

BOOK REVIEWS

Copeia, 2007(1), pp. 234–239
© 2007 by the American Society of
Ichthyologists and Herpetologists

THE SAUROPODS: EVOLUTION AND PALEO-BIOLOGY. Kristina A. Curry Rogers and Jeffrey A. Wilson (eds). 2005. The University of California Press, Berkeley, California. ISBN 978-0-520-24623-2 (hard cover). 358 p. \$65.00 (hard cover).—The giant sauropods have captured the imagination of the public since their discovery. Their enormous size and morphological oddities embody the exotic nature of dinosaurs and present conundrums of physiology and biomechanics that have, for decades, challenged scientists who study them.

The monophyly of sauropods as a group is unquestioned (Upchurch, 1998; Wilson and Sereno, 1998; Wilson, 2002; Upchurch et al., 2004), and their close relationship to prosauropods as an ancestral taxon is likewise robustly supported. However, relationships within the clade are less clear, a problem exacerbated by fragmentary remains and missing or incomplete skull material that would be diagnostic. Evolutionary relationships aside, this dinosaurian taxon poses many questions that were thought to be unanswerable. However, in the book *The Sauropods*, edited by K. Curry-Rogers and J. Wilson, many of these issues are addressed, and new light is being shed, not only on relationships, but on many aspects of the paleobiology of the group as a whole. New techniques, analytical approaches, and comparisons, coupled with new sauropod discoveries, are beginning to provide answers to questions regarding growth strategies (Chapter 11), feeding mechanisms and strategies (Chapters 4–6), behavior (Chapter 9) and even reproduction (Chapter 10).

Most chapters in the multi-authored book end with a heartfelt dedication to Jack MacIntosh, whose unfailing passion for this wonderful group of animals has inspired many present and future generations of scientists. I am not a morphologist, or an expert in phylogenetic analyses, and sauropods are not the focus of my research. But I love dinosaurs, and I will not soon forget the pleasure of sitting next to Jack at a dinner after one of many meetings celebrating dinosaur diversity. I have never met a nicer, more humble, kind, warm human being—a rarity among academics devoted to obscure and esoteric studies, including paleontology. Jack's passion for sauropods was and is immediately apparent, but his childlike curiosity for all things dinosaurian is

captivating—and motivating as well. He has a gift for encouraging beginning and 'old guard' scientists alike, and his enthusiasm radiates to all who study any aspect of dinosaur science. These accolades to an exceptional scientist, and more, a wonderful human being, and the high praise and recognition of his contributions to this discipline, are richly deserved.

The book ranges from overly technical in places to an almost folksy discussion of topics. The early chapters in this book are dedicated to the history of scientific investigation of the sauropods, and to the evolutionary relationships between sauropod clades and of sauropods to other dinosaurian taxa. The copious reference list at the end of every chapter provides a comprehensive summary of work done in the area discussed, and provides a wonderful starting place for students of dinosaur biology interested in any area of study.

Chapter 1 is a thorough description of diagnostic characters that nest the sauropod clade within Saurischia, and that diagnose individual clades within Sauropoda. It also presents a brief history of the attempts to classify this group of dinosaurs and the various methods employed to do so. It also discusses the various 'defining' characters of sauropods, including elongation of cervical vertebrae and adaptations of the limbs to a columnar stance, requirements for terrestrial animals of such great mass. Chapter 2 embraces the outlandish and bizarre features of titanosaurs, arguably one of the most successful of sauropod lineages, and describes the geographical and temporal distributions of this clade. Curry-Rogers segues nicely from the phylogenetic overview of sauropods presented in Chapter 1 to a narrower cladistic analysis of characters defining the titanosaurs within the sauropods. The discussion and diagnosis of *Rapetosaurus krausei* as a 'keystone titanosaur' provides some resolution to the phylogenetic and evolutionary picture of this dominant, widespread, diverse clade. The list of diagnostic characters provided in the appendix is impressive, and forms a robust framework for future phylogenetic hypotheses as new specimens are discovered and described.

