Insect Diversity and Evolution

ENTOM 3310/3311 – Fall 2017

Professors:
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Lecture (3310): T/Th 11:40-12:55 (B108 Comstock)
Lab (3311): T 1:25-4:25 (2109 Comstock)
Prerequisites: Insect Biology (Entom 2120) or equivalent, or permission of instructor.

This course is designed for undergraduate entomology or biology majors and graduate students from any department with an interest in insects. The course will provide a broad overview of insect diversity, morphology, phylogeny, evolution, and fossil history. We will discuss the origins of insects, evolutionary relationships among orders and families, the fossil record of insects, the methods commonly used to reconstruct phylogenies, and how the phylogenies of insects are changing with new data and new methods. We will also discuss how phenotypes and phylogenies contribute to taxonomic decisions.

Because morphology forms the basis for much of what we know about insect phylogeny and because morphology is something you need to know to understand insect evolution, we will spend some time on the comparative external morphology of adult insects. Insects are the most diverse group of animals on the planet, and, in no small part, this is due to their morphology. Morphological features of insects which are related to their incredible diversity include complex and highly variable mouthparts, the ability to fly, wing folding, their modular style of development, metamorphosis, and their incredible reproductive capacities. You will develop a good understanding of the basic morphological features of insects and how these features have been modified over 400 million years of insect evolution.

LECTURE: ENTOM 3310
3 CREDITS

Learning objectives:

- understand phylogenies: the methods and data used to build trees, the terminology used to describe phylogenetic relationships, and how to interpret a phylogenetic tree
- understand the groundplan morphology of the hexapod orders and identify external anatomical features
- develop a comprehensive understanding of the insect orders and families and their evolutionary relationships – including demonstrating the ability to draw the phylogeny of the hexapods
- develop a broad understanding of insect natural history, and identify key innovations and life history strategies of major hexapod lineages
- describe the process of describing and naming a species and understand the importance of natural history museums as a resource in the biological sciences
- read and evaluate the primary literature in insect diversity and evolution
- communicate phylogenetic and evolutionary concepts in written and oral form

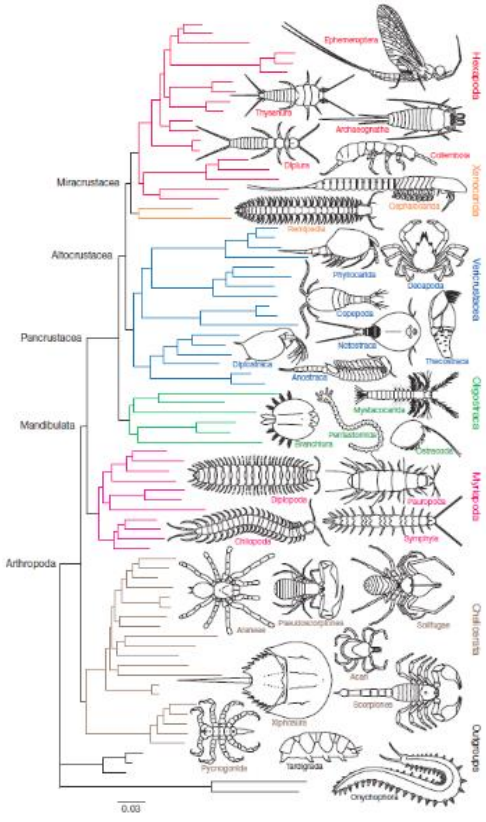
Grading:	participation & attendance	10%
	quizzes	30%
	final presentation	15%
	webpage	20%
	final exam	25%

We will have six short quizzes throughout the semester (30%), a final exam scheduled for Dec. 6th 9:00-11:30am (25%), a short final presentation (15%), and a webpage-building project on your favorite local insect species (20%). An additional 10% of the grade will be based on attendance, occasional short in-class or Blackboard activities, and participation in the in-class discussions.

The quizzes will allow us to assess your knowledge as we go and will also encourage you to keep up with the reading and lecture material. The final project will be to read and evaluate a paper from the primary literature on insect phylogeny and systematics. We'll ask you to find a paper on a group of insects that interests you. You will read the paper, evaluate the methods and results, and make a ~8-minute, in-class presentation based on the paper. The webpage project will involve scientific writing for the public, website design, and the use of our insect museum collection. More information will follow on the presentation and the webpage.

