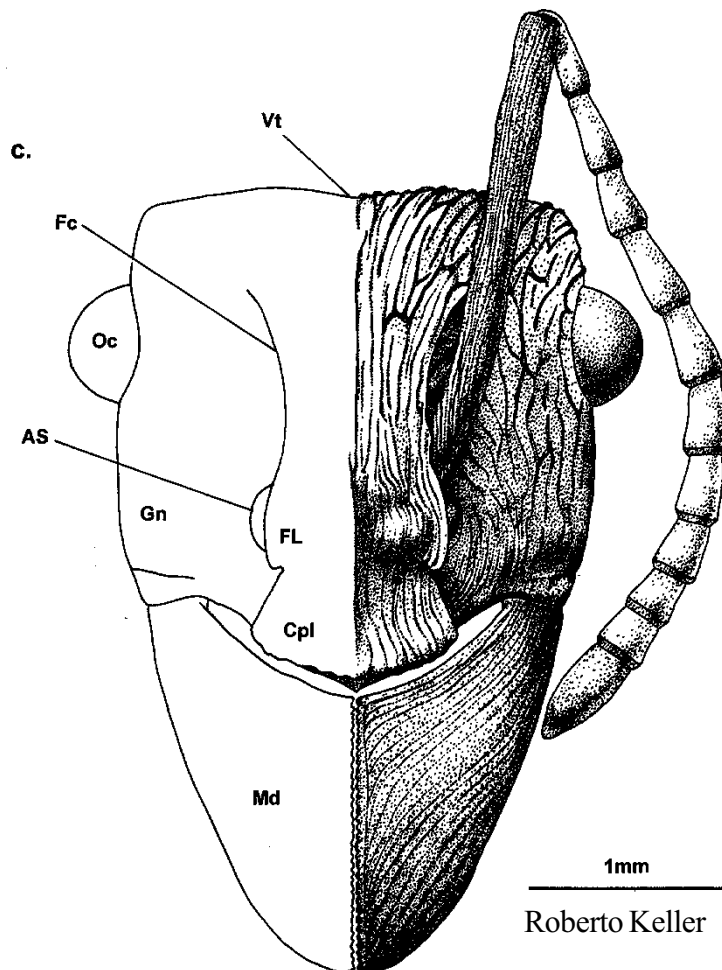


Eickwort's Manual of Insect Morphology



Bryan N. Danforth
Christopher J. Marshall
Department of Entomology
Cornell University
Ithaca, NY
14853
Copyrighted by the authors

Version 2.2 (January, 2003)

Preface

George Campbell Eickwort (1940 - 1994) was an exceptional teacher and a productive scientist. His wide ranging interests included systematics of bees and mites, social behavior and evolution, behavioral ecology, pollination biology, chemical ecology, and foraging behavior. One of the unifying themes connecting all of these disparate interests was the study of insect morphology. George felt, and rightly so, that a good understanding of insect morphology was essential for high quality research in entomology, and liked to call morphology “the queen of sciences.”

George taught Insect Morphology at Cornell University from 1968 to 1992 — a total of 15 times (twice in 1968!). During this period George’s course evolved into one of the most challenging and popular courses taught in the College of Agriculture and Life Sciences at Cornell and, without a doubt, the preeminent course in Insect Morphology in the United States. George combined his love of insects, encyclopedic knowledge of morphology, and natural enthusiasm to make the course a fun and challenging experience for students. The course was so popular that students from other Universities (Harvard University and the University of Alaska, to name just two) came to Cornell to take the course. In recognition of his teaching excellence George was awarded the Entomological Society of America Distinguished Achievement Award in Teaching in 1986, and received numerous teaching honors at Cornell, including the President’s Teaching Award in 1994.

