BOOK REVIEWS

Ryan, M.J., B.J. Chinnery-Allgeier & D.A. Eberth. Eds. 2010. New Perspectives on Horned Dinosaurs: The Royal Tyrrell Museum Ceratopsian Symposium. – Bloomington, Indiana University Press

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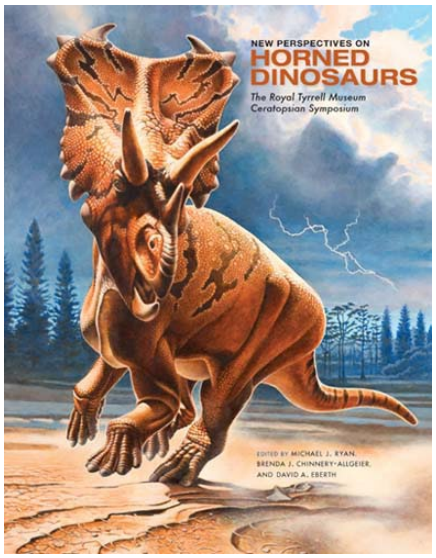

The Ceratopsia or horned dinosaurs are a very distinctive group of ornithischian dinosaurs. All have a narrow beak, and most have bony collars or frills extending from the back of the skull. The earliest forms were still rather small and bipedal. Later taxa attained large head and body size and became quadrupedal; they are often considered the dinosaurian analogue of a rhinoceros. Most of these derived forms also sport prominent nasal and/or supraorbital horns. One of the geologically youngest ceratopsians, *Triceratops*, ranks among the most widely known dinosaurs, rivaling its likely predator, *Tyrannosaurus rex*, in popular recognition.

Despite their appeal, ceratopsians have been the subject of only a few comprehensive studies. The classic monograph of the Ceratopsia by Hatcher *et al.* (1907) summarized all that was known about these dinosaurs at the time, with emphasis on the collections of *Triceratops* that had been made for Othniel Charles Marsh at Yale during the second half of the 19th century. Lull (1933) published an updated review of the group, which had grown considerably in known diversity during the intervening years, mainly as the result of discoveries of new taxa from the Upper Cretaceous of Alberta, Canada. Like most research on dinosaurs, work on ceratopsians proceeded at a slow pace during the next three decades. One noteworthy exception was the monograph by Brown & Schlaikjer (1940) on *Protoceratops andrewsi* from the Upper Cretaceous Djadokhta Formation of Mongolia. This study was based on a spectacular series of speci-

mens collected by the legendary expeditions by the American Museum of Natural History led by Roy Chapman Andrews to the Gobi Desert in the 1920s. *Protoceratops* represented an earlier stage in the evolutionary history of Ceratopsia, and the large samples for the first time offered insights into the ontogeny and variation of a single dinosaurian species.

Starting in the early 1970s, the revolution in our understanding of dinosaurian biology impacted research on ceratopsians. Paleontologists started viewing the frills and horns of ceratopsians as behaviorally important features, which, by analogy to extant ungulates, suggested that these animals might have engaged in complex social behavior. In a study of various taxa related to *Protoceratops*, Marya ska and Osmólska (1975) argued that *Psittacosaurus* from the Early Cretaceous of Mongolia and China represented an even earlier stage in ceratopsian evolution than *Protoceratops*. *Psittacosaurus* was still bipedal, has an at most incipient parietosquamosal frill, and a much simpler dentition than the tooth batteries present in *Triceratops* and other ceratopsids. Based on his monographic review of *Psittacosaurus*, Sereno (1986) undertook the first detailed phylogenetic analysis of ornithischian dinosaurs. His pioneering work demonstrated that Ceratopsia is a monophyletic group and most closely related to the enigmatic Pachycephalosauria; Sereno united these two groups in a clade Marginocephalia. Dodson (1996) published a highly readable introduction to what was then known about the structure and evolutionary history of horned dinosaurs. By that time, research on ceratopsians, like all work on dinosaurs, had undergone a dramatic change: intensified collection of new material as well as revisionary studies of previously collected fossils led to a veritable torrent of discoveries that, at the present time, shows no sign of ebbing. In recent years, basal ceratopsians were first described from the Upper Jurassic of China (*e.g.*, Xu *et al.*, 2006), and, most recently, the first undisputed ceratopsian fossils from Europe were reported from the Upper Cretaceous (Santonian) of Hungary (Ösi *et al.*, 2010).

