Book review

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Dinosaur paleohistology: Current state of knowledge

Anusuya Chinsamy-Turan 2005. *The Microstructure of Dinosaur Bone: Deciphering Biology With Fine-scale Techniques*. x + 195 pp. The John Hopkins University Press, Baltimore and London. Hardcover USD 85.00.

The book gives a synthesis of more than 150 years of paleohistological research. It is the first to encompass the results of the last decades of rapid development of paleohistology, including its possible impact on various aspects of the biology of extinct vertebrates. It is also the first book on dinosaur bone microstructure.

Basic knowledge of bone microstructure, including the organization of the Haversian system, dates to the time of the discovery of light microscopy by Leeuvenhoek in the 1680s. Quikett (1849) pioneered comparative studies on fossil and extant vertebrate bone histology. As early as 1798, however, John Hunter formulated the fundamental concept of skeletal growth involving resorption, deposition, and remodeling of bone that was fully shown by Enlow only in 1963. Earlier than this, Schmidt (1936) documented the basic organization of the bone matrix (the crystallographic axes of the minerals aligned with the collagen fibers). This is the state of knowledge presented conventionally in the histology text-books up to now.

The second phase of research began with Amprino's (1947) statement that the differences in bone tissue types reflect variation in bone deposition rates, which still holds true in general terms. The development of paleohistology was heavily dependent on the application of transmission, and then scanning electron microscopy first used by Enlow and Brown in the 1950s, and by Pawlicki and colleagues in the 1960s.

Beginning in the 1960s, fundamental histological studies on a variety of extinct tetrapods by Armand de Ricqlès brought a clear but oversimplified picture of dinosaur compact bone. This largely consisted of fibrolamellar bone and Haversian bone, similar to the bone tissue of fast-growing mammals rather than to the lamellar-zonal type of growth in extant non-avian reptiles. These results had a tremendous effect on ideas concerning the physiology and behavior of dinosaurs, occurring at the same time that the perception of dinosaurs as awkward, slow-moving animals was changing to that of "hot-blooded", swiftly running creatures (papers by Bakker in the 1970s). The value of these stimulating ideas is not diminished by the fact that it is now believed that dinosaurs usually possessed zones of fibrolamellar bone with lines of arrested growth in between, as well as the fact that the interpretation of Haversian bone has changed.

Basic information on the composition and organization of bone matrix are briefly reviewed and updated in Chapter 1, which also includes a meticulous account of the changes in bone composition and microstructure during fossilization. Very helpful for beginners are practical instructions (Chapter 2) for preparation and research methods: paleoecological analysis, through soft tissue reconstruction, X-ray computed tomography, and microscopic studies. Chapter 3 concentrates on growth phenomena and their bearing on the resulting bone microstructure. It also highlights the pitfalls and risks of simplistic interpretation of differences in bone microstructure.

Beginning in the 1990s ever increasing numbers of researchers became engaged in paleohistological studies of dinosaurs, early birds, and extant groups. Most of the results of this phase of research are included in Chapters 4–7. A detailed account of dinosaur bone microstructure (Chapter 4) is presented, along with a discussion of the biological information that can be gained from fossil bone tissue. Chapter 5 reviews the most recent studies by Chinsamy and others on dinosaur embryos, hatchlings, and juveniles, which reveals their flexible growth strategies. Methods of estimating ontogenetic age of bones by various methods, including the so called skeletochronology are presented in this chapter.

According to current opinions dinosaurs had variable growth rates. They did not grow as fast as birds or mammals, nor did they grow as slowly as extant non-avian reptiles. Some of them still retained the plesiomorphic flexible growth strategies, some others may have grown at a sustained rapid rate. This flexible strategy was inherited by basal birds, which have been shown to have had generally lower rates of growth compared to extant birds (Ornithurinae),which beginning with the earliest known Cretaceous representatives, had a rapid rate of growth with no indication of arrests of bone deposition. Different hypotheses have been advanced to explain this evolutionary shift, which is generally visualized as resulting from changes in habitus (mainly decrease in body size, probably associated with flight capabilities) and breeding biology (precociality) that may have occurred precisely at the origin of modern birds. Birds constitute an extant endothermic group confidently nested within the extinct theropds. This is important in deciphering their biology.

Two crucial conclusions appear in the last two chapters of the book. Firstly, in contrast to earlier authors, bone microstructure is argued to have no direct translation to metabolic level of extinct animals, but may only be interpreted in terms of growth rate strategies. Secondly, speculative as they are, biological hypotheses based on bone microstructure, and supplemented by paleoecology and the reconstruction of soft tissues (lungs, diaphragm, respiratory turbinates), are fascinating approximations of possible key evolutionary events. They are irreplaceable stimuli for further studies, and we cannot neglect them.

The book clearly bears the stamp of this brilliant author. She is not only a leading expert of paleohistology, but also shows great understanding towards the work of her colleagues, her paleohistological predecessors, and the young students in the field. Her excellence as a teacher shows in her use of clear and very pertinent language, and in her careful explanation of complex subject matter. Difficult terms are all clearly defined. An index helps to find technical terms in the text. The illustrations of types of bone tissue, provided with arrows showing the structures discussed, elucidate the text. The friendly style, far from being a dry report, makes this expert and comprehensive account a fascinating book even for leisure reading. Only in the last chapter does the style become repetitious, but this reflects the author's struggle between her conviction that a researcher should not interpret beyond the evidence and her enthusiastic desire to find biological meaning in the structures she studies.

The book is not free of small editorial errors, such as e.g., the use of the specific name *neanderthalensis* as the generic one *Neanderthalensis* (p. 18), and quotation in the References of the paper by Z. Jaworowski and J. Peńsko, 1967 (*Nature* 214: 161–163) as by Z. Kielan-Jaworowska and J. Peńsko.

Taking apart all shortcomings of paleohistology as a method of direct reconstruction of metabolic level of extinct animals, it has a unique potential for highlighting all sort of problems of vertebrate paleobiology, and thus becomes one of the important domains of vertebrate paleontology of the 21st century. The book by Anusuya Chinsamy-Turan is an irreplaceable manual for all students working in this field.

Magdalena Borsuk-Białynicka [borsuk.b@twarda.pan.pl], Instytut Paleobiologii, Polska Akademia Nauk, ul. Twarda 51/55, Pl 00-818 Warszawa, Poland.