organs and Risk Assessment. Fourth edition, Frank C. Lu and Sam Kacew ed., Taylor and Francis, USA.
6. Patty's Industrial Hygiene and Toxicology, Sixth Edition, Wiley-Interscience, Clayton and Clayton, Eds.: 2000.
7. Principles and Methods of Toxicology Fourth Edition, Hayes, A.W., Ed.: Raven Press, New York, 2001 and 5<sup>th</sup> edition (2008).
8. Woolley, Adam, A Practical Guide to Toxicology, 2nd ed., Informa Healthcare, 2008.
9. Timbrell, John, Principles of Biochemical Toxicology, 3rd ed, Taylor and Francis, 2000 and 4<sup>th</sup> ed, 2008.
10. Molecular and Biochemical Toxicology, fourth edition, Robert C. Smart and Ernest Hodgson and Patricia E. Levi. John Wiley and Sons, New Jersey, Canada.
11. Analytical Toxicology: For Clinical, Forensic, and Pharmaceutical Chemists, Hans Brandenberger, Robert A. A. Maes.de Gruyter, Berlin, New York.



# UNIVERSITY OF CALICUT

## DEPARTMENT OF ZOOLOGY

### M. Phil SYLLABUS

#### Paper III – Restoration Ecology

##### 1. Introduction:

- 1.1 Definitions, Goals, Purpose of Ecological Restoration,
- 1.2 Overview and Social Aspects of Restoration Plan,
- 1.3 Basic Approaches, Methods, General Principles and Limits of Restoration Ecology,
- 1.4 Criteria used to judge the Success of Restoration and Adaptive Management.

##### 2. Ecotoxicology:

- 2.1 Environmental Contaminants, Bioassay, LD<sub>50</sub>, LC<sub>50</sub>, and EC<sub>50</sub>
- 2.2 Metameres of Dose and Response,
- 2.3 Bioremediation, Biodgradation, Bioconversion,
- 2.4 Ecological Indicators and Biological Monitoring,
- 2.5 Molecular Characterization of Bacteria.

##### 3. Pedology:

- 3.1 Inorganic and Organic Matter in Soils,
- 3.2 Plant Nutrients and Fertilizers in Soil,
- 3.3 Soil loss: Desertification, Deforestation, Soil Erosion,
- 3.4 Soil Pollution and Contamination.

##### 4. Hydrology:

- 4.1 Runoff Patterns, Precipitations, River Channels.
- 4.2 Ground Water Uses and Problems
- 4.3 Wetland and Coastal Management

##### 5. Pollution:

- 5.1 Water Pollution
- 5.2 Contaminations.

##### 6. Ecosystem:

- 6.1 Basic Characteristics of Ecosystems,
- 6.2 Ecological Communities and Food chains,
- 6.3 Categories and General Effects of Pollutants,
- 6.4 Anthropogenic Effects on Endangering of Species.

##### 7. Restoration:

- 7.1 Stream and River Restoration, Rebuilding of Degraded Soil, Reforestation, ,
- 7.2 Reversing Eutrophications, Treating Contaminated Waters, BOD, COD
- 7.3 Revegetation from Seeds or Stocks, Re-establishment of Native Forests, Invasive plants,
- 7.4 Habitat Restoration of Vertebrates and Invertebrates, Biological control of Introduced Species, Habitat Improvement for Targeted Species
- 7.5 Removing of Non-native Species and Weeds, Reintroduction of Native Species,
- 7.6 Restoration through Trophic Interactions,
- 7.7 Wetland, Coastal and Marine Restoration.