George’s influence in entomology went far beyond his morphology course (not to mention the fact that he taught 11 other courses at Cornell as well!). During his 27 years as a Cornell professor, George advised numerous undergraduates, 33 PhD and MS students, and 8 postdoctoral associates. Many of his students have gone on to become leaders in their own fields of entomology, acarology, behavioral ecology and sociobiology. George helped found the International Society of Hymenopterists (for which he served as President) and was the President of the Acarological Society of America (1984-1989). George was also Editor (and founder) of the Cornell University Press Arthropod Biology Series, which reprinted Snodgrass’ classic Principles of Insect Morphology (1935), as well as books on tent caterpillars (T.D. Fitzgerald [1994], The Tent Caterpillars), and army ants (W.H. Gotwald, Jr. [1995], Army Ants: The Biology of Social Predation). He served as a consultant to the Museum of Comparative Zoology, Harvard University (1974) and the American Museum of Natural History (1977, 1991-1993). He was a visiting professor at several major universities and research institutes, including the University of California, Davis (1979), the Organization for Tropical Studies (1983), the Rocky Mountain Biological Laboratory (1983, 1984, 1988), Brackenridge Field Laboratory, University of Texas (1988), and the University of Arizona (1992). George was also a consultant for Time Life Books from time to time and was involved in several international research and training projects, including Cooperativo sobre la Apifauna Mexicana (1985-1992). He even brought his morphological expertise to the courtroom as an expert witness for S. Brunk Law Offices, in Arizona. In short, George’s influence in the field of insect biology was on a national and an international level.

While teaching Insect Morphology George developed a laboratory manual for the course. This manual is based on the principle that morphology is essentially a laboratory science. Neither books nor lectures can convey the structural diversity and complexity of insects. A real understanding of insect morphology requires detailed dissections, careful observation through the microscope, and accurate drawings. George’s lab manual emphasized all those skills and encouraged students to investigate the morphology of one insect (“your bug”) in particular detail.

While improvements to the lab manual were made over the years by Teaching Assistants and students, the manual was principally a product of George Eickwort. In 1995 we (BND and CM), with

input from Byron Alexander (University of Kansas), added additional exercises and figures to the manual and laid out the individual lab exercises in Adobe PageMaker format. In 1997 additional changes were made to exercises and in 2001 additional changes were made. In 2001 lab exercises were exported as individual pdf files and posted on the web for use by interested faculty and students. We dedicate our efforts to George, and hope that by publishing his lab manual we will be passing on to future undergraduate and graduate students the spirit of George's enthusiasm for insect morphology.



Table of Contents

Preface
Introduction
Laboratory Exercises

<u>Lab no.</u>	<u>Title</u>	<u>File name</u>
1	Annelida — body plan	lab01.pdf
2	Arthropoda — body plan	lab02.pdf
3	Abdomen of adults (camera lucida demo)	lab03.pdf
4	Abdomen of larvae	lab04.pdf
5	Arthropod appendages and locomotion (sketch 1)	lab05.pdf
6	External thoracic structure (sketch 2)	lab06_07.pdf
7	“	
8	Thoracic musculature and flight mechanisms (sketch 3)	lab08_09.pdf
9	“	
10	Wings (inking demo)	lab10_11.pdf
11	“	
12	Head capsule	lab12.pdf
13	Insect mouthparts (sketch 4)	lab13_14.pdf
	Table 13.1	table13.pdf
14	“	
15	Digestive tract	lab15_16.pdf
16	“	
17	Circulatory and respiratory systems (half-tone demo)	lab17_18.pdf
18	“	
19	Exocrine glands	lab19.pdf
20	Female reproductive system (sketch 5)	lab20.pdf
21	Ovipositor	lab21.pdf
22	External male genitalia (sketch 6)	lab22_23.pdf
23	“	
24	Male reproductive system	lab24.pdf
25	Central nervous system	lab25.pdf
26	Insect mechanoreceptors and ears	lab26.pdf

