REVIEWS

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The Dinosauria (second edition). D.B. Weishampel, P. Dodson, and H. Osmólska, eds. 2004. University of California Press, Berkeley, 861 p. ISBN 0-520-24209-2. $95; hardbound with many illustrations.

Standing out among the glut of dinosaur books that has swamped the market in recent years, the new edition of *The Dinosauria*, much like the first edition, is the book that most scientists and amateurs would agree is the number one ''must have'' for anyone seriously interested in dinosaur paleontology. Of course, this is not a book for kids, or even for semi-interested adults. This is a serious, scholarly tome that straddles the boundary between review and primary literature. Many concepts and data in it see their first time in print, but most of it is an up-to-date (as of 2002–2003 at least) synthesis of what we know about dinosaurs, especially anatomy, systematics, and related areas like biogeography. Judging from the previous edition, this one will be extremely widely cited in technical dinosaur papers. It is the first book that a graduate student or other researcher doing anything connected with dinosaur paleontology should purchase, without hesitation. I look back fondly on how important the first edition was for my Ph.D. years in Berkeley; I often referred to it on a weekly basis, and used those 733 pages voraciously. It was often the first stop for any information on any dinosaur taxon. So here we are with the second edition, which came out in Fall 2004 to much fanfare at the Society for Vertebrate Paleontology meeting and on the Dinosaur Mailing List (to which I owe thanks for its detailed coverage; search the October–November 2004 archives at http://dml.cmnh.org). Has dinosaur science changed that much in just 14 years to warrant an 861-page behemoth?

Of course, if you follow dinosaur research or have read the first edition, you know the field has indeed changed drastically, so a new edition is very timely. Communist Russia was collapsing as the first edition emerged; now much more of the east (especially China) has opened to an explosion of paleontological research. The chapters of the first edition were written during the unsteady adolescence of phylogenetic systematics (cladistics), and many chapters therein danced around the topic superficially. None included phylogenetic analyses rendered reproducible by the inclusion of a data matrix. It was a mix of antiquated Linnaean approaches to systematics with splashes of cladistic rigor. The new edition is unabashedly phylogenetic, with cladograms for every group (based on real analyses, sometimes considering alternative cladograms), phylogenetic ''tree thinking'' applied throughout, and yes, even data matrices (as online versions at http://dinosauria.ucpress.edu, which are better than book text matrices anyway). Similarly, the first edition covered avian theropod dinosaurs (birds) only in passing. Although most paleontologists at the time accepted this theory, competing hypotheses were still in their death throes. In contrast the present edition features Zenlike acceptance of the theory, symbolically shown in Mark Hallett's lovely ''Yixian Faunal Scene'' cover illustration: the back cover is adorned by the basal avian theropod *Confusciusornis*. This elegant cover reminded me how dinosaur art has also come of age since the first edition. It is now a more respected blend of art and science, as anyone who attends SVP and similar meetings can see. World events and social changes aside, these two advances of applying a rigorous and consistent, explicit phylogenetic context and embracing the theropod origin of birds are what stand out most in this volume. Of course, there's much more to it than that.

The brief introduction notes that there has been a 70% increase in dinosaurian genera since the last volume, a stunning statistic (average ~14 new taxa per year). In light of this, it is commendable and impressive that the editors managed only a 17% increase in the length of the volume. Fifty-nine percent of the book is a treatment of anatomy and systematics with a sprinkling of paleobiology. The chapter on dinosaur distributions is another 10% of the book, and will be an indispensable reference to anyone doing terrestrial Mesozoic field or museum work in paleontology. The main text of the book closes with relatively cursory treatments of taphonomy, paleoecology, biogeography, two counterpoint chapters on physiology and growth, and naturally a final chapter on the extinctions of the nonbirds. This section totals 9% of the book, and is followed by a beefy index (arranged in sections of genera and species, stratigraphic and geographic, and subject sub-indices) at almost 10% of the book's page count, and a hefty reference section (surely the best modern dinosaur bibliography for those that want to brush up on the literature) of similar length. The main text is 30 chapters by 43 authors, many of whom differ from the scribes of the 1990 version although the editors have remained unchanged.