##### 8. Bioremediation:

- 8.1 Introduction, phytoremediation
- 8.2 Biofilters, Biomethanation

8.3 USAB Reactor.

**9. EIA and Environmental Audit:**

9.1 National Policy on EIA and Regulatory framework, Public Participation in Environmental Decision Making.

9.2 Planning and Selection of Appropriate Resource Management Procedure for Water, Air, Soil.

9.3 Benefits and Draw backs of EIA, Environmental Risk Assessment.

**REFERENCES:**

1. Botkin.Keller,Environmental Science, 2011. International Student Version, Eighth edition, John Wiley and sons, Inc, ISBN: 978-0-470-52033-8.
2. Rajendran, P., P. Gunasekaran, 2006. Microbial Bioremediation, , MJP Publisher, Chennai, ISBN: 81-8094-022-5.
3. Stanley E.Manahan, Fundamentals of Environmental and Toxicological Chemistry,2013, Sustainable Science, Fourth Edition,CRC Press,Taylor and Fansis Group-Boca Raton, London, Newyork.
4. Stephen Darby, David. A. Sear, River Restoration,24-March-2008, Wiley Publisher.
5. Philip Roni, Stream and Watershed Restoration: A Guide to Restoring Riverine Process and Habitats, 26-December-2012, John Wiley & Sons Publications.
6. Rattan Lal, B.A Stewart, Advances in Soil Science: Soil Restoration, 28-September-2011,Volume 17, Springer, New York,.
7. Birgitte K Ahring(Ed), Biomethanation 1, 07-April-2003, Science and Business Media.
8. Carolann D. Webber, Eutrophication, 2010,Nova Science Publishers,ISBN 978-1-61728-911-8.
9. Nicholas.P.Cheremisinoff, 2009. Handbook of Water and Wastewater Treatment Technologies, N&P Limited Butterworth Heinemann Publishers, ISBN: 0-7506-7498-9.
10. Shibu Jose, Harminder Pal singh, DaizyRaiBatish, Ravinder Kumar Kohli, Invasive Plant Ecology, January-9-2013, CRC Press, Taylor and Francis Group.
11. Thomas-R-Biebighauser, 2007. Wetland Drainage, Restoration and Repair, University press of Kentucky Publisher, ISBN: 9780 813124476, 0813124476.
12. Donald L. Hey, Nanoy S. Philippi, A Case for Wetland Restoration, 1999, Wiley-Inter Science Publisher.
13. Thomas J. Goreau, Robert Kent Trench ,Innovative Methods of Marine Ecosystem Restoration, 04-December-2012, CRC Press.
14. M. Luisa Martinez, Juan B.Gallego-Fernandez,Patrick A.Hesp- Restoration of Coastal Dunes,2013, Springer Publisher, ISBN-978-3-642-33444-3.
15. Anji Reddy Maredd , Environmental Impact Assessment: Theory and Practice, 15 Jun 2017, Butterworth-Heinemann Publisher, ISBN-10: 0128111399,ISBN-13: 978-0128111390.

**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**  
**M. Phil. ZOOLOGY**

**Paper III: MOLECULAR BIOLOGY & BIOTECHNOLOGY**

**1. Genome organisation**

Outline of Prokaryotic and Eukaryotic genomes, Organelle genomes in eukaryotes, Evolution of genomes, Repetitive and unique sequences, DNA polymorphism, Satellites and microsatellites

**2. Molecular Techniques**

PCR methods, Primer designing, PAGE, Blotting techniques, Hybridization methods, Molecular probes, Molecular markers

**3. Recombinant DNA Technology**

Tools and Techniques used in Recombinant DNA Technology: Restriction endonucleases, Vectors, Gene transfer, Screening of transformants, Expression of recombinant proteins

**4. Genome sequencing**

DNA sequencing methods, Next generation sequencing, Whole genome sequencing, Sequence assembly

**5. Transgenesis**

Transgenic and Gene Knockout technologies, Gene silencing techniques, Patenting of transgenics and DNA sequences, Ethical and Biosafety aspects of transgenics

**6. Application Biotechnology**

SNP analysis, DNA fingerprinting, Molecular taxonomy, Phylogeny analysis, Gene therapy, Diagnosis and treatment, Molecular pharming, Drug designing

**7. Microbial Technology**

Isolation, screening and culture of microflora, Improvement of microbial strains, Metagenomics, Microbes and bioremediation, Microbial biofilms, Whole cell immobilization and applications

## 8. Bioprocessing Technology

Bioreactors and Bioprocess monitoring, Upstream and Downstream processing, Biosensors and Biological indicators, BOD concepts, Biodegradation strategies

## 9. Biological databases

Nucleic acid databases (EMBL, DDBJ, GenBank), Protein databases (UniProt, Swiss – Prot, TrEMBL, NRL–3D, PDB, SCOP, CATH), Genome databases, Specialized databases, Data storage and retrieval

## 10. Sequence Analysis

Sequence alignment – Pair-wise and Multiple, Similarity searching tools (FASTA, BLAST, Clustal), Phylogenetic analysis tools (ClustalW, PHYLIP), Phylogenetic tree construction, Homology modeling

## References

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2002). Molecular Biology of the Cell 4<sup>th</sup> Edtn. Garland Science, New York
2. Attwood T. K., Parry-Smith D. J. (2003). Introduction to Bioinformatics. Pearson Education, Singapore.
3. Ausubel , F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A. and Struhl, K. (2003). Short Protocols in Molecular Biology 5<sup>th</sup> Edn. John Wiley and Sons, Inc.
4. Bailey, J. E. and Ollis, D.F. (2010). Biochemical Engineering Fundamentals 2<sup>nd</sup> Edn. Tata McGraw Hill, USA
5. Brown, T. A. (2006). Genomes 3, 3<sup>rd</sup> Ed., John-Wiley & Sons, New York.
6. Chatterjee. A. K. (2011). Introduction to Environmental Biotechnology 3<sup>rd</sup> Edn. Prentice Hall.
7. Claus, W.G. and Balkwill, D. (1989). Understanding Microbes: A Laboratory Text Book for Microbiology. W.H. Freeman & Company, New York.
8. Doran, P. M. (2012) Bioprocess Engineering Principles, Latest Edition, United Kingdom: Academic Press
9. Doran, P.M. (2012). Bioprocess Engineering Principles. Academic Press, USA
10. Glick, B. R., Pasternak, J. J. and Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, Washington DC.