Appendix I — morphological terms of orientation and position (from Duporte)	append_1.pdf
Appendix II — dissection tools and techniques (BND)	append_1.pdf
Appendix III — sketching techniques (CM)	append_2.pdf
Appendix IV — inking techniques (CM)	append_2.pdf
Appendix V — carbon dust techniques (Francis Fawcett)	(not available)
Appendix VI — Stains, fixatives, slide mounting media, etc. (GCE)	append_1.pdf
Appendix VII — Recommended reading list, broken down by lab no. (BND)	reading.pdf
Literature cited — to be added later	

Introduction

This lab manual is designed to be used by junior and senior undergraduates and graduate students. We assume throughout that the student has had an introductory course in Entomology and is at least somewhat familiar with the major orders of insects. While the lab manual was originally developed for use in a 5 credit course in Insect Morphology at Cornell University, we realize that Insect Morphology as a full course may only be offered at a few institutions. We have therefore modified the manual slightly so that students wishing to learn insect morphology may use the lab manual as a tutorial.

Each laboratory exercise or series of exercises begins with a step-by-step dissection of a “generalized” insect. The exercises that follow consist of examining additional specimens to illustrate relatively primitive, derived or bizarre morphologies. Many of the subsidiary exercises are based on demonstration dissections which can be prepared by the instructor (when the manual is used in a course) or prepared by the student (when used as a tutorial). The demonstration dissections are not absolutely necessary to gain a general understanding of insect morphology, but they are essential to gaining a comprehensive and comparative overview of the bewildering diversity in insect form and function. By using the lab manual along with readings from selected texts (listed in Appendix VII) a student with a background in basic entomology and physiology should be able to perform the dissections outlined in the manual.

This lab manual is not meant to serve as a general textbook of insect morphology. Snodgrass’s 1935 Principles of Insect Morphology remains the single best source for an overview of insect morphology. While the chapters on development, histology, and physiology are now outdated, Snodgrass’s coverage of comparative skeleto-muscular morphology is unparalleled by any modern text. Additional readings from other text books, such as Chapman’s The Insects: Structure and Function (1982) and Blum’s Principles of Insect Physiology (1985) provide more modern coverage of internal anatomy and physiology. Additional recommended readings for each laboratory exercise are listed in Appendix VII.

For students wishing to use the lab manual for a study guide a number of generalized insects will be needed. We recommend that at a minimum the following insect taxa be available for study: live crickets (*Acheta domestica*), milkweed bugs (*Oncopeltus fasciatus*), roaches (*Periplaneta americana* or *Nauphoeta* sp.), preserved lubber grasshoppers (*Romalea micropteryx*), live or preserved honey bees (*Apis mellifera*), and preserved cicadas (*Magicicada* sp.). Most of these insects can be collected locally in most areas of the United States in the summer months, or obtained live or preserved from Carolina Biological Supply (800-334-5551) or Fluker Farms (P.O. Box 378, Baton Rouge, LA, 70821 [800-735-8537]) in the winter. Additional specimens are needed for specific labs as outlined in each exercise. Many of these should be available either locally or through Carolina Biological Supply.

Finally, each student is expected to select one species of insect (“your bug”) for intensive study and illustration. The important criteria to consider when choosing your bug include size (>1cm in body length to make dissections easier), availability (ideally live specimens should be available throughout the semester, but specimens may also be frozen or fixed in a Kahle’s [see Appendix VI]). The insect chosen should also show a number of generalized features of insects, such as the possession of well-developed flight musculature (otherwise labs 8-11 will not be very interesting!). Both males and females should be collected in order to study the morphology of the reproductive tract, male genitalia, and the female ovipositor. In each lab or group of labs you will be asked to make sketches and, in some cases, inked drawings of the internal and external anatomy of your bug, so that by the end of the course you may find yourself the world’s expert on the morphology of this interesting species!

Equipment necessary for dissections and drawings are outlined in Appendices II-V and recipes for fixatives, stains and mounting media are given in Appendix VI.