An informative discussion of fluctuating patterns of sauropod diversity is the focus of Chapter 3. The attempts to distinguish taphonomic artifacts from true evolutionary trends is thoughtful and emphasizes the need for consideration of sedimentary and stratigraphic context when attempting to discern true extinction and/or diversification events vs. number of opportunities to observe. This is not often directly addressed in

dinosaur paleontological literature. The trend of increasing diversity throughout the Jurassic, followed by a dramatic decrease at the Jurassic-Cretaceous boundary and, surprisingly, a second peak of diversification and radiation in the Campanian-Maastrichtian is highlighted in this chapter. These trends can be validated when sedimentary context is considered in light of the possibility of collection and/or preservational bias. For example, when the number of opportunities to observe is high and diversity is low, this probably represents a real decline, rather than sampling artifact. The need for environmental context in paleontological studies is often not given adequate attention in the recovery of dinosaur remains.

Sauropod diversity as a function of various adaptations is the focus of Chapters 4–6. Diversity in feeding mechanisms, including tooth shape, occlusal strategies, and jaw action, are discussed in Chapter 4. Characteristics of tooth and jaw structure are outlined for the major taxa within Sauropoda, and peaks in sauropod diversity are correlated to peaks in the diversity of tooth morphology. Although no attempts are made to hypothesize dietary components or textures based on these dental features, intra- and interspecific competition, as illustrated by food processing adaptations, is briefly addressed. The authors briefly address the possibility that feeding diversification, as illustrated in the sauropod clades, might be tied to plant diversification, but stress that little floral diversity, turnover, or replacement is noted in the Jurassic, when many of the adaptations of sauropod lineages were acquired. It seems that an opportunity to address paleoecological interactions potentially involved in the change in crown height or other adaptations could be expanded upon, but they do conclude by crediting the radiation and diversification of the sauropods to complex adaptations in feeding strategies.

Sereno and Wilson continue the discussion that adaptations in feeding mechanisms were tied to sauropod success. In light of the hypothesis that sauropod diversity declined with the advent and radiation of ornithischian herbivores, presumably made possible by the advanced food processing abilities of complex dental batteries, the authors describe the evolution of a complex dental battery in at least one sauropod lineage, the rebbachisaurid *Nigersaurus taqueti*. They partially refute the causal relationship between ornithischian radiation and sauropod demise due to the lack of mechanisms for increased feeding efficiency, and thus decreased ability to compete, in the latter. The origin of dental batteries in response to the rise and diversification of angiosperms has been

posited, but these authors point out that because dental batteries evolved separately in at least three dinosaurian lineages (the ceratopsians, euornithopods, and sauropods), this trend cannot be linked specifically to any one environment or trend.

The concept of a feeding window as an evolutionary force in various sauropod lineages is addressed in Chapter 6. Based upon inherent flexibility in the cervical vertebrae, Stevens and Parrish separate various sauropod lineages into habitual stance and feeding habits. Through detailed tomographic images and digital reconstructions, they portray the possible ranges of neck curvatures and flexibility in sauropod groups. Evidence that some sauropods were rather limited in browse height, while others were capable of quite extensive vertical range, provides a mechanism of niche separation, and thus reduced competition, among groups of sauropods with overlapping geographic and temporal ranges. Finally, the correlation between feeding strategies and floral evolution is addressed, and the authors link height of growth within known groups of Mesozoic flora to possible sauropod feeding strategies.

A shift from feeding mechanisms to overall paleobiology begins with Chapter 7, where skeletal pneumaticity is considered in light of overall mass of these gargantuan terrestrial herbivores. Wedel first examines criteria for recognizing pneumaticity in sauropod elements, and distinguishes between pneumatic and non-pneumatic fossae, discusses the possible mode of evolution of pneumaticity in sauropods, and links this to ontogenetic trends. He distinguishes between pneumatic diverticula and the avian-type air sacs, and the biomechanical implications of pneumatic skeletal lightening for sauropod biomechanics. I found the over-use of abbreviations in this chapter rather distracting, but the information it contains is quite comprehensive.