11. Griffiths A.J.F., Gelbart, W.M., Miller J. H. and Lewontin, R. C. (1999). Modern Genetic Analysis, W.H. Freeman, NY.
12. Jeremy W. D. and Simon F. P. (2010). Molecular Genetics of Bacteria 5<sup>th</sup> Edition. Wiley-Blackwell.
13. Jin Xiong (2006). Essential Bioinformatics, Cambridge University Press.
14. Kanika Sharma (2011). Manual of Microbiology: Tools and Techniques 2<sup>nd</sup> Edn. Ane Books Pvt. Ltd. New Delhi.
15. Krebs, J. E., Goldstein, E.S. and Kilpatrick, S.T. (2012). Lewin's Genes XI. Jones and Bartlett Learning, USA
16. Madigan, M. T. and Martinko, J. M. (2006). Brock Biology of Microorganisms, 11<sup>th</sup> Edition, Prentice Hall, USA
17. Maheshwari, D.K. (2006) Biotechnological Applications of Microorganisms – A Techno Commercial Approach. I. K. International Publishing House, New Delhi
18. Mayers, R. A. (Ed) (1995). Molecular Biology and Biotechnology: A Comprehensive Desk Reference. VCH Publishers, Inc., New York.
19. Mount, D.W. (2000). Bioinformatics: Sequence and Genetic Analysis 2<sup>nd</sup> Edn. CSHL Press, NY.
20. Pelczar, M. J. (Jr.), Chan, E. C. S. and Kreig, N. R. (1998). Microbiology 5<sup>th</sup> Edn., Tata McGraw Hill Inc. New York.
21. Sambrook, J., Fritsch, E. F. and Maniatis, T. (2001). Molecular cloning: A Laboratory Manual, Vol 1 – 3. CSHL Press, New York.
22. Schuler, M.L. and Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Prentice Hall, USA
23. Watson, J. D., Gilman, M., Witkowski, J. and Zoller, M. (1992). Recombinant DNA, 2<sup>nd</sup> Edition, Scientific American Books, W.H. Freeman and Company, New York.
24. Wheelis, Mark. (2010). Principles of Modern Microbiology. Jones and Bartlett Publishers, New York.

**UNIVERSITY OF CALICUT**  
**DEPARTMENT OF ZOOLOGY**

**Syllabus for M.phil (Zoology)**

**Paper- III- Advances in Taxonomy and Biosystematics**

- 1) Introduction to biological systematics: Definition and basic concepts of biosystematics and taxonomy, History and importance of systematics.
- 2) Trends in biosystematics- Concepts of different conventional and newer aspects: Eco taxonomy, behavioural taxonomy, cytotaxonomy, biochemical taxonomy, numerical and molecular taxonomy.
- 3) Nomenclature & Classification: Phylogeny and classification, taxonomic hierarchy of categories and higher taxa, International code of Zoological nomenclature.
- 4) Dimension of species concept: Typological species concept, biological species concept, evolutionary species concept, subspecies and other infra-specific categories.
- 5) Descriptive Taxonomy: Taxonomic characters - Different kinds, selection of characters- measurements, taxonomic procedures, Collections of specimens, curation, process of identification, preparation of taxonomic keys.
- 6) Measuring and measures of biodiversity indices: Species diversity indices, Shannon-Weiner index, Simpson, Bergar-Parker, Brillouin Mathematics and dominance index.
- 7) Introduction to Modern Taxonomy – DNA barcoding, single locus probes and multilocus probes, Molecular Phylogenetics reconstruction, Molecular Homology and sequence alignment.
- 8) Geometric Morphometrics : Major goals of Morphometrics, Types of geometric representation, Shape theory, scaling of shape- Isometric and allometric scaling, Landmarks, Semi-landmark, Criteria for choosing landmark, Centroid Size, Consensus configuration, Procrustes Superimposition, Principal component Analysis (PCA), Visualizing shape variation as deformation: Thin-Plate Spline, future scope of morphometrics and coordination in systematics.
- 9) Gene-environment interaction and phenotypic plasticity: Homology and character concept in morphological and molecular data, Combining DNA and morphology.

## REFERENCES

- 1) Ashok Verma (2015): Principles of Animal Taxonomy- Alpha Science, Speedy Hen, London.
- 2) Ernst Mayr and Peter D. Ashlock (1991): Principles of Systematic Zoology- McGraw-Hill.
- 3) James Rohlf (2011): Biometry- 4<sup>th</sup> Edition, W H Freeman & Co Ltd.
- 4) Kapur V.C (1983): Theory and Practices of Animal Taxonomy – Oxford & IBH- New Delhi.
- 5) Miriam Leah Zelditch., Donald L., Swiderski H., David Sheets., William L. Fink (2004): Geometric Morphometrics for Biologists: A Primer- Elsevier Academic Press, London , UK.
- 6) Narendran T.C (2001): Taxonomic Entomology: Research and Education in India- Current Science Vol.81, No.5, 445-447.
- 7) Ramesh Chandra Tripathi (2005) : Biosystematics and Taxonomy, University Book House pp.216.
- 8) Randall T. Schuh (2000): Biological Systematics: Principle and Applications- Cornell University Press, Ithaca & London.
- 9) Vogler A.P & Monaghan M.T (2007): Recent advances in DNA Taxonomy- J.Zool.Syst.Evol.Res.45: pp 1-10.