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Introduction

Recent advances in Chinese palaeontology

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Discoveries are a driving force for progress in palaeontology. Palaeontology as a discipline of scientific inquiry has gained many fresh insights into the history of life, from the discoveries of many new fossils in China in the last 20 years, and from the new ideas derived from these fossils. This special issue of *Proceedings of Royal Society B* entitled *Recent Advances in Chinese Palaeontology* selects some of the very latest studies aimed at resolving the current problems of palaeontology and evolutionary biology based on new fossils from China. These fossils and their studies help to clarify some historical debates about a particular fossil group, or to raise new questions about history of life, or to pose a new challenge in our pursuit of science. These works on new Chinese fossils have covered the whole range of the diversity through the entire Phanerozoic fossil record.

Keywords: palaeontology; evolution; paleobiogeography; morphology; China

A major evolutionary pattern from the Phanerozoic fossil record is that the extinct lineages of life have a far greater morphological disparity than extant life forms. Also, many more species evolved and gone extinct in the deep times of geological history than those living today (Gould 1990; Conway Morris 1998). Palaeontology provides a unique perspective, and can make an arguably indispensable contribution to enrich our understanding of evolution by exploring the greater diversity of fossils with a vast time dimension of geological history than is afforded by living biological diversity.

Many recent and notable palaeontological contributions to evolutionary theory have come from China. A vast variety of fossils recently discovered in China could not be pigeon-holed into previously known groups; this helps to expand our knowledge of the ancient biological diversity. Because many new, exquisite fossils of known lineages are exceptionally complete, they revealed characters in unique combinations, some of which had not been 'expected' according to the received wisdom. Where to place these new fossils on the tree of life and how to interpret their way of life can influence our understanding of evolutionary history. For example, the vetulicolians from the Early Cambrian Chengjiang biotas represent a new and distinctive clade of deuterostome animals (Shu *et al.* 2001). The surprising combination of features of the enigmatic yunnanozoons has stimulated a long and passionate debate about their place on the deuterostome family tree (Chen 2008). Shu *et al.* (2010) reviewed the diverse deuterostomes from Chengjiang with emphasis on vetulicolians and yunnanozoons, and argued that these two groups are very basal among the diverse deuterostome lineages. With well-preserved fossils from Chengjiang, Zhang *et al.* (2010) demonstrated that the lingulate brachiopods—a premier example of living fossil lineage—have long occupied their distinctive ecological niches, from the Cambrian to the Recent.

More than just the scintillating curiosities of extinct life forms, some of these fossils have raised new research questions and forced us to reconsider the previous paradigms. How can students of biomechanics and functional morphology develop new models to account for the flying function of four-winged pre-avian theropods and birds (Xu *et al.* 2003; Zhang & Zhou 2004; Chatterjee & Templin 2007)? New fossils challenge the traditional hypothesis of tetanuran theropod manual digits and promise to solve the long-debated problem of avian digital homologies (Xu *et al.* 2009). Contrary to the prevailing idea of the 1970s that the mammalian tribosphenic molar was a singular evolutionary innovation, Chinese fossils suggest that tribosphenic molars evolved homoplastically in several lineages (Wang *et al.* 1998; Luo *et al.* 2001, 2007; Luo 2007). New Jurassic mammals capable of swimming and gliding suggest that they invaded diverse ecological niches in the dinosaur-dominated ecosystem (Ji *et al.* 2006; Meng *et al.* 2006). So how did such interaction influence the terrestrial ecosystem? What are the palaeoecological implications of the earliest-known angiosperm plants that have turned out to be aquatic (Sun *et al.* 1998, 2002)?

Several research areas on China's fossils and biostratigraphy have attracted attention from the broader communities of scientists in earth science and biology, such as the studies of the Neoproterozoic animal embryos, earliest known metazoans and the Ediacaran

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forms (e.g. Zhu *et al.* 2008), and the voluminous and exacting studies on the Permian–Triassic mass extinction and recovery (Jin *et al.* 2000; Erwin 2006). But the discoveries and studies in Chinese palaeontology have been more diverse in topics and richer in content than these noteworthy highlights. In this special issue of *Proceedings of the Royal Society B*, we invited the latest studies on important fossils and data newly collected by Chinese palaeontologists and their international collaborators. These works cover a much wider range of topics in morphology, taxonomy, phylogeny, functional analysis and palaeoecology of fossils from China.