The focus of Carrano's chapter (Chapter 8) is sauropod locomotion, and he places the development of adaptations for mass in the limbs, manus, and pes in an evolutionary context. These adaptations are present in the earliest sauropods for which we have data, and he notes the progressive increase in size within all sauropod clades except the derived macronarians, which show a significant decrease in size over time. Primary graviportal adaptations discussed include reduction or elimination of phalanges and unguals in the manus and pes, resulting in a loss of propulsive ability in favor of mass support, coupled with elongation and expansion of the ilium. The suggestion that in some sauropods elongation of the forelimbs resulted in expansion of the feeding window (Chapter 6)

was an especially intriguing illustration of possible exaptation, as elongation originally may have been a response to mass increase, but secondarily resulted in feeding advantages.

How these massive animals moved within their ecospace progresses from skeletal adaptations to evidence gleaned from trackways in Chapter 9. The discussion begins by linking foot morphology, inferred from pedal skeletal elements, to ichnological traces. The predictive model of Unwin (1989), which produces idealized, completely detailed tracks based upon skeletal patterns and morphology, is combined with the cladistic model of Olsen (1995) and Carrano and Wilson (2001) to achieve a track classification model. Tracks are assigned to various sauropod groups based upon manus/pes relationships and narrow vs. wide track gauges. In this chapter, Wright also discusses the spatio-temporal distribution of various tracks, with tracks referable to sauropods identified from Triassic sediments and throughout the Jurassic and Cretaceous. The author refers to accompanying lithological information for possible environmental interpretations that may be loosely employed to suggest habitat preferences; however, the cautionary observation that sauropods may have lived in habitats not conducive to preservation of tracks is well advised. Interesting concepts highlighted in this chapter include the idea that preserved tracks attributed to sauropods show a greater size distribution than preserved skeletal elements. The latter are strongly weighted to adults, while the former show a more even size distribution to include a range of sizes, perhaps better reflecting population ratios, environmental preferences, and behaviors than do skeletal elements, when taphonomic bias is taken into account. From trackway data, gregarious behavior can be inferred, and instances of herding, though rare, can be supported.

Sauropod behavior is also addressed in the discussion by Chiappe et al. (Chapter 10) of the extensive nesting horizons discovered at Aucas Mahuevo in Patagonia, Argentina. This site has produced abundant evidence of site fidelity, gregarious nesting, nest building behavior, and nest attendance, although parental care is not suggested by the data. This is one of the few instances where eggshell morphology and microstructure can be definitively assigned to a particular dinosaur taxon because the one necessary criterion for this assignment, the presence of identifiable embryonic remains within the eggshells, is met. The presence of embryos also provides previously unknowable information regarding developmental and ontogenetic patterns in this clade of titanosaurid sauropods, as

embryos vary in size by as much as 25%, and skull elements are more completely ossified than other skeletal remains. In fact, the presence of abundant embryonic skull material associated with this site provides more cranial information than has yet been gleaned from any adult sauropod taxon. In addition, pathologies were noted in eggshell formation that may shed light on reproductive strategies and physiologies in these animals. Further studies of this nesting ground will no doubt continue to yield biological and behavioral insight into this abundant and successful sauropod group.

The academic portion of this volume ends with a thorough and informative discussion by Erickson and Curry of bone histological patterns as applied to sauropod taxa. The chapter includes a well written and concise summary of histological patterns exhibited in bones of various vertebrates, and the correlation between these patterns and bone deposition rates. For example, bone deposition rates can be estimated by considering apatite crystal arrangement as it reflects once living collagen fiber orientation, variation in vascular organization is an indicator of growth rates, where reticular and/or laminar organization indicates the upper end of rapid growth, and longitudinally oriented osteonal bone reflects the slowest rate of deposition. The authors discuss many cautionary notes in rigid interpretations of histological data and stress the need for multi-element studies when estimating overall organismal growth, as inter-element variation in deposition is considered. Histological analyses of all sauropods studied to date indicate that in no case is the typical 'reptilian' pattern of growth supported, but that these animals grew at a far more rapid pace. In fact, the largest of these dinosaurs grew most rapidly, while the smaller ones grew at a slightly slower pace. While the rate of growth of these massive animals was spectacular, all apparently grew more slowly than the rates observed by extant blue whales.

The general rules for histological interpretation, along with the limits regarding what can be said from histological studies, is then applied to one particular taxon of sauropods for which a growth series exists, that of *Apatosaurus*. Based upon these data, maximum growth rates are proposed. Much of the information presented in this chapter can be applied to the study of other dinosaurs, and indeed to most vertebrates distributed throughout the fossil record.