In September 2007, the Royal Tyrrell Museum of Palaeontology hosted an international symposium on ceratopsians. It proved to be a tremendous success. Michael Ryan, Brenda Chinnery-Allgeier and David Eberth have edited an augmented collection of papers from this symposium for the volume under review here. The authors, editors and Indiana University Press are to be congratulated on publishing a landmark volume, which not only contains a wealth of information but is also a nicely designed book.

Part One of the volume is an overview by Peter Dodson, who is variously referred to as the 'dean', 'senior citizen' and even 'king' of ceratopsian studies. In his inimitable style, Dodson presents an *apologia pro vita sua*, which traces the history of research on horned dinosaurs from the perspective of a leading 'ceratophile' (his term for people afflicted by an obsession with horned dinosaurs).

Part Two is concerned with the diversity and phylogeny of ceratopsians. It contains a number of chapters describing newly identified taxa or reporting on new material for previously poorly known taxa (*e.g.*, "*Styracosaurus*" *ovatus*). All of the major groups of Ceratopsia receive coverage in this section, beginning with a superbly illustrated review of the cranial morphology, taxonomy, and phylogeny of *Psittacosaurus* by Sereno. Indeed, the only additional contribution that I would like to have seen in this section is a multi-authored phylogenetic analysis of all Ceratopsia (although several contributors do present more restricted analyses in their chapters). One new species of basal neoceratopsian (*Archaeoceratops yujingziensis*) and six new monotypic genera of Ceratopsidae are named and diagnosed for the first time. My clear favorite among the latter is the basal centrosaurine *Diabloceratops eatoni*, from the Upper Cretaceous (Campanian) Wahweap Formation of Utah (Kirkland & DeBlieux, Chapter 8). This relatively small form (with a skull length of 62 cm) has a spectacular frill with steeply posterodorsally rising parietals that terminate in a pair of long posterior horns separated by a median notch. One of the new taxa, the small *Tatankaceratops sacrisionorum*, is an unexpected addition to the dinosaurian assemblage from the uppermost Cretaceous Hell Creek Formation. Based on the description by Ott & Larson (Chapter 14) and in view of recently discovered non-adult specimens of *Triceratops* (see Goodwin & Horner, Chapter 36), however, I am not convinced that this new taxon is not referable to the latter, which is probably the most common dinosaur in the Hell Creek Formation.

Part Three comprises studies on the anatomy, 'functional biology' and behavior of ceratopsians. The first two chapters by Dodson, Tanoue & You present new morphological information on the basicranium and palate and the mandible, respectively, of a variety of basal ceratopsians. Tumarkin-Deratzian looks at ontogenetic changes in the texture of the surface of the bony frill in *Centrosaurus apertus.* Farke *et al.* present a biomechanical analysis of the cranial frill in *Triceratops horridus*, looking at factors critical to the structural stability of this prominent feature. The focus of their study is on testing the utility of the frill as a defensive-protective structure, but the authors note that other functions such as display cannot be ruled out. Based on a new, unusually preserved specimen, Happ presents a compelling case that the extensively vascularized horns of *Triceratops* may have had a thermoregulatory function. Krauss *et al.* review the great diversity of horn and frill structures in chasmosaurine ceratopsians. They suggest that the initial development of the parietosquamosal frill was possibly related to expansion of the origins of the adductor jaw musculature but that sexual selection could account for the subsequent elaboration of this feature. Based on two-dimensional modeling, Krauss *et al.* hypothesize a correlation between the position of the postorbital horns and shape of the openings in the frill. Henderson presents an elegant analysis of ceratopsid cranial structure using beam theory. He argues that centrosaurines have structurally stronger skulls and presumably were capable of generating greater bite forces than sympatric chasmosaurines. This would have allowed niche partitioning for these large herbivores. Longrich suggests that *Protoceratops* was possibly nocturnal because the diameter of its scleral ring is larger than predicted by a regression line of ring diameter versus body mass in ornithischians. The orientation of the orbits also indicates that this taxon also had some binocular vision. Ford & Martin argue that *Psittacosaurus* may have been semi-aquatic. However, I find none of their morphological and taphonomic arguments in support of this hypothesis particularly compelling. Based on a specimen of *Chasmosaurus* with pathological changes to its first manual digit, Rega *et al.* examine the posture of the ceratopsian forelimb. They argue that the humerus remained everted during the entire step cycle. This would have resulted in a slight rolling of the hand, with a shift of weight toward the preaxial side during locomotion and stress on the pollex (thumb) at an angle to the axis of the digit. The inferred rolling gait of ceratopsians would be unique among amniotes. In the last chapter, Tanke & Rothschild review pathological changes in a number of ceratopsid specimens from Alberta. They interpret the most common type of injury, fractures of mid- and posterior dorsal ribs, as evidence for non-lethal flank-butting behavior.

