Revised March 29, 2009, K. C. Kim

ENT 497F Insect Biodiversity Science (INSECT BIO SCI), 4 credits

Lectures: Monday 09:05-09:55AM
Lab Sessions: Tuesday and Thursday 01:25–04:25PM

About the Course:

The course ***Insect Biodiversity Science: Synthesis*** is a new offering of biodiversity science at Penn State based on the result of an experimental course presented as ENT497C *Essence of Insect Biodiversity Science* (3 credits) in the fall Semester 2008. This course takes a new integrated approach to the study of insect biodiversity by the synthesis of relevant contemporary scientific disciplines related to biodiversity, namely taxonomy, community ecology, and resources management. This course challenges students in the upper baccalaureate and graduate programs in the study of insect biodiversity through the three parallel tracks and expects students in the class to acquire: a) the essence of biodiversity along with introduction to insect biodiversity; b) principles and practice of applied taxonomy based on the essence of biodiversity and practical taxonomic capacity for taxa identification of insects and related arachnids; and c) the process and techniques of field inventory and assessment of insect biodiversity through team research which can be applied to sustainable management and conservation of natural resources that include biodiversity. This course delivers these subject areas in a series of lectures and laboratory exercises with advanced reading of key papers and hands-on experience in insect biodiversity science.

Background:

Biodiversity is the essence of life on our planet Earth and basic natural resources for our life-support system, referring to the totality of living species of plants, animals, fungi, and microorganisms. As taxonomy is instrumental in exploration, documentation and synthesis of global biodiversity, biodiversity science as a newly emerging scientific study of biodiversity integrates diverse scientific and scholarly perspectives and knowledge of contemporary disciplines related to biodiversity. For over 250 years since the Linnean days natural historians and taxonomists subsequently have described and documented biodiversity from backyards to worldwide expeditions which resulted in approximately 1.76 million species of global biodiversity that represents barely 18% of what presently extant on our planet estimated to be 10 million species.

Insects and related arachnids are most diverse and abundant group of organisms making up the largest group of global biodiversity. They are major components of diverse ecosystems and important elements in ecosystem function and as major ecological players in the production of ecosystem services which we must depend on. Yet, insects and related arthropods are vanishing along with all other animals and plants at the rate unprecedented in the history of life as they are very little known. They are commonly considered as pests or vermin by our culture, particularly in the western world and thus are not usually taken into serious consideration in environmental protection and conservation. However, insects and related arthropods are important ecological partners in sustaining our life-support system. Considering the poor state of knowledge and close relationships to humanity we must vigorously study insects and arachnids so as to conserve and rationally manage them for our sustainable future.

Management and conservation of natural resources, particularly biodiversity, crop, fishery, forest, wildlife, forest, wetland, and watershed, has to be site-specific based on the biodiversity assessment. Backyard biodiversity, the totality of all living organisms at a specific spatial unit, is unique and deterministic due to geographic location and physical configuration of the site including soil quality, elevation, and weather. Similarly, prevention and containment of adventive invasive species and mitigation of environmental disasters and climate changes by global warming require information on backyard biodiversity along with ecosystem structure. Backyard biodiversity does not refer to a taxonomic listing of what animals and plants known from the site but what species of organisms constitute it and how all these resident species sustain ecosystem function of the site which is the assessment of backyard biodiversity based on biodiversity inventory that requires accurate species identification along with principal taxonomy. This course is therefore designed to provide a hands-on experience of biodiversity assessment based on the essence of biodiversity and biology and evolution of species.

Requirements and Grading:

No entomological background is required for this course. As the course is tightly organized and involves broad areas of several biological disciplines, the course contents are rich in information and rigorous in perspectives requiring a full attention of individual students in the class. Students are expected to read assigned reading materials in advance and prepare for discussion on the subject areas. Final grading consists of 3 parts: A) Lecture grade is based on two written examinations; B) Lab grade is based on weekly lab quizzes and class participation; and C) Team research is graded on the final Team Report and individual contributions to the team research.

A. Lecture Topics (14 sessions, one per week):

1. **Introduction:** *About the course; introduction to contemporary issues on biodiversity, extinction, global warming, biodiversity science*.

