Meeting report

Vertebrate palaeontology of Australasia into the twenty-first century

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The 13th Conference on Australasian Vertebrate Evolution Palaeontology and Systematics (CAVEPS) took place in Perth, Western Australia, from 27 to 30 April 2011. This biennial meeting was jointly hosted by Curtin University, the Western Australian Museum, Murdoch University and the University of Western Australia. Researchers from diverse disciplines addressed many aspects of vertebrate evolution, including functional morphology, phylogeny, ecology and extinctions. New additions to the fossil record were reported, especially from hitherto under-represented ages and clades. Yet, application of new techniques in palaeobiological analyses dominated, such as dental microwear and geochronology, and technological advances, including computed tomography and ancient biomolecules. This signals a shift towards increased emphasis in interpreting broader evolutionary patterns and processes. Nonetheless, further field exploration for new fossils and systematic descriptions will continue to shape our understanding of vertebrate evolution in this little-studied, but most unusual, part of the globe.

Keywords: vertebrate palaeontology; evolution; systematics; Quaternary extinctions; ancient DNA

1. INTRODUCTION

The fossil record of vertebrates in Australasia helps us to understand the origins, evolution and history of this region’s unique fauna. Despite encompassing a vast temporal range (Ordovician to Recent), the vertebrate fossil record of Australasia has been likened to a cheap grade of Swiss cheese [1]—riddled with many voids. These voids, however, are shrinking in number and magnitude. In the last 20 years, the fossil record of Australasia has expanded dramatically, inspiring a growth in research on vertebrate evolution, ecology and extinctions [2]. An increase in research activity on fossil mammals, for example, can be attributed to the discovery of several new sites (figure 1).

Australasia also represents an important system for testing hypotheses concerning vertebrate evolution derived from the northern record, as well as for studying vertebrate extinctions in the late Quaternary. The latter has proven to be a rather challenging issue, not least because of the considerable uncertainty over the timing of human arrival and the extinction of various vertebrate species in Australia. Consequently, other sources of evidence, including analysis of ancient DNA, have recently been brought to bear on this area of research.

The 13th Conference on Australasian Vertebrate Evolution Palaeontology and Systematics (CAVEPS) showcased an impressive array of questions and themes in vertebrate evolution. The conference opened with a full-day symposium entitled ‘Vertebrate palaeontology of Australasia into the twenty-first century’, which included a series of keynote presentations that spanned the breadth of modern palaeontology. There were also symposia dedicated to functional morphology, extinctions and ancient biomolecules. Presentations and discussions focused on aspects of morphology, phylogeny, taxonomy, ecology, taphonomy, evolutionary trends, geochronology and biogeography. Many, but not all, contributions concerned local research in Australasia. The next CAVEPS will be held in Adelaide in 2013.

2. UNCOVERING THE FOSSIL RECORD

Several presentations at this year’s CAVEPS featured new additions to Australasia’s fossil record, including material from under-represented geological periods and vertebrate groups: Darren Hastie (Deakin University) described new fossils of monachine seals from the Late Miocene of Victoria, representing the first-ever detailed study of fossil seals in Australia; and Trevor Worthy (University of New South Wales) reported fossil cormorants from the Oligo–Miocene Etadunna and Namba Formations of South Australia. Until now, the Neogene record of cormorants was restricted to the Northern Hemisphere.

The hitherto meagre Australian record of dinosaurs is receiving renewed attention. A re-interpretation of the mid-Cretaceous Lark Quarry dinosaur trackway near Winton, Queensland, was presented by Anthony Romilio and Steve Salisbury (University of Queensland). Salisbury and colleagues also analysed a large sample of non-avian theropod dinosaur teeth from four Cretaceous deposits in eastern Australia. Collectively, these data corroborate the presence of cosmopolitan clades such as carcharodontosaurs, which seem to have been a ubiquitous component of Australia’s Cretaceous dinosaur fauna.

