Phyllostomid Bats

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A Unique Mammalian Radiation

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We dedicate this book to past, present, and future students of this fascinating group of mammals

CONTENTS

1

Overview of This Book

Theodore H. Fleming,
Liliana M. Dávalos,
and Marco A. R. Mello

Introduction

Adaptive radiations have always fascinated biologists because they provide dramatic evidence of the power of natural selection and opportunism in the evolution of life on Earth. Although the concept of adaptive radiation has itself evolved over its century-long history, contemporary definitions agree with Givnish (2015, 301) who emphasized "the rise of a diversity of ecological roles and associated adaptations within a lineage, accompanied by an unusually high level or rate of accumulation of morphological/physiological/behavioral disparity and ecological divergence compared with sister taxa or groups with similar body plans and life histories." These features have made Darwin's finches, Hawaiian honeycreepers, African Rift Valley cichlids, and Australian marsupials into textbook examples of radiations whose species have evolved to fill a variety of ecological niches via changes in their behavior, dietary choices, morphology, and other aspects of their life histories. Certainly, the evolution of New World leaf-nosed bats (Phyllostomidae) qualifies as an adaptive radiation. While their closest relatives in the chiropteran superfamily Noctilionoidea—Mormoopidae—exhibit modest taxonomic and ecological diversity (two genera, 18 species), the phyllostomids (60 genera, 216 species) have radiated into an unprecedented variety of ecological and behavioral types in the past 36 Ma. Thus, several decades after the first monographs of New World leaf-nosed bats (Baker et al. 1976, 1977, 1979), a wealth of new scholarship has accumulated that merits review.

This book is about the adaptive radiation of these abundant and ecologically highly diverse bats. Reflecting this abundance, anyone aiming to capture bats using Japanese mist nets set at ground level throughout the tropical and subtropical Americas can hardly avoid catching one or more species of phyllostomids in very short order. For example, in his survey of tropical rainforest bats at La Selva, Costa Rica, in 1986, Fleming and his field crew caught 94 individuals of 11 phyllostomid species in 10 ground-level nets in 3.5 h (THF, unpubl. data). These species represented six of the eight phyllostomid subfamilies (clades); three species of frugivorous *Carollia* (Carolliinae) dominated the captures. Food habits of these bats included insects, blood, vertebrates, nectar and pollen, and fruit. In their much more extensive survey of bats in a lowland rainforest in northern French Guiana, Nancy Simmons and husband Rob Voss recorded a similar abundance but much higher species richness of phyllostomids. Forty-eight of the 59 species they captured in ground-level nets were phyllostomids, and *C. perspicillata*, *Phyllostomus elongatus* (an omnivore), and *Artibeus obscurus* (a frugivore) were caught most frequently (Simmons and Voss 1998). Recent syntheses on phyllostomid diversity show that single localities in Brazil's Atlantic Forest can surpass the mark of 60 bat species (Bergallo et al. 2003; Muylaert et al. 2017; Stevens 2013). Phyllostomids also dominate bat assemblages throughout the Caribbean islands, where they are found in massive cave-roosting colonies alongside several species of mormoopids. At hot caves such as La Chepa in the Dominican Republic, six out of the 10 species are phyllostomids, and captures of *Macrotus waterhousii* and *Monophyllus redmani* outnumber those of mormoopids (Núñez-Novas et al. 2016). From these and many other studies, there can be no doubt that phyllostomid bats are among the most common and species-rich mammals in lowland Neotropical forests.