2. **Planet Earth and sustainability:** *Explore biosphere, its various ecosystems and the essence of our life-supporting system. Discuss the effects of anthropocentrism, economic development, global warming and related climate change, human population growth, and land conversion on biodiversity in world-wide development activities. Introduce the meaning of 'sustainability' and an exploration of what it means to have species lost.*

3. **Biodiversity and evolution:** *Define the concept and explore the essence and composition of biodiversity and its theoretical and practical perspectives, including issues facing backyard and global biodiversity.*

4. **Species, community and our life-support system:** *Discuss ontology and dynamics of species, community and ecosystem for understanding our life-support system and why biodiversity must be protected and conserved.*

5. **Species: definition, theory, boundary:** *Introduce the concept of species and discuss how species is applied in our contemporary world. Explore infraspecific variation and discuss how species maintain genetic integrity: gene pool, reproductive isolation; adaptation and selection. Discuss how species boundary is defined and drawn in its application.*

6. **Speciation and phylogeny:** *Explore how species is formed and discuss speciation models: allopatry, sympatry, etc. Discuss phylogeny and coevolution and discuss how phylogeny is constructed; introduce the concept of species loss: extinction and extirpation and discuss the scope and mode of species loss and what species loss means to community assemblage, species composition and to our life-support system*

7. **Applied taxonomy and biodiversity science**: *Discuss how biodiversity has been studied and documented and how we can facilitate the study of global biodiversity; introduce the alpha-taxonomy in discovery and description of new species and classification of taxa and in application of biodiversity and species. Introduce what biological classification is and how it is organized by different methods: evolutionary and cladistic approaches; discuss the needs and value of biological nomenclatures and how biological nomenclatures are managed by international codes; discuss what taxonomic characters based on morphological, molecular, ecological and genetic data, and how they are determined; introduction to morphospecies and taxonomic surrogates in application and DNA barcode tools.*

8. **Global biodiversity and homogenization***: Introduction to adventive and invasive ecology and the problem of biodiversity homogenization by anthropogenic movements of insects and other organisms; discuss anthropogenic factors of homogenization of global biodiversity by human movement and immigration; detection and containment against adventive organisms; what's rational and successful approaches to detecting and managing adventive pests.*

9. **Biodiversity assessment:** *Introduction to fundamentals of biodiversity assessment and monitoring and discuss the concept and process of biodiversity inventory: design, field sampling and collection and sampling methodology and tools, and taxonomic processing of samples and collection; discuss the issues involving monitoring for changing ecosystem.*

10. **Taxonomic procedure:** *Introduction to taxonomic tools for application; descriptions, keys, species list and to backyard biodiversity and site-specific database; discuss the issues of taxonomic surrogates: theory, application and problems*.

11. **Ecology of biodiversity:** *Introduction to biodiversity as the basis of ecosystem function and services, species as ecological partners and ecosystem management; explore the ecology of community pertaining to niche and habitats and the issues related to species composition and assemblage, indicator specie; introduction to biodiversity analysis of backyard biodiversity.*

12. **Community Ecology:** *Explore the ecology of community pertaining to niche and habitats and the issues related to species composition and assemblage, indicator species. Introduce to biodiversity analysis of backyard biodiversity*.

13. **What's next for biodiversity:** *Introduction to concept of biodiversity assessment and approaches to describing site-specific biodiversity profiles, measuring the changes of biodiversity composition and monitoring ecosystem functions and services*; d*iscuss the essence of backyard biodiversity that is the primary resources for sustainable economic development in the developing regions and many underdeveloped and developing nations and what infrastructure is needed to achieve biodiversity inventory and management in these countries*.

14. **Biodiversity science, integrating scientific disciplines:** *Explore what biodiversity is for humanity, biophilia, ecological economics, and sustainability science and discuss what biodiversity informatics we need for Biodiversity conservation: how fundamental it is to mitigate the impacts of global warming and climate changes and how we could expand our biodiversity knowledge base for the future of humanity as global biodiversity shapes our destiny*; d*efine biodiversity as science: concept and essence and explore what's needed for biodiversity conservation, ecosystem management, land management, natural resources management, and pest management*

Laboratory Sessions (30 sessions, 3 hours per session):

[Three periods for Tuesday and Thursday per week; (a) first period – lecture, (b) Second period – hands-on work; (c) third period – team research]

Heading format = **[Topic:** *Lecture contents.* Lab exercises]

1. **Biodiversity inventory: Concept and Planning:** *Introduction to lab exercises and expected outcome; organization of research teams for class projects; selection of collecting site; discuss matters concerning field collecting methods and insect preservation and collection management.* Gather team members, organize a team and develop strategies for field work: design of the study site, collection of samples, and taxonomic process assignments.

2. **Study site and field sampling for team research:** *Preparation for field work: location of collecting sites with placement of collecting tools in the field; assignment of field collecting protocols*. Establish the study site and collect the samples from the study site and prepare specimens for study.