Progress towards developing a chronological framework of Australian Cenozoic fossil deposits also featured at CAVEPS. A key challenge in refining a national framework has been the relative paucity of radiometrically dated deposits. A team jointly led by Jon Woodhead (University of Melbourne) and Michael Archer (University of New South Wales) is addressing this issue and has obtained the first radiometric dates for the fossil-rich limestone deposits of the Riversleigh World Heritage Property, using U-Pb dating of speleothem. These dates refine previous mid-Cenozoic age estimates derived from biocorrelation of faunal assemblages. Given the extraordinarily rich nature of Riversleigh’s Tertiary assemblages, radiometric dating of these sequences will both facilitate correlation of other
The relative sizes of molars are often used as diagnostic features in palaeontology and palaeoanthropology. To investigate the mechanisms that govern relative molar proportions, Alistair Evans (Monash University) and colleagues conducted experimental manipulations of developing mouse tooth germs [3]. They found that molar size patterns were principally determined by an activation/inhibition network. These results aided the development of a testable model for predicting macroevolutionary patterns in molar proportions in various mammal groups.

Computed tomography and X-ray synchrotron microtomography have been increasingly used to obtain detailed visualizations of the internal matter and structure of fossil and living organisms (e.g. [4,5]). These techniques are invaluable to palaeontologists because they allow us to explore structural features that are inaccessible or hidden from direct observation without damaging the specimen. An example of the quality and quantity of information that can be revealed by synchrotron imaging was presented by Sophie Sanchez (Uppsala University) and colleagues, who obtained three-dimensional bone histology data for the placoderm Compagopiscis croucheri from the late Devonian Gogo Formation of Western Australia.

4. QUATERNARY EXTINCTIONS GO INTEGRATIVE
The relative importance of climatic and anthropic impacts on vertebrate species in the Late Quaternary is a perennial source of interest [6]. Our view of this time period is coloured by the disappearance of iconic fauna such as Diprotodon, the marsupial lion (Thylacoleo) and dromornithid birds (Dromornithidae). Although the losses of large mammals and birds represented the most conspicuous events, the focus on arbitrarily defined ‘megafauna’ has long been regarded as an impediment to our understanding of the factors affecting population dynamics in the Late Quaternary [7]. Several conference delegates emphasized this point. For example, Gilbert Price (University of Queensland) argued that small vertebrate species, which have received limited attention, could be potentially important palaeoenvironmental indicators for that period. Scott Hocknull (Queensland Museum) also stressed the importance of including small vertebrates in the development of Quaternary extinction chronologies.

North American extinctions have been investigated in considerable detail, aided by favourable taphonomic conditions and the relatively recent timeframe of human colonization [8]. The study of Quaternary extinctions in Australia, however, represents a much more challenging prospect. Associated themes that were discussed at CAVEPS include the availability of reliably dated samples, the timing of colonization by modern humans, the role of fire and even the identification of species depicted in ancient rock art. In Australia, human arrival and the extinction of many megafaunal species are likely to have occurred around 40–60 kyr ago, at the upper limits of radiocarbon dating [9,10]. This has made it difficult to determine the duration of coexistence between modern humans and now-extinct species. Gavin Prideaux (Flinders University) presented several Australian cases in which a prominent anthropogenic impact could be identified, although it remains difficult to decouple this from climatic effects and changing fire regimes.

Some researchers are now looking towards ancient biomolecules as a source of evidence for investigating Quaternary population dynamics in the Southern Hemisphere. The extinct moa of New Zealand provide an accessible study system because of the abundance of...
remains, favourable conditions for preservation and the recent timing of their extinction. Morten Allentoft (Murdoch University) presented his recent work in identifying and using microsatellite loci to analyse moa data, and described a large-scale analysis of ancient DNA from four sympatric moa species. Nicolas Rawlence (University of Adelaide) reported the successful use of DNA from feathers to investigate the population histories of extinct birds. Compared with New Zealand, preservational conditions in Australia are generally inferior, meaning that studies of ancient biomolecules have been limited to relatively young samples. However, James Haile (Murdoch University) described the extraction of DNA from a 19,000-year-old emu eggshell, pushing the limits of ancient DNA analysis of Australian subfossils and opening the way for a new source of data for investigating Quaternary extinctions in this region.