The book ends with a delightful discussion between the editors and Jack McIntosh, the father of sauropod paleobiology. Jack's long life and career, and his lifelong interest in these wonderful creatures, provide a historical context

for the study of sauropods and dinosaurs in general. Jack's career was interrupted by war, but his opportunities and interest allowed him to have first-hand contact with some of the historical greats of early paleontology, including Barnum Brown, Richard Lull, Ed Lewis, and Alfred Romer, men who helped to lay the foundations of present-day dinosaur science. The opportunity to see the field of vertebrate paleontology through the eyes of one who has been so fundamental to it was an exciting and fitting way to end this comprehensive book on sauropod evolution, phylogenetic relationships, biomechanics, reproduction, physiology, and growth. The volume will be an important addition to the reference library of any serious dinosaur paleontologist, but contains a wealth of useful information for anyone interested in the diversity and evolution of life on this planet.

LITERATURE CITED

- CARRANO, M. T., AND J. A. WILSON. 2001. Taxon distributions and the tetrapod track record. *Paleobiology* 27:564–582.
- OLSEN, P. E. 1995. A new approach for recognizing track makers. *The Geological Society of America Abstracts* 27:86.
- UNWIN, D. M. 1989. A predictive method for the identification of vertebrate ichnites and its application to pterosaur tracks, p. 259–274. *In: Dinosaur Tracks and Traces*. D. D. Gillette and M. G. Lockley (eds.). Cambridge University Press, Cambridge.
- UPCHURCH, P. 1998. The phylogenetic relationships of sauropod dinosaurs. *Zoological Journal of the Linnean Society* 124:43–103.
- UPCHURCH, P., P. BARRETT, AND P. DODSON. 2004. Sauropoda, p. 861. *In: The Dinosauria*, 2nd edition. D. B. Weishampel, P. Dodson, and H. Osmolska (eds.). University of California Press, Berkeley, California.
- WILSON, J. A. 2002. Sauropod dinosaur phylogeny: critique and cladistic analysis. *Zoological Journal of the Linnean Society* 136:217–276.
- WILSON, J. A., AND P. C. SERENO. 1998. Early evolution and higher level phylogeny of sauropod dinosaurs. *Society of Vertebrate Paleontology Memoir* 5:1–68.

MARY HIGBY SCHWEITZER, *Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina 27695; E-mail: schweitzer@ncsu.edu.*

Africa. ISBN 1-920033-01-7. 488 p. \$40.00 (paperback).—Co-written by Phil and Elaine Heemstra, and illustrated by Elaine, this book is a well organized and attractively presented guide aimed primarily at anglers, enthusiasts, and divers/snorkelers who want a general overview of the fishes found along the South African coasts, rather than an exhaustive species-level treatment of any one group. The original illustrations by Elaine Heemstra are excellent, and the many features presented for identifying specimens to both family and species levels are easy to understand and can be utilized by those with only a limited knowledge of fish anatomy. The wealth of introductory material and included glossary are useful additions.

My main complaint with this book is due to its cursory (and uneven) treatment of nearly all families at the species level. Only 400 of approximately 1800 species occurring in the region are included. In the Introduction the authors note, “this book will help to identify the fish found around [the South African] coastline . . . as well as deep sea species of interest to sport and commercial fishermen”; however, treatment of most families is not sufficient for the book to function as a reliable identification source. This is mainly a book for the amateur hobbyist, diver, and angler, which is evident from the uneven treatment favoring popular sportfish groups (e.g., sparids, for which 37 of 41 species in the region are illustrated and described) over groups exhibiting much more diversity in the region (e.g., gobies, for which only three of 111 regional species are included) but not targeted by anglers. In addition, coverage also favors colorful and well-known groups (e.g., butterflyfishes) over less conspicuous, yet more diverse, members of the reef community (e.g., blennies, apogonids). The end result is an attractive book that unfortunately is not comprehensive enough for identification of species beyond common sportfishes or well-known and conspicuous reef fishes.