3. **Processing of field samples with specimen preparation**: *Introduction to taxonomic process and specimen preparation for study; building and making of taxonomic keys for identification.* Sort field samples, prepare specimens for study with proper labels, practice key making and use for identification of taxa.

4. **Principles of insect taxonomy**: *Introduction to principles and convention of taxonomy: alpha-, beta-, and gamma-taxonomy; taxonomy of infraspecific populations, subspecies, species, species groups, genus, subgenus, family, order, class, phylum; biological classification and phylogeny; classifying process; species and species boundaries; characterization of taxa Introduce what biological classification is and how it is organized by different methods: evolutionary and cladistic approaches; discuss the needs and value of biological nomenclatures and how biological nomenclatures are managed by international cod.* Discuss what taxonomic characters based on morphological, molecular, ecological and genetic data, and how they are determined; introduction to morphospecies and taxonomic surrogates in application and DNA barcode tools..

5b. Comparative morphology of insects and arachnids: *Introduction to general insect morphology with focus on external structures and diagnostic characters used in identification keys at different taxonomic levels.* Learn general insect morphology with focus on external morphology and key characters and identify specimens into higher taxa at the Class and Order levels.

5c. Biodiversity informatics I: *Introduction to biodiversity data: data structure, data parameters, kinds of software, database management.* Learn and use one or two software for database building.

6b. Taxonomy and identification of insects and related arachnids: *Introduction to classification of insects and arachnids and the use of taxonomic keys to higher taxa at different taxonomic levels from orders and family groups: family, subfamily and tribe, genus, species and morphospecies.* Identify specimens into taxa at different taxonomic levels.

6c. Biodiversity informatics II: *Introduction to biodiversity data: data structure, data parameters, kinds of software, database management.* Learn and use one or two software for database building

7b–23b. Taxonomy of insect orders: 16 sessions (7-23): *Introduction to taxonomy of major orders of insects and arachnids of which each order is studied per one or two sessions for classification, characterization of each* *taxon at different taxonomic levels, and hands-on identification of specimens to family and genus; the following major orders and order groups will be covered: Apterygota, small orders: Dermaptera, Embiidina, Zoraptera; orthopteroids: Orthoptera, Phasmatoidea, Manophasmaroidea, Grylloblatodea, Mantodea, and Blattodea; aquatic insects: Odonata, Ephemeroptera and Plecoptera; Isoptera and Psocodea: Psocoptera, Phthiraptera, and Thysanoptera; Hemiptera (Homoptera and Heteroptera); Neuroptera, Mecoptera, and Trichoptera; Coleoptera and Strepsiptera; Diptera; Lepidoptera; and Hymenoptera.* Learn how to identify specimens of common species to family and genus by practice identification of representative specimens of major families at different taxonomic levels.

7c--23c. Identification of team research samples: 16 sessions (7-23): *Identify all the specimens collected from the team research site to family, genus, and species following the sequence of taxonomy labs.* Continue specimen identification until all the samples are identified and organized into the Team Research database.

24b. Identification of common insects to lower taxa (review and practice): *Provides an opportunity to test your taxonomic capacity using common insects you were not familiar with.* Try to identify 10 common insects of unknown species into lower taxa.

25. Biodiversity data analyses: *Introduction to the organization of site-specific biodiversity data and application of appropriate statistical analyses to the data for defined objectives.* Organize site-specific biodiversity data into the insect biodiversity database of the study sites with regard to biodiversity assemblage, species composition, indicator species, and monitoring procedures and protocols.

26. **Guilds analysis and functional units**: *Introduction to guilds analysis and classification of functional unit; application of guilds.* Study guilds or functional groups based on foraging behavior and microhabitat characteristics; classify those insects collected from the study site into guilds or functional groups.

27. Building a community model: *Introduction to the study of insect community model based on guild analysis and builds a network of functional groups in insect community.* Identification of species found in the study site into guilds or functional groups. Build community assemblage with species composition and functional network for the study site.

28. Preparation of the Team Report: *Introduction to preparation of the Team Report: Species list by order, family and species, species composition and assemblage, guild analysis, community profile (model), and how to apply the site-specific biodiversity data to application sciences.* Conduct team discussion on the results of the project and prepare the Final Team Report.

29. **Class symposium for presentation of Team Report:** *Presentation and evaluation of Team Reports.* Present final team report.

30. ***Summation of the Course activities:*** *Course evaluation and suggested revision.* Summarize and review the course with suggestions from the class.

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