Part Four presents contributions on the paleobiogeography, taphonomy, and paleoecology of ceratopsians. Chinnery-Allgeier & Kirkland provide a detailed overview of the paleobiogeography of ceratopsian dinosaurs. As have earlier authors, they hypothesize multiple dispersal events between Asia and North America and vice versa. Such is the pace of research that during the time since their review was written several new finds from Asia and Europe have already made this scenario even more complex. Sampson & Loewen present a comprehensive review of the evolutionary radiation of the North American ceratopsid dinosaurs in space and time. Although the data are patchy, Eberth provides a valuable summary of the paleoenvironmental and taphonomic information available for ceratopsians. As a group, these dinosaurs appear to show a preference for wetland paleoenvironments. Hunt & Farke briefly examine the potential behavioral significance of ceratopsid bonebeds. They caution that there is only evidence for possible gregarious behavior in some centrosaurine taxa. Fiorillo *et al.* present a detailed report on a recently discovered earliest Maastrichtian dinosaurian bonebed dominated by *Pachyrhinosaurus sp.*, the Kikak-Tegoseak Quarry north of the Brooks Range in Alaska. Getty *et al.* discuss the taphonomy of ceratopsid dinosaurs from the upper Campanian Kaiparowits Formation of Utah. Eberth *et al.* argue that a number of bonebeds of *Centrosaurus apertus* discovered in the Hilda area of southern Alberta, in fact, represent a vast, single 'mega-bonebed'. According to their reconstruction, more than one thousand of these horned dinosaurs, along with a number of other large vertebrates, perished during a major flooding event on the coastal plain. Clusters of dinosaurian carcasses formed as the waters receded, and the entire assemblage was subsequently buried during another coastal-plain flooding

event. Kirkland & Bader describe insect trace fossils in a skeleton of *Protoceratops* from Tugrugiin Shireh in Mongolia. Such ichnofossils, presumably produced by necrophagous beetles or other insects, are frequently found associated with dinosaurian remains from the Djadokhta Formation. Sankey discusses the composition and significance of mixed bonebeds including Agujaceratops from the Campanian Aguja Formation of Big Bend, Texas.

Part Five, the last section of the volume, comprises two historical papers. Tanke writes about the history of the discovery of and subsequent rediscovery in 2005 of a ceratopsid skeleton collected from present-day Dinosaur Provincial Park in Alberta by the ill-fated Canadian 'dinosaur hunter' William E. Cutler. Goodwin & Horner review the occurrence of and the history of collecting efforts for *Triceratops* from the Hell Creek Formation of Montana. They argue that baby, juvenile, and subadult specimens of this taxon are, in fact, not as rare as long assumed, but that a historical collecting bias toward complete adult skulls, along with lithology and taphonomic factors, may have been responsible for this assumption.

A brief afterword by Currie concludes the volume. The accompanying CD-ROM contains two very long articles. Ford has compiled a synopsis of known records of ceratopsian dinosaurs (up to January 2008), and Tanke provides a minutely detailed, year-by-year chronology of ceratopsian discoveries in Alberta.

As is the case for any symposium proceedings, the individual contributions vary in scope and quality. However, this volume contains numerous excellent studies with a wealth of new data and ideas. Thus, 'New Perspectives on Horned Dinosaurs' is an essential reference of lasting importance for anyone interested in horned dinosaurs. Indeed, anyone with a serious interest in dinosaurs will want to own a copy of this fine volume.

Ryan, M.J., B.J. Chinnery-Allgeier & D.A. Eberth. Eds. 2010. New Perspectives on Horned Dinosaurs: The Royal Tyrrell Museum Ceratopsian Symposium. – Bloomington, Indiana University Press. 624 pp and supplementary CD-ROM. ISBN 13: 978-0-253-35358-0. Price $ 110.0 (cloth). Www. iupress.indiana.edu.

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