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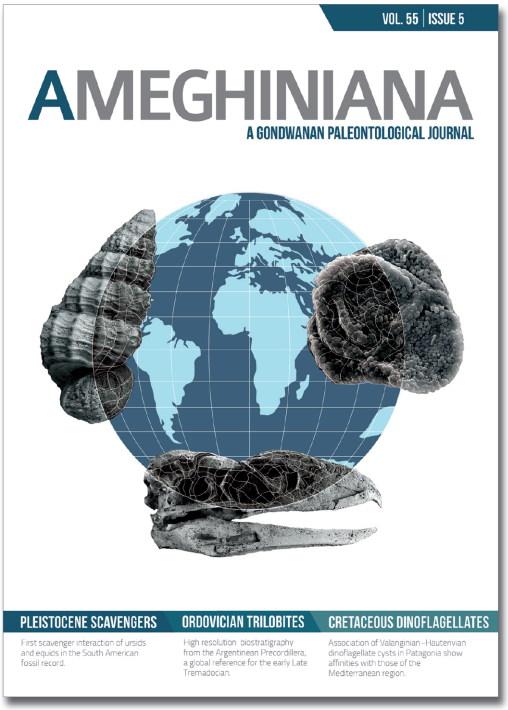

GREAT TRANSFORMATIONS IN VERTEBRATE EVOLUTION

Kenneth P. Dial, Neil Shubin, and Elizabeth L. Brainerd (Eds.). 2015. 424 pp. University of Chicago Press, Chicago, IL, USA. ISBN: 9780226268255 (paper); ISBN 9780226268392 (e-book).

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GREAT TRANSFORMATIONS IN VERTEBRATE EVOLUTION. *Kenneth P. Dial, Neil Shubin, and Elizabeth L. Brainerd* (Eds.). 2015. 424 pp. University of Chicago Press, Chicago, IL, USA. ISBN: 9780226268255 (paper); ISBN 9780226268392 (e-book).

The study of morphological adaptations in vertebrates remains a central topic in evolutionary biology. In *Great Transformations in Vertebrate Evolution*, the editors, Dial, Shubin and Brainerd bring together a collection of diverse research aiming to highlight the importance of integrative approaches when examining 'transformations' and 'key innovations' in the history of vertebrate evolution.

The book is targeted at specialists in evolutionary biology. It opens with an introductory chapter and has two large sections. Part I covers 'Origins and Transformations' in fifteen chapters, presenting discrete—mostly clade-specific—case studies. Part II introduces 'Perspectives and Approaches', with seven chapters showcasing key topics in evolutionary biology. There is some overlap and repetitiveness, but each chapter remains individually engaging. The volume is wonderfully illustrated, featuring artwork by Robert Petty. Each chapter includes impressive artwork ranging from photographs of specimens, anatomical and histological cross-sections, virtual reconstructions, novel graphics with new data, and phylogenetic trees.

The first chapter covers the evolution of vertebrate teeth (Moya Meredith Smith and Zerina Johanson), with an emphasis on the importance of molecular, developmental, and histological studies. The authors describe the evolution of vertebrate jaws and outline competing hypotheses regarding the evolution of organized functional dentition and recent modifications to classic theories.

Chapter 2 concerns ray-finned fishes (Actinopterygii). George Lauder highlights their great diversity and describes ray-fins as an understudied 'key trait'. Lauder explains the major anatomical characteristics of the fins, drawing attention to their bilaminar and segmented structure and the applications of experimental zoology. Lauder also introduces recent advances in robotics and computational approaches, and suggest these methods are key to exploring how fossils may have functioned.

Three chapters in Part I address evolutionary transformations in vertebrate trunk anatomy. In chapter 3, Elizabeth Brainerd describes the evolution of breathing mechanisms such as lungs and the development of a swim bladder in acanthomorph teleosts. Brainerd highlights X-ray reconstruction of moving morphology (XROMM) as a valuable tool for examining the interface between respiratory actions, rib morphology, and kinematics in extant model taxa. Chapter 6 covers similar topics, this time focusing on archosaurs. Leon Claessens outlines their morphological and ecological diversity and provides a detailed account of archosaur trunk anatomy, emphasizing respiratory innovations and locomotory constraints. Claessens raises important points about the difficulties of studying archosaur trunk evolution, such as the absence of important anatomical information in the fossil record and extrapolations required for reconstructing bone movement and musculature. Chapter 5 reviews the enigmatic origin of the turtle body plan, including the evolution of a carapace and plastron. A central issue in solving this riddle is the contentious phylogenetic position of turtles. Ann Campbell Burke clearly explains the current competing hypotheses about potential anapsid and diapsid affinities, describing evidence from morphological, molecular, fossil and developmental data.

The famous transitional taxon, *Tiktaalik roseae*, is the star of Chapter 4. Neil Shubin, Edward Daeschler, and Farish Jenkins Jr. describe the significance and challenges of the water to land transition in vertebrates. Of central importance were innovations in the neck, girdles, and appendages for support and propulsion. The authors give a comprehensive description of the pectoral girdle in *Tiktaalik* and use the morphological data to outline transformational trends in the pectoral girdles of elpistostegalians and early tetrapods.

Corwin Sullivan reviews archosaur hind limb posture and functional adaptations in Chapter 7. The importance of erect posture in tetrapod evolution is noted, and Sullivan considers when it evolved in archosaurs, describing evidence from Triassic trackway records. Sullivan then explores

whether postural shifts can be considered a 'key innovation' giving advantageous functional adaptations compared sprawling tetrapods. The chapter ends by highlighting the importance of bipedality and freeing forelimbs from previous constraints. Postural evolution and locomotion are also addressed in Chapter 8, where James Hopson presents a novel analysis based on trackways (*Dimetropus* ichnogenus) and the pelycosaur *Dimetrodon* (putative trackmaker).