When one compares such figures to those for the first edition, the proportion of the volume dedicated to sundry topics has changed little except for a slight increase of some nonsystematic/anatomical sections. The index in the new edition has greatly benefited from its relatively increased length (almost 50% more), but partly at the cost of relatively less coverage of the basic science (83% in the first edition, 79% now). As most of my comments so far suggest, the book will be quite familiar to fans of the first one, but it is still novel and superior.

Most of the systematic/anatomical chapters are the same as before in this volume (1 dinosaur introduction, 9 theropod [including birds], 2 sauropodomorph, and 10 ornithischian chapters) as in the last (1, 10 [excluding birds], 2, and 9 respectively). The short introductory sections for Saurischia and Ornithischia replace old headings for Theropoda, Sauropodomorpha, and four ornithischian clades, with a much improved phylogenetic context that will help introduce unfamiliar readers to theropods, sauropods, and ornisthichians. New or completely transformed chapters on basal Tetanurae (including Carnosauria proper), Avialae, and Ceratopsia represent our progressive understanding of these stem groups. Two former chapters on basal Ornithopoda (heterodontosaurids, hypsiolophodontids, etc.) are now merged, and the old Elmisauridae chapter is now properly part of Oviraptorosauria, reflecting the hitherto unappreciated diversity and disparity within that clade (*Caudipteryx*, the once-ambiguous *Avimimus*, etc.). Gone are the two ''problematic'' theropod chapters; most of these troublesome taxa have found a better home in other chapters, or are at least penned within appropriate basal clade sections. Furthermore, tyrannosauroids now enjoy phylogenetic separation from other large theropods, once lumped together as ''carnosaurs'' but now occupying their own chapter. Like the recognition of ''segnosaurs'' as theropod (not other saurischian) dinosaurs properly called therizinosaurs, these are enheartening contributions, revealing quick progress toward general consensus on where certain taxa fit into the dinosaurian tree. As an aside, I was

interested to see *Deinocheirus* (the giant Mongolian arms) potentially excluded from the Ornithomimosauria, deepening the mystery of what this oddball taxon is.

Certainly the devil (*Satanosaurus*?) is in the details, and any dinosaur expert will find details to argue about in the new edition; that's what makes this field so fun for many. It would take a third edition to summarize and correct such quibbles, which we should look forward to in perhaps 2018. As more of a basal dinosaur and theropod afficionado, I was surprised that the four or more genera of Alvarezsauridae, some of the strangest and most controversial/phylogenetically labile of theropods, did not get their own chapter or at least more thorough treatment. They look out of place in the basal Avialae chapter, especially as the author (Padian) notes that many workers (excluding Chiappe, whose 2001 cladistic analysis this chapter is based on) find them to lie outside of Avialae. If Troodontidae (~7 genera) have their own chapter, why not this or other clades such as the Spinosauroidea (~10 genera, left in basal Tetanurae), or Abelisauroidea (>6 genera; in Ceratosauria)? I was surprised that the question of whether prosauropods were strictly monophyletic or not was not given more coverage. Such criticisms, however, might seem excessive. For many of these groups, phylogenetic arrangements remain very contentious, and space is always an important consideration.

The most novel systematic chapters in this volume include the basal birds section, which succeeds at the difficult task of summarizing the exponential burst of new bird discoveries. Recall that little more than *Archaeopteryx*, a few enantiornithines, and Ornithurae were known at the last writing; now a six-page taxon list! The basal Saurischia chapter by Langer is an in depth analysis of various likely basal dinosaurs, most of which were very poorly known at the time of the last volume. The basal Tetanurae chapter by Holtz et al. is a comprehensive perspective that cleans up a lot of mess in this region of the theropod tree. The 75-page Sauropoda section is a huge leap forward from 14 years ago, thanks to a string of new discoveries around the world (and good phylogenetic analyses thereof; almost absent in the last edition) by the authors (Upchurch et al.) as well as Curry, Wilson, Sereno, and many others. Many of the Ornithischia chapters didn't seem as novel to me. The Ankylosauria chapter (Vickaryous et al.) was more thorough (also the only section with computed tomography scan images). It is also clear that some needed stability of relationships within basal Iguanodontia (Norman) and Hadrosauridae (Horner et al.) has been attained.