Textbook:
Insects: their natural history and diversity: with a photographic guide to insects of eastern North America.
2nd ed: Marshall, S.A. (2017). Firefly Books (ISBN: 1770859623) [2006 1st ed. is OK]

Overview of the major themes we plan to develop in the course:

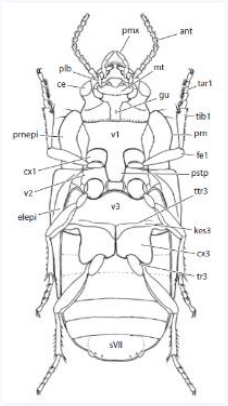


I. Phylogenies and why they are important
"Nothing in evolution makes sense except in the light of phylogeny" (Sterelny and Griffiths 1999).

Phylogenies are amazing things. They are graphical representations of the evolutionary history and diversification of life on earth. As such, they provide the comparative framework for understanding the evolutionary history of organisms and their traits, including their morphology, behavior, ecology, life history, and biogeography. When fossils are incorporated, phylogenies can be calibrated relative to the geological timescale and they can give us insights into the tempo and mode of diversification. On a more practical level, phylogenies provide a hierarchical arrangement of taxa which often provides the basis for developing a stable classification. One of the key points of this class will be the concept that phylogenies are hypotheses which are constantly being tested as new data become available. In the latter part of the class we will investigate how phylogenies can be used to unravel evolutionary questions in insects.
[figure: Reiger et al. 2010]

II. Phylogenetic methods and approaches
In order to understand how systematists build phylogenies, one needs to know something about the tools and methods of phylogenetic reconstruction. There are diverse methods for reconstructing phylogenies and we will cover several of the more important methods, including parsimony, maximum likelihood and Bayesian methods. We will also cover how phylogenies are used to test hypotheses about evolutionary processes, such as cophylogeny, historical biogeography, and evolution of morphological diversity. Additionally, we'll cover phylogenomic methods and why this new data source is widely-used.

III. External morphology of adult insects
Insects are among the most extraordinarily diverse groups of animals on earth. There are over 900,000 described insects, and they originated over 400 million years ago. Since that time insects have diversified into an astonishing array of forms with an equally amazing array of functions. The external morphology of insects is therefore a fascinating subject in its own right, but also provides the primary data set for understanding insect relationships. We will cover in some detail external anatomy of insects. You will come away from the class with a good understanding of the basic groundplan morphology of insects and how this groundplan morphology is modified in different orders.
[figure: Buetel et al. 2015]



IV. What do we know about ordinal and family-level relationships in Hexapoda?
We will spend much of the semester discussing what we know about ordinal and family-level relationships in insects. The phylogeny of the insects is constantly being refined. We will discuss what traditional morphological approaches suggest about hexapod relationships and how the view of insect phylogeny has changed when analyzing molecular data. There will be many opportunities for debate and discussion when different data sets provide conflicting results.

V. Delimiting, describing, and documenting a species
We will discuss the process of placing an insect specimen in the context of its evolutionary and taxonomic position. A part of this process involves how taxonomists decide that a new specimen/series of specimens are a new species and then proceed to delimit this species from other related species. Describing a new species also requires that you follow nomenclatural rules and designate a holotype specimen, and we'll discuss recent controversies in the taxonomic world related to these issues.

Additional Information:

Attendance: Please contact Elizabeth ahead of time if you know you'll be unable to make a class period.

In compliance with the Cornell University policy and equal access laws, we are available to discuss appropriate academic accommodations that may be required for students with disabilities.

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student for academic credit will be the student's own work.

The instructors will provide -- and expect from students -- an atmosphere for learning that respects diversity. Respect in the classroom includes: being on time for class, directing attention to the speaker, refraining from browsing the internet/fiddling on your phone during class, and other social courtesies appropriate in a community setting.

LABORATORY: ENTOM 3311
1 CREDIT

The focus of the laboratory will be to develop a good understanding of insect diversity and identification to the family and subfamily level. We will develop skills in working specimens through the keys as well as sight identification. We will use the first month of class to conduct local field trips to collect insects and will also have an overnight field trip to a local natural area and participate in the community BioBlitz (Cayuga Nature Center on Sept. 8-9). In the latter part of the semester, we will work systematically through the major groups of insects and identify material to family and subfamily. The identification portion of the class will build on the skills you learned in ENTOM 2120 (Insect Biology). We will use keys to the families from Borror & DeLong's "Introduction to the Study of Insects" (7th edition) in addition to the keys and identification guides in the textbook "Insects: their natural history and diversity, with a photographic guide to insects of eastern North America". We will supplement these resources with more specialized keys to families from the primary literature.

