

THE SAUROPODS: EVOLUTION AND PALEOBIOLOGY, by Kristina A. Curry Rogers and Jeffrey A. Wilson (editors), 2005. University of California Press, 349 + ix pp. US\$65.00. ISBN 0-520-24623-3.

Sauropods are the reigning champions of the superlatives; it is difficult to argue against their appeal. This group of dinosaurs includes some of the largest vertebrates ever, only eclipsed in size by some balaenopterid whales of the marine realm. Yet, beyond the intrinsic fascination with world records, what can sauropod dinosaurs tell us about evolution and other aspects of biology? *The Sauropods: Evolution and Paleobiology* hopes to answer these questions.

This book is a collection of papers by the younger generation of sauropod dinosaur workers that resulted from a 2001 symposium at the Society of Vertebrate Paleontology annual meeting; it is not meant to be a comprehensive review of all aspects of sauropod paleontology. Symposium volumes are always difficult to review because a mélange of contributions is inherently less cohesive than an authoritative overview by one or two authors. Accepting this limitation, how well do the assembled papers of *The Sauropods: Evolution and Paleobiology* address the most interesting avenues of sauropod research, and will they stimulate future research?

To answer this question, we have to evaluate what topics in sauropod paleontology address questions that inform us more generally about evolutionary biology. Surprisingly, the public's fascination with size may be more informative than we recognize. Sauropod dinosaurs are one of the best possible case studies for the interaction of large body size and evolutionary constraint. Several fundamental questions can potentially be informed by sauropod paleobiology: is there a limit to terrestrial body size, and if so, what is it? How does an organism grow to large size? How does large size constrain physiology and ecology, or vice versa? What are the effects of large size on the biomechanics of an organism?

To begin to answer these questions, we first must ask: "what is the largest sauropod?" The answer is: "it depends." Size is difficult to quantify; even with simple geometric shapes, mass does not scale isometrically with length, width, surface area, or volume. Complex biological shapes are even more difficult because allometry differentially affects each region of the organism's body. Thus, we may first want to understand the scaling relationships of sauropods before we address how large they actually became. Although this complex subject is further complicated by fragmentary fossils, I am surprised that none of the contributions tackles these questions. The chapter on postcranial pneumaticity by Wedel is the only one that addresses maximal body size of sauropods by demonstrating the effect that air sacs have on mass estimates. In order to discuss possible limits to terrestrial body size of animals, it is crucial to understand what maximum size sauropods actually achieved.

Regardless of maximum size, sauropods were massive, so how did they grow to be so big? We know that like other archosaurs, sauropods hatched from hard-shelled eggs; the physical construction of eggshell constrains the embryo to a small size that cannot scale in proportion to body size. This is aptly demonstrated by the fantastic sauropod embryos described in the chapter by Chiappe and colleagues. Given that other dinosaurs had elevated metabolisms and rapid growth rates, sauropod dinosaurs must have either accelerated their growth rate or extended their period of maximum growth rate to achieve such large sizes. Currently the growth trajectories are not well resolved because so few sauropodomorph dinosaurs have been subjected to histological study. The chapter by Curry Rogers and Erickson summarizes our knowledge of sauropod histology, primarily from *Apatosaurus*. They suggest that at least *Apatosaurus* took the first proposed route and had a maximal growth rate similar to that of the fastest growing eutherian mammals.

Of all the sauropod research questions listed above, the area that is most successfully addressed by *The Sauropods: Evolution and Paleobiology* volume is how large body size affects ecology and macroevolutionary trends. Although the studies are not explicitly framed around body size, I found two chapters by co-authors Barrett and Upchurch extremely illuminating. The first study examines sauropod taxonomic diversity through time and contrasts phylogenetic and taxic approaches. The general conclusion is that sauropods experienced several separate radiations throughout the Jurassic and Cretaceous. This record is more complex than previously supposed, and it would be productive to have these results interpreted in the context of body size. For example, do any of the diversification events correlate with body size changes among lineages? The second contribution by these authors takes a broader view of sauropod diversity through time and focuses particularly on feeding ecology. Their analysis reveals a strong temporal trend from a preponderance of taxa with narrow-crowned teeth to broad-crowned teeth. Again, given that food processing is essential to growth, do these changes in feeding ecology correlate with changes in body size?

Similarly, the biomechanics of multi-ton organisms are not well understood. Large body size has an obvious effect on locomotion—limb loading can be a severe problem if body plan construction is not appropriate. But with so few modern analogues beyond elephants, we have little context for the biomechanics of such massive quadrupeds. How did sauropods cope with these problems? Carrano's chapter explicitly analyzes sauropod locomotion within the context of the evolution of large body size. He finds that several features, such as columnar limb posture, increased limb robusticity, and shortened distal limbs evolved in sauropods simultaneously with increasing body size. Interestingly, these features are independently acquired in other dinosaur clades that also evolve large body size. Among large sauropods, Carrano finds that there are several different locomotory body plans; it would be interesting to know how these interface with other aspects of sauropod biology, such as feeding ecology, that are addressed elsewhere within the book. Carrano provides an excellent study that demonstrates the effect of body size on other aspects of biology. This approach suggests that integrating biomechanical, ontogenetic, and ecologic data with body size can effectively illuminate how evolving large size effected sauropod dinosaurs through time.

The broad spectrum of topics investigated by the authors of this book is blemished only by the presentation in several contributions of a lot of previously published data without sufficiently new interpretations. The long gestation period for this volume (4 years) provided ample opportunity to add new data; it is disappointing to see papers that are nearly identical to earlier publications by the same authors. However, several other studies are filled with new data, interpretations, and most importantly, insight. Although *The Sauropods: Evolution and Paleobiology* may not address or answer all of the questions most pertinent to sauropod paleobiology, it does provide several innovative contributions that demonstrate why sauropod dinosaurs are interesting biological case studies, and the conclusions of these studies will undoubtedly inspire new questions.

RANDALL B. IRMIS  
Museum of Paleontology  
University of California  
Berkeley, CA 94720-4780