Other minor concerns have to do with presentation and organization. Although the authors state (p. viii) that the families are [presented] in a phylogenetic (evolutionary) order, the presentation is, in fact, far more traditional than phylogenetic. The presentation does not proceed hierarchically from more to less inclusive clades in the context of a phylogenetic hypothesis. Above the family level, no additional information on the relatedness of the various families is presented (e.g., it would have been helpful to include ordinal rank). In general, a more up-to-date systematic treatment throughout would have been welcomed. For example, Scaridae is treated as a separate family, and not included within Labridae.

COASTAL FISHES OF SOUTHERN AFRICA. Phil and Elaine Heemstra. 2004. South African Institute for Aquatic Biodiversity and National Inquiry Service Centre, Grahamstown, South

Overall, this book presents a nice introduction to the fishes one might encounter angling or diving in South African waters, and it can serve as a starting point for those wanting to dig deeper into the diverse marine fauna of the region. General and easy to locate external features for identifying specimens to family and species are presented and will be useful to both anglers and divers/snorkelers. The included notes on similar species one might confuse with the featured species are quite helpful and well written. Species-level coverage, however, is not comprehensive enough for the book to be useful as a regional identification guide. In all fairness to the authors, that does not appear to have been the intention in writing this book.

JOHN S. SPARKS, *American Museum of Natural History, Department of Ichthyology, Central Park West at 79th Street, New York, New York 10024; E-mail: jsparks@amnh.org.*

AN ATLAS OF MICHIGAN FISHES WITH KEYS AND ILLUSTRATIONS FOR THEIR IDENTIFICATION. Reeve M. Bailey, William C. Latta, and Gerald R. Smith. 2004. Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 192, Ann Arbor, Michigan. ISBN 0076-8405. 215 p. \$35.00 (paperback).—Bailey et al. have written a practical and much needed atlas and key covering the important ichthyofauna of Michigan. This state is center stage to the largest freshwater lake system in the world. Of the 172 species of Great Lakes fishes, 153 are found in Michigan. This atlas, which tackles each one of these Michigan species, will be a great resource to anyone studying the fauna of this region. Its only flaw is its textual economy.

Of the 215 pages, 154 are devoted to one-page species (and two subspecies) descriptions. There is little description on these pages. Each species page provides the common and scientific name, a large map of Michigan with spots representing localities for vouchered specimens, and stippling for approximated localities based on records without vouchers. A black and white illustration of the fish is also given for each species, and many species also have separate detailed illustrations for less conspicuous diagnostic features (e.g., fin spines showing serrations for the catfish) or juvenile stages. The beautifully drawn illustrations by Karen Klitz provide enough detail for many scale and fin-ray characters to be compared. A scale bar and Peterson-esque

markers for diagnostic features also accompany the illustrations, as do short phrases explaining these features. No natural history or life history is discussed. The lack of any such information makes the Atlas perhaps a less enjoyable text, but certainly the concision does not detract from it functioning as an excellent guide to identification.

A nice touch is several pages of large illustrations outlining the general body shape and characteristics of different fish families, followed by a few lines of text to aid identification. A novice should have no problem identifying a particular fish to family using this key. The Atlas also contains keys to genera for 28 families and keys to species for 29 genera. These are generally easy to use and straightforward, or at least as straightforward as possible. (Given the number of hybrids it seems some of these species have a hard time telling each other apart.) Keys to species use characteristics from life, but also meristics, and more general attributes that can be used on preserved specimens (e.g., dorsal-fin margin falcate, lips plicate). A very useful glossary of over 200 terms used in the keys includes everything from “abbreviate” to “Weberian complex.” Unfortunately the keys are not indexed. Someone that has just caught what they think may be a common shiner can go to the front of the book, browse through the list of fishes and find the scientific name (*Luxilus cornutus*) and the family (Cyprinidae) and then flip through the 20-odd pages of keys to find the appropriate pages. This will certainly frustrate the novice, but also the more seasoned researcher having many species to key out. An index by common and scientific name listing every associated page for maps and keys would have made the Atlas more user-friendly.