Learning objectives:

- develop skills in collecting, preserving, labeling, curating, and shipping hexapod specimens
- learn taxonomic skills such as clearing insects for examination, simple slide mounting of a wing, and illustrating a specimen with the aid of a camera lucida
- identify insects to family using taxonomic keys
- sight identify all hexapod orders and the more common families in our area
- develop an understanding of the natural history and biology of local insect families

Grading:		
	participation & attendance	5%
	mini mid-semester collection	10%
	final collection	60%
	final test	20%
	insect illustration	5%

Grading in the laboratory will be based on the final collection of 200 insect specimens (70% total), a final, in-class exam (20%), a draft illustration of an insect, done using a microscope and camera lucida (5%), and your participation and attendance (5%). Collection requirements will be distributed at the first lab. We will give you guidance on how best to organize your collection and will address proper collection practices throughout the semester. The final laboratory exam will focus on insect identification based both on keys as well as sight identifications.

Recommended textbook [not required]:
Introduction to the study of insects, 7th ed. Johnson and Triplehorn (2005).

Wk	#	Date		Lecture	Quizzes	Lab topic and activity
1	1	22-Aug	Tues	Course overview; Insecta; Why are phylogenies important?		**Field Trip 1**
	2	24-Aug	Thurs	Tree-building process; types of data & methods; phylogenetics vs -omics		
2	3	29-Aug	Tues	Trees II -- likelihood methods, trait mapping; comparative analyses		**Field Trip 2**
	4	31-Aug	Thurs	The concept of homology; arthropod phenotypes & structures		
3	5	5-Sep	Tues	Importance of natural history collections		**Field Trip 3**
	6	7-Sep	Thurs	Phylogeny of Metazoa: Arcticulata vs. Ecdysozoa	quiz 1	
						BioBlitz - Sept 8-9 overnight
4	7	12-Sep	Tues	Phylogeny of Arthropoda: Pancrustacea hypothesis		**Field Trip 4**
	8	14-Sep	Thurs	Phylogeny of basal Hexapoda (apterygote orders)		
5	9	19-Sep	Tues	Phylogeny of the Paleoptera and the "Paleoptera Problem"		Entognatha to Paleoptera
	10	21-Sep	Thurs	Phylogeny of Polyneoptera I	quiz 2	
6	11	26-Sep	Tues	Phylogeny of Polyneoptera II		Polyneoptera
	12	28-Sep	Thurs	Phylogeny of Paraneoptera		
7	13	3-Oct	Tues	Phylogeny of Holometabola I		Paraneoptera
	14	5-Oct	Thurs	Phylogeny of Holometabola II	quiz 3	
8		10-Oct	Tues	***FALL BREAK (Oct. 7-10)***		**NO LAB**
	15	12-Oct	Thurs	'Key innovations'; diversification; evolutionary 'success'		
9	16	17-Oct	Tues	Phylogeny of Hymenoptera		Hymenoptera
	17	19-Oct	Thurs	Evolution of eusociality in insects	quiz 4	
10	18	24-Oct	Tues	Phylogeny of Coleoptera		Coleoptera
	19	26-Oct	Thurs	insect biogeography; distributions, relect taxa		
		27-Oct	Friday	mini-collections due (20 families ID'd)		
11	20	31-Oct	Tues	Phylogeny of Diptera		Diptera
	21	2-Nov	Thurs	Phylogeny of Lepidoptera (guest: Jason Dombroski)	quiz 5	
12	22	7-Nov	Tues	**no class -- please work on finalizing your collections**		**NO LAB [ESA meeting]**
	23	9-Nov	Thurs	amazing diversity of bees (Bryan)		
13	24	14-Nov	Tues	taxonomy, nomenclature, ICZN		Lepidoptera/Trichoptera, etc.
	25	16-Nov	Thurs	guest speaker (/ "Skyper"): Doug Yanega (UCR), ICZN & student questions		
14	26	21-Nov	Tues	website analytics, get in pairs for phylogeny paper presenation work	quiz 6	illustrations due, review time!
		23-Nov	Thurs	***THANKSGIVING BREAK (Nov. 22 - Nov. 26)***		
15	27	28-Nov	Tues	wrap up and work on final paper presentations		**LAB PRACTICAL**
	28	30-Nov	Thurs	Student presentations		
		1-Dec	Friday	final collections due (100 families ID'd)		
		6-Dec	Wed	3310 final exam, 9:00 - 11:30 am		