

BOOK REVIEW

The origins of diversity: A review of *Evolution of the Insects*, by David Grimaldi and Michael S. Engel

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Evolution of the Insects. David Grimaldi and Michael S. Engel. 2005. Cambridge University Press. New York. 772 pp. Hardcover \$75.00. ISBN-10: 0-521-82149-5. ISBN-13: 9780521821490.

Insects are the evolutionarily most successful group of organisms in the history of life on earth. A persistent challenge to evolutionary biologists is to explain the causes of this success. For example, how is it possible that most modern insect orders were already in place 250 million years ago (Ma), while most other organismal groups outside the insects that originated this early are now either extinct or represented merely by relict taxa? How can we explain that of the roughly 1.4 million named species about 1 million are insects? What allowed insects to become and remain the ecologically dominant group of herbivores and disease vectors? In *Evolution of the Insects*, David Grimaldi and Michael S. Engel address these and many related questions central to insect evolutionary biology. The critical success of their work rests primarily on the authors' ability to authoritatively contribute and integrate a perspective thus far lacking from the literature on insect evolution: the origin of insects and insect diversity as told through their fossils and paleoecology. However, this book is not exclusively, or even primarily, about fossil insects. Instead this is a solid work on insect biology, integrating morphology, behavior, ecology, and biogeography. But throughout the book, insect paleobiology is used to provide a highly informative historic framework for discussing the causes and mechanisms underlying the success of the world's dominant class of organisms.

Evolution of the Insects begins like many Entomology text books. Chapter 1 identifies the insects' dominance across space, time, and trophic levels, and defines and discusses terms and concepts crucial to the remainder of the book,

such as the biological species concepts, known and estimated unknown insect species diversity and why there is such a dramatic variation among estimates, the history and methods of reconstructing phylogenetic relationships, and of course the use of fossils in documenting extinction, lineage age, and phylogenetic and biogeographic affiliations. Chapter 2 then strays off course compared with mainstream entomology texts by taking time to document that insects indeed have a rich and often beautifully preserved fossil record, which must not be ignored when attempting to explain extant patterns of diversity. This chapter includes, as does the book throughout, amazing images of remarkably well preserved insect fossils, and breathtaking detail of what can be recovered from a fossil if only one cares to find out, including muscle fibers, brain structures, mitochondria, and also secondary components such as fecal pellets or nematode parasites. Chapter 3 then sets the stage for early insect evolution by introducing the phylum Arthropoda and their closest relatives. It also provides a succinct introduction to non-insect hexapods, while Chapter 4 overviews and introduces basic insect morphology. Beginning with Chapter 5, and ending with Chapter 14 over 500 pages later, the authors then walk their readers through the cladogram of insect diversity, starting with the most primitive insects (bristletails and springtails) and ending with the more recent radiations of angiosperm pollinators and phytophagous insects. While this may sound like a standard layout for an entomology text, the actual book, and in fact most chapters, are far from it. Each chapter begins with an often surprisingly detailed overview of the defining morphological characteristics of each group and its taxonomic affiliation, including a treatment of uncertain placements and current debates. Although the detail provided in these sections is probably overkill for most readers, it represents an excellent reference for those who want or need to know more. This

section is then typically followed by a discussion of how the evolutionary history of a given group, as told through fossil and biogeographic data, have given rise to present-day patterns of morphological and ecological diversity. Needless to say that not only extant orders receive such treatment, but all major extinct orders do as well.

Many chapters stand out, too many to do them all justice here. I was particularly drawn into Chapter 14 *Insects become modern: the Cretaceous and Tertiary periods*, which examines the consequences of major events during these periods for subsequent insect evolution, such as the Gondwanan breakup, the emergence and radiation of flowering plants in the mid-Cretaceous, and the tertiary radiations of mammalian hosts. To me, it illustrated particularly well how understanding the past history of life is clearly key to making sense of its present.

This book is doubtless a major contribution to the field, though not surprisingly some areas receive far greater attention than others. *Evolution of the Insects* emphases are clearly on morphology, taxonomy and (paleo) ecology; development,

genetics, physiology and embryology are largely or entirely left out. While this should be viewed less as a criticism and more as motivation for the next generation of integrative insect evolutionary biologists, this book is still very appropriate for developmental biologists. It highlights the diversity we all too often ignore, the diversity some groups have once been capable of expressing (and may still have the developmental machinery to do so), and the diversity we must know about when we discuss topics such as the genetic and developmental origins of novel traits, convergence and parallelism.

Lastly, this book is simply a pleasure to thumb through, to marvel at photographs and drawings, and to learn about aspects of insect biology that normally receive little exposure. It is very well written and accessible, and above all beautifully illustrated. All this comes at over 750 pages, with over 1000 high-quality illustrations, at a relatively affordable \$75. *Evolution of the Insects* will without doubt remain a primary scientific reference for years to come and will appeal in many different ways to anyone engaged in insect diversity.