Nearly 175,000 georeferenced records are recorded in the Atlas. The Michigan maps of all localities by county and watershed are so peppered with collection sites that the background maps are almost unnecessary to see the outline of the state and its drainages. The maps on each page take over half the page so the dots and stipples representing sites can be easily seen. Much of the original collecting work that is represented by these points were based on the work of Carl Hubbs and Milton Trautman (along with Hubbs's students) in the early part of the last century. (Trautman is perhaps best known for his wonderful *Fishes of Ohio*, 1957.) Major collections by Bailey and Latta in the 1990s verified some of the earlier work including confirming a number of extirpations. Lists of Michigan extirpations, endangered, threatened, extinct, and introduced species are presented

without comment (save for a brief discussion of a few species in the introduction). Also unfortunate is the lack of temporal information; no distinction can be made between current and historical records. All points on the maps must therefore be taken as part of a species entire historical distribution in Michigan.

The almost total lack of any temporal information about collections and natural history about species must be seen as the publication's major flaw. There is a mere four pages of text in the introduction, which accounts for most of the text in the publication. In these few pages, only minimal explanations are given for taxonomic changes such as the elevation of sub-species. Equally brief are accounts of introductions and extirpations. Because the authors were often the discoverers of some of these extirpations, more information should have been presented. The Introduction promises that the publication will "enhance land-use planning from the community to the state level. Distributional patterns in relation to global warming and other environmental disturbances can be considered . . . and management plans for rare, threatened and endangered species can be made." Without the associated temporal information for these collections these comments are difficult to justify.

Associated UMMZ (University of Michigan Museum of Zoology) and MDNR (Michigan Department of Natural Resources) websites are recommended and can add a temporal component to the dots on the distribution maps; however, a few comments providing more information with the species pages could have informed the reader about vulnerable sites, conservation efforts, and distributional changes over time without having to refer to other sources.

The lack of peripheral information is disappointing only because no three individuals can claim a better understanding of this diverse fauna. Between them, there is literally centuries' worth of experience researching Michigan fishes. University of Michigan Professors Emeritus Reeve Bailey and Gerald Smith are still very active researchers at the University of Michigan Museum of Zoology (UMMZ). Dr. Latta is the retired director of the Institute for Fisheries Research (IFR) of the Michigan Department of Natural Resources and a former student of Karl Lagler. He remains an active member of the IFR, which was started by Carl Hubbs. This institute, under Dr. Hubbs's guidance, did much of the original

collecting in the state. Most of those early collections were left unidentified in the UMMZ basement until the 1970s when a young Jerry Smith and then UMMZ Division of Fishes collections manager, Ellie Koon, sorted and catalogued them. Without that work and the collections Hubbs made with his students, much of the coverage of localities reported in the Atlas would have been lost. Dr. Smith recently authored an updated version of Hubbs and Lagler's (2004) "Fishes of the Great Lakes Region" and is former director of the UMMZ. Dr. Bailey is an inspiration at 94; he continued major fieldwork for this book until its publication.

The *Atlas of Michigan Fishes* provides an important supplement to the *Atlas of North American Freshwater Fishes* (Lee et al., 1980). That text had major gaps for some Michigan species because some distributional information from the UMMZ was unavailable to the authors at the time of publication.

Perhaps too few people know that one of the largest and most diverse collections of fishes in the world is kept at the UMMZ. The Fish Division has a long and storied history and someone scanning the locality maps in the Atlas may not realize that some of the vouchered specimens were from collections made by Louis Agassiz, E. D. Cope, and Carl Hubbs, among others. The lack of this bit of history, temporal information, and the natural history of these fishes is the only downside to this publication. I hope in a future version a little surplus detail can be exchanged for concision.

LITERATURE CITED

- HUBBS, C. L., AND K. F. LAGLER (REVISED AND UPDATED BY G. R. SMITH). 2004. *Fishes of the Great Lakes Region*. University of Michigan Press, Ann Arbor, Michigan.
- LEE, D. S., C. R. GILBERT, C. H. HOCUTT, R. E. JENKINS, D. E. MCALLISTER, AND J. R. STAUFFER, JR. 1980. *Atlas of North American Freshwater Fishes*. North Carolina State Museum of Natural History, Raleigh, North Carolina.
- TRAUTMAN, M. B. 1957. *The Fishes of Ohio*. Waverly Press, Inc., Baltimore, Maryland.
- PROSANTA CHAKRABARTY, *American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024; E-mail: prosanta@amnh.org.*