Because of their abundance, ecological diversity, and ease of capture and maintenance in captivity, phyllostomids have been intensively studied by many research groups in recent decades. Much of the early research on these bats was summarized in a landmark, three-volume monograph edited by Robert Baker, J. Knox Jones Jr., and Dilford Carter in the late 1970s (Baker et al. 1976, 1977, and 1979). Since then, our knowledge about the evolution, general biology, and ecology of these bats has increased tremendously, and a book summarizing these findings has been long overdue. The overall aim of this book, therefore, is to review our current knowledge about these bats, particularly from a phylogenetic perspective. Compared to the 1970s, our understanding of phylogenetic relationships within this family and the timing of the appearance of its evolutionary clades is much deeper. We can now use this information to better understand the evolution of all aspects of the biology of these bats. We can ask, for example, what were the ancestral states of morphology, physiology, and behavior in this family, and how long did it take for the specialized adaptations associated with blood, nectar, and fruit feeding to evolve? What is the historical biogeography of the family and how long have contemporary assemblages of species been interacting with each other and, in the case of nectar and fruit eaters, with their food plants?

While this book clearly focuses on only one of the 20 families of bats, it should have a much broader appeal than simply to bat biologists. Because of the unique biological and ecological diversity found in this family, which easily comprises the most diverse diet of any mammalian family, it can serve as a model system for understanding many aspects of the adaptive radiation of mammals during the latter half of the Cenozoic Era. As chapters in this book reveal, a plethora of recent field, laboratory, and bioinformatics studies have provided us with an unprecedented view of how this group of mammals has responded to geological, climatic, and biological changes and challenges that have occurred in the Americas over the past 30 Ma. Moreover, because these bats provide many important ecosystem services such as insect control, pollination, seed dispersal, and nutrient input to caves, as well as negative economic effects resulting from vampire attacks on livestock, these animals can have enormous ecological and economic impacts on tropical and subtropical ecosystems of the Americas (Kunz et al. 2011). As a result, their conservation and protection is critical for the health of Neotropical ecosystems. In sum, phyllostomid bats have played an extremely important role in the evolutionary and ecological dynamics of these systems for tens of millions of years.

The 24 chapters of this book are arranged in six major sections, beginning with a review of the physical and biological environment into which these bats evolved and ending with a review of their conservation status and needs. In the sections in between, chapters discuss the evolutionary history of these bats, their major physiological and behavioral adaptations, and their ecological roles in the web of life. Wherever appropriate, adaptations are discussed from a phylogenetic perspective to emphasize the evolutionary pathways that this adaptive radiation has taken. Major takeaway messages from these sections and their chapters include

1. Knowledge of the biology of bats of the New World family Phyllostomidae has advanced tremendously since Baker et al.'s seminal

monographs. The range of disciplines that now use phyllostomid bats as a model system is huge and encompasses not only many traditional biological fields such as systematics, behavior, and ecology but also transdisciplinary fields such as complexity and robotics.

2. Phyllostomid bats have undergone a much broader evolutionary radiation in terms of species richness, body size, ecology, physiology, and behavior than their noctilionoid relatives and other bat taxa and most other mammalian taxa. Ancestrally insectivorous, the basic foraging mode of this family involves gleaning prey from vegetation instead of aerial hawking. This foraging mode is probably the key adaptation that allowed these bats to evolve into a diverse array of feeding niches, including sanguinivory, carnivory, nectarivory, and frugivory. Biogeographical history and ecological interactions among trophically similar species and their food resources seem to be key for understanding this radiation.
3. The roles played by phyllostomid bats in the web of life go far beyond those traditionally considered. For instance, these bats now receive much attention from public health authorities for being reservoirs of emerging diseases such as coronaviruses. Their relative contribution to different ecosystem services together with those of other animals such as birds and reptiles is now much better understood. They are also considered outstanding models for cutting-edge studies on biomimetics, ranging from drug development to aerodynamics and communication.
4. Deforestation, habitat fragmentation, and roost disturbance are major threats to phyllostomid bats, and an important focus on their conservation has emerged in the last few decades. Major bat conservation networks have developed within Latin America and the Caribbean with an emphasis on basic research, public education, and local conservation actions. Despite this activity, much remains to be done to increase public awareness and appreciation for the ecological and evolutionary importance of phyllostomid bats.

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