Illustrations in these anatomical chapters are an extremely important part of such a book, and I found myself often disappointed that they were of mediocre quality or unchanged from the last edition. Sure, ceratopsid skulls haven't evolved since 1990 (and I'm no Leonardo myself) but computer and imaging technologies have. We can do better. This would be my first big gripe with the book. For the third edition, I urge the editors, if possible, to use some proceeds from this volume's sales to fund a professional illustrator(s) to standardize the figures (cladograms too, as the format for these varies in all chapters), make improvements on old figures, base as many images as possible on single specimens while noting specimen numbers along with these, and clean up the labeling of figures. A useful labeling index is at the front of the book and is applied throughout. Yet I was struck by how many chapters had awful arrangements of labeling figure parts: letters A–I, for example, would usually read left-right, up-down, but in several chapters this was abandoned, and the lettering followed little rational organization. This should have been caught; it harms the quality of the book. The chapters on basal Saurischia, Ceratosauria, Sauropoda, and basal Ceratopsia in my opinion have the better anatomical illustrations. To be fair, in most second editions of books one wouldn't expect greatly revised figures—it is common practice to mostly use the same ones. But in a book that is such a highly regarded monolith of dinosaur research, we should have high standards; not to mention at $95 a pop, which is certainly still a bargain.

A primary strength, and secondary weakness, of the systematic section of the volume in particular is its strong emphasis on phylogenetic systematics, done fairly well throughout. Today such practice is considered a sine qua non of evolutionary work, so overly praising it is unwarranted. We should expect and demand it—a book like the 1990 version would be derided if published today. More problematically in some ways, the editors have required authors first to adopt standardized anatomical nomenclature (largely based on the Nomina Anatomica Avium and other nonhuman terms) and second to present phylogenetically defined taxon names for major (and many minor) clades.

In the first case, this is an admirable standard and should help communication of those terms to other anatomists. I was, however, dismayed to spot redefinition of some terms, which I didn't see discussed anywhere in the book. What was once called the lesser trochanter of the dinosauromorph femur (widely recognized as not homologous with the mammalian structure of the same name, yet analogous in terms of some deep dorsal thigh muscular connections) in recent decades started to sometimes be called the anterior trochanter. Now with the abandonment of ''anterior'' and ''posterior'' terminology in dinosaur anatomy, a change that I favor and employ, the anterior trochanter has become the cranial trochanter. The justification for this double redefinition, from what I can gather, has been that: 1) the lesser trochanter confuses too many people that it might be the same as the mammalian one, so use anterior trochanter to avoid this confusion, and 2) ''anterior'' is bad, so use cranial trochanter now. The result of these changes, in my opinion, is not only the dismissal of a widely used and acceptable anatomical term but also more—not less—potential confusion. Now will neophytes wonder if this trochanter is on the skull? Birds, pterosaurs, and bats all have wings, but we needn't have three names for wings to distinguish them just because they evolved convergently; simple phylogenetic thinking is all that is required for effective communication of anatomical terms. This is not an isolated case. For example, I also noticed that Ostrom's posterior trochanter has now become, well, a bump on the tail to people who don't know better. I expect that in the primary literature, though, the traditional terms will continue to be used; after all, jargon is a tool of the scientist, not the opposite. Granted, as I have studied femoral anatomy in detail, this is a matter of personal preference. Language always evolves, but it still is an important judgment call when to change it, and opinions will vary.