Not surprisingly, several contributions come from the studies of dinosaurs from the well-known Jehol group and its stratigraphical equivalents of lower Cretaceous in northern China. Li *et al.* (2010) report a new tyrannosauroid with intermediate morphologies between the derived gigantic tyranosaurids and the more basal, smaller members of this lineage, highlighting the patterns in feeding adaptation and evolution of size in tyrannosauroids. Makovicky *et al.* (2010) report a new giant ornithomimosaur, which gives an insight in the growth mechanism of gigantism that occurred in parallel in several lineages of beaked theropods. Sereno *et al.* (2010) report a new species of psittacosaurids, a group of the horned and frilled dinosaurs endemic to Asia. Their novel functional analysis on the psittacosaurid jaws suggests that psittacosaurs and the unrelated psittaciform birds have many similarities in chewing mechanism. Zheng *et al.* (2010) report an unusual dromaeosaurid with relatively short arms and small furcula, suggesting that aerodynamic capability might have evolved in the common ancestor of the paravian clade of birds, dromaeosaurids and troodontids, but was secondarily lost in several paravian taxa early in paravian evolution. This is echoed by the interesting results from Zhou *et al.* (2010*a*) on a primitive and toothless bird. Given the character distribution pattern across the avian phylogeny presented by the authors (Zhou *et al.* 2010*a*), the presence of dentition and a long skeletal tail in some basal birds would be best explained as reversals to the ancestral condition. These would provide the strongest evidence yet for the widespread and radical reversals in morphological evolution of the earliest avians.

Each contribution on fossil mammals in this issue offers a fresh insight. Hu *et al.* (2010) report on one of the earliest known eutherian mammals that is ancestral to placentals. Gao *et al.* (2010) revealed the upper tooth features for the amphilestid mammals—a group with plesiomorphic dental features for mammalian dental evolution. Ni *et al.* (2010) report a new primate from the Eocene beds of Inner Mongolia that has a close relationship to coeval primates of North America, consistent with a broader mammalian palaeobiogeography of the Eurasian–North American continents during the Eocene (Beard 1998), and supports a close relationship between dermopterans and primates, as corroborated by molecular phylogeny (Springer *et al.* 2003).

Palaeobiogeography is a topic of general interest to palaeontologists and a thread through several publications of this special issue: Zhou *et al.* (2010*b*) present a nice analysis on the evolutionary trends and palaeobiogeography of an Ordovician trilobite genus. Wang & Zhang (2010*a*) provide new information concerning the Silurian biostratigraphy and palaeogeography based on new data from sporomorph and graptolite fossils. Sha's (2010) work on non-marine Cretaceous trigonioidid bivalves provides new information concerning the palaeogeography in the Cretaceous of Asia.

The mainstay of this theme issue is on the evolutionary morphology of various fossil groups. Liu *et al.* (2010) present the skull morphology of the most primitive anomodont—a therapsid mammal-like reptile from the Permian. Lu & Zhu (2010) report one of the oldest-known onychodont fishes from the Early Devonian of South China. Its skull structures shed new light on feeding mechanisms of onychodonts and corroborate their place on the family tree of lob-fin sarcopterygian fishes, which are relevant to water-to-land transition in vertebrate history. Wang & Pfefferkorn (2010) report a new gymnosperm plant that has plesiomorphic ovulate structure but derived characters in leaves and branches, clarifying the pattern of evolution of the gymnosperm reproductive structures. Wang & Zhang (2010*b*) describe the rarely preserved fertile structures of a new dipteridaceous fern. Kellner *et al.*'s (2010) detailed observation on a well-preserved pterosaur specimen provides new information on the comparatively poorly known morphology of soft tissues in this extinct group. Mo *et al.* (2010) demonstrate the presence of the lepidosaurian lower temporal bar, a structure considered to be lost in lizards and snakes, in a boreoteiioid lizard, and present a functional analysis on the cranial morphology of this taxon. Wu *et al.* (2010) present the newest study on the brain endocast of the Peking Man (*Homo erectus*) and brain evolution in hominins.

This special issue on *Recent Advances in Chinese Palaeontology* is limited in its selection and can only serve as a snapshot of the rapid and continuous discoveries of interesting fossils of all sorts from China. Over the last two decades, palaeontology in China has maintained a great momentum, thanks to the dedication of Chinese palaeontologists who are working with extensive international collaboration and in a favourable climate of scientific funding. In many cases, China's rapid economic development, and the spontaneous search for fossils by peasants for profit, also accelerated the pace of discoveries. New and active research is being published at faster pace and in much larger volumes than can be sampled by this special issue. We regret that we could not accommodate many equally worthy research works in this issue.

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