Chapter 9 represents a change in theme, switching to physiology and the evolution of endothermy in mammals and birds (Tomasz Owerkowicz, Catherine Musinsky, Kevin Middleton, and Alfred Crompton). The authors list proxies for endothermy, such as posture and plumage, and then give an excellent overview of intra-narial respiratory turbinates. The authors critically consider whether respiratory turbinates can be used as the key proxy, or the "Rosetta Stone", for identifying endothermy in the fossil record. Their work shows that respiratory turbinate shape correlates with metabolic rate in extant mammals, but not in birds (and therefore dinosaurs).

Chapters 10 through to 15 of Part I all cover mammalian evolution. In Chapter 10, Zhen-Xi Luo outlines novel hypotheses for anatomical transformations in mammalian shoulder evolution, using a combination of paleobiological and developmental data. Chapter 11 returns to the topic of endothermy in mammals (Alfred Crompton, Catherine Musinsky, and Tomasz Owerkowicz). The authors describe transformations in the nasal chambers of early nonmammalian synapsids (ectothermic with small chambers), through to cynodonts and mammaliaforms (larger chambers and endothermic). The evolution of the placenta is covered in Chapter 12 by Kathleen Smith, including a thorough description of placental anatomy and physiology. Smith questions if the contrasting reproductive strategies of marsupials and eutherians, alone, determined their relative success; eutherians are considerably more diverse and disparate, but this may also be linked to ecology and biogeography. Chapter 13 (Andrew Biewener) returns to the importance of limb anatomy and postural evolution, this time in relation to the great body size diversity in terrestrial mammals. The archetypal evolutionary transition from land to sea in whales is covered by Philip Gingerich in Chapter 14. Gingerich introduces important fossil taxa, such as *Pakicetus*, *Ambulocetus*, and *Dorudon*, emphasizing major morphological transformation and links this to environmental changes, such as the early Eocene climatic optimum. In the final chapter of Part I (Chapter 15) John Fleagle and Daniel Lieberman describe the repertoire of locomotory behaviours in primates and the evolution of hominin bipedalism.

Part II begins with three varied and insightful chapters covering important aspects of bird evolution. Chapter 16 (Kenneth Dial, Ashley Heers, and Terry Dial) describes the significance of ontogenetic changes in modern birds and the potential implications for flight evolution in theropods. Importantly, the authors emphasize the role of studying development, juvenile ecology, and rudimentary limbs, rather than focusing solely on 'adultcentric' research. Chapter 17 (Stephen Gatesy and David Baier) discusses the advanced imaging technique XROMM and how it can be used to investigate bird flight, by linking anatomy, motion and skeletal form and function. In chapter 18 Arkhat Abzhanov notes the pivotal role of developmental and heterochronic transformations for morphological evolution in archosaur skeletal morphology. Excellent examples are provided for axial skeleton evolution, craniofacial geometry in birds, and bird beak shape variation.

Microevolutionary transitions are the topic of Chapter 19. Using molecular genetic studies, Sydney Stringham and Michael Shapiro show that important morphological changes can be driven by mutations in a modest number of genetic loci. These adaptations include pelvis and armor reduction in sticklebacks (Gasterosteidae) and pigmentation in Mexican Cavefish (Characidae). However, other morphological transformations, such as feeding morphology in cichlids, eye loss in Characidae and body shape in Gasterosteidae, are far more complex.

Chapter 20 (Kevin Padian and Hans-Dieter Sues) returns to large-scale trends, this time in Triassic tetrapods. The authors discuss phylogenetic relationships, ecological expansions, diversifications, and extinctions of the major Triassic tetrapod groups. Padian and Sues point out that most major living tetrapod groups evolved by the end of the Triassic. An important part of this was the momentous faunal turnover that took place on land during the Triassic, including the demise of surviving 'Late Paleozoic fauna', the rapid rise and fall of 'indigenous' Triassic forms and the establishment of the 'living fauna'.

The volume concludes with two chapters on homoplasy

in amphibians. Marvalee Wake (Chapter 21) provides a helpful overview of homoplasy and explores the prevalence of amphibian viviparity (live birth). Wake highlights that, although all amphibians (and reptiles) have the necessary anatomical and physiological 'equipment' to evolve livebearing, it is not universally present, and that untangling the processes linked to evolving viviparity are highly complex. In Chapter 22 (David Wake, David Blackburn, and Eric Lombard), the authors show widespread convergence in projectile tongue morphologies; they reveal multiple origins for this complex anatomical feature using a revised phylogeny of plethodontid salamanders.

The collection of research presented in *Great Transformations in Vertebrate Evolution* covers much of vertebrate diversity. There is some imbalance in the selection of case studies, with mammals featuring far more frequently than squamates and amphibians, for example. Across the varied topics there are reoccurring themes. Firstly, it is clear that traditional hypotheses remain an important source of inspiration for researchers, and many classic hypotheses continue to evolve. Secondly, the importance of data quality and diversity are ever apparent. Many chapters describe how major advances have come from both morphological and molecular data. Linked to this, the importance of new technologies, for collecting, visualizing and analyzing data are repeatedly highlighted. Finally, there is an underlying tone of optimism and excitement for future study. Many contributors discuss the importance of further investigation and actively point out important avenues for the future.

In conclusion, *Great Transformations in Vertebrate Evolution* is a substantial and timely volume that I highly recommend. I found myself equally interested in topics from both inside and outside my area of expertise. This is testament to the quality of presentation, the cutting-edge research being showcased, and the fundamental evolutionary questions being addressed.

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