Many readers, however, will have much more difficulty with the second aspect of the phylogenetic approach in the second edition. I have endorsed and published using phylogenetic nomenclature, but also realized that this practice, which can be very useful for explicit and consistent, objective communication, has spiraled out of control in dinosaur systematics. Clades supported by one or a few characters are frequently named, often with three novel names coined for each of those clades (node and two stems). I doubt we need so many names for so few taxa and cladograms that are usually very sensitive to new discoveries or different character analyses. This book is a prime example of the current state of anarchy in dinosaur higher-level taxonomy. Take, for example, the venerable names Ornithischia and Saurischia for the two main clades of dinosaurs. Three different definitions are proposed in the book for each of these, often in successive chapters! I respect that phylogenetic taxonomy is still in its tentative adolesence (there are no real rules yet, just lots of suggestions), and expect that if the PhyloCode survives to maturity much of this chaos will be reined in, but such proliferation of taxon definitions in one book seems avoidable. Furthermore, even with a quick glance I found many taxon names that were defined without

inclusion of the genus from which their name was derived—e.g., Abelisauroidea, Dromaeosauridae, Titanosauria, Chasmosaurinae, etc. Regardless of where dinosaur taxonomy goes in the future, I felt that the erratic application of phylogenetic taxonomy in the second edition, although commendable in principle, dealt yet another blow to my hope for an expedient and scholarly resolution to this basic, if semantic, technical issue. I doubt I'm just part of a small minority of the readership that will depart with this impression.

The second ''Dinosaur Distribution and Biology'' section of the book likewise has its ups and downs. I've already praised the dinosaur distribution chapter for its utility, but I was puzzled to see the biogeography chapter separate from it, with intervening chapters on taphonomy and paleoecology. Fossil distributions are distinct as fairly objective, empirical data, whereas biogeography involves application of methods to these data, but I don't see a good reason to keep them so separate. Yet as the first edition essentially lacked a biogeographic component, addition of this research was still a superb choice. Additionally, division of the old ''behavior patterns of dinosaurs'' chapter into Taphonomy and Paleoecology chapters is a wise choice, as is dissemination of the old Carnosaur and Sauropod Paleobiology chapters among relevant systematic and paleobiological chapters. I really like those old chapters but they did seem lonely out in the systematic section of the first edition; and was ornithischian paleobiology just not interesting enough?

I heartily applaud the style of presenting the two most contentious, challenging issues in dinosaur science, physiology and extinction, in chapters of two opposing views and one dialogue. The former pits modern ectothermy advocates Chinsamy and Hillenius against modern endothermy champions Padian and Horner. The latter pairs Archibald, in the intrinsic gradualist extinction corner, with Fastovsky, from the extrinsic catastrophist faction. This is the third highlight of the book: giving due justice to the difficult nature of these crucial issues, and leaving the reader with enough information to come to their own decision. As a researcher who pays close attention to these controversies yet is personally uninvested in either one as my research subject, and still relatively noncommittal on both, I found them exceptionally balanced and informative. Like the systematics chapters, these exchanges reveal healthy, fertile, and dynamic areas of investigation in dinosaur research.

The dialectic between the physiology chapters is quite heated, making it clear that similar evidence (e.g., lines of arrested growth in bones, or bone tissue types) can be interpreted very differently by different researchers. The fundamental challenge is that there is still no litmus test for endothermy, even respiratory turbinates, protofeathers, or rapid growth patterns. What remains lacking is a definitive link between fossilized form and metabolic function that would unambiguously diagnose endothermy. The complexity of endothermic metabolism in extant animals, and the gradation in physiology between ends of the ecto/endothermy dichotomy, hint that finding such a simple link might be a harder quest than many might anticipate, barring exceptional biochemical preservation. Happily, consensus is that dinosaurs were rapid growers (about 5–20 years to maturity) but also some could have reached somewhat high activity levels, even homeothermy, at least in larger forms. Extinct dinosaurs aren't now envisaged simply as sluggish reptiles and nothing else. Whether their growth patterns were more primitive or derived for non-avian dinosaurs or basal birds, or whether activity levels were sustained or very intermittent, are issues forming the major gulf between these schools of thought. I disagree with Chinsamy and Hillenius's contention that ectothermy for all non-ornithurine dinosaurs is a more parsimonious solution than endothermy. In a phylogenetic context, these are equally equivocal, as endothermy must have evolved somewhere, which involves at least one step change on the line to Neornithes regardless of where it occurred. Moreover, some readers might object to how Padian and Horner state that ''dinosaur physiology is less a matter of evidence than of preconception,'' but then base their case on evidence. Nonetheless, their argument for endothermy is the most sophisticated synthesis of this evidence I've seen yet. Regardless of one's preconceptions of this controversy, reading these two review chapters is excellent preparation for diving into the primary literature, and is ideal for those just wanting a modern overview.

The extinction chapter is refreshingly sedate and less polarized, but like the physiology chapters is honest about many ambiguities inherent to interpretations of the fossil record for analyzing patterns and inferring processes of extinction. This chapter focuses on the end-Cretaceous extinctions of dinosaurs. To read about the extinctions near the end of the Triassic period, which may have given dinosaurs their big break to diversify, one can find a short section in the first chapter of the book, by Benton. Other extinctions of dinosaurs between their origin and extinction have far less coverage. Archibald and Fastovsky review the most important geologic, biotic, and extraterrestrial evidence. Also like the physiology chapters, they show that much consensus on formerly contentious issues exists. However, they conclude with two opposing views: one favoring multiple causes for the disappearance of nonneornithine dinosaurs at the K/T boundary (i.e., bolide impact just delivered the coup de grace); another preferring a ''more parsimonious'' single cause (the wayward asteroid). The authors concede that the evidence remains scant and geographically restrictive, so the most conclusive tests of the opposing hypotheses await discovery of terrestrial K/T data from continents other than North America. Again, this chapter is a valuable resource for everyone interested in the mystery of why the only living dinosaurs are neornithine birds.

My final critique of the book is its focus. As in the last edition, the breadth of the field of dinosaur research was not granted as balanced coverage as I'd prefer. The title ''The Dinosauria'' implies a comprehensive treatment of the clade. Yet the majority of the book emphasizes dinosaur osteology, systematics, and the fossil record; paleobiology takes a back seat to this important foundation. Additionally, the book lacks a synthesis of two other forms of core data important for paleobiology: fossil footprints and eggs (one might add integument or other soft tissues). These data are spread throughout many of the chapters, but a review that integrates them would have been worthwhile. Likewise, for the systematic chapters my general reaction was that biological inferences (other than phylogeny) were usually treated superficially. The osteological and systematic detail was inarguably comprehensive, then trailed off into slim coverage of other methods and evidence. This proportion of paleobiology coverage does not match the balance in the literature very well.

One explanation for this pattern is probably current scientific practice: many dinosaur researchers are systematists first and foremost, then only dabble in nonosteological/phylogenetic questions. No one can or should do everything. I'm not sure if the way the paleobiology chapters were reorganized for the new edition—leaving much of this work to those of a more systematic bent—was the best choice. Leaving it out altogether would be much worse, of course. An alternative would be to take the paleobiology chapters and end-chapter paleobiology overviews out and maintain the focus on the core data and phylogenetics (adding in more treatment of eggs and tracks?), extracting nonsystematic paleobiological questions for a separate volume. I thought the choices of authors for the anatomy/systematics and other traditional paleontology chapters were optimal, and I couldn't think of better authors for the paleobiology chapters. Yet there should have been

a better way to portray the diversity of dinosaur research in such an ambassadorial volume.

Dinosaurophiles can effervesce with enthusiasm for this book, and there's no denying that it's a huge improvement over the last edition, which is saying a lot. If you work on dinosaurs, I'd hope you already obtained it; if not, shame on you. If you don't do dinosaur research but want to catch up on dinosaurs or fill in a gap in your bookcase with the best modern reference, make speed to your nearest bookseller for it and ignore other candidates until you own it. For those interested in the history of science, comparison of this edition and the last is a good exercise in observing the swift maturation of a science into a confident yet increasingly circumspect, integrated yet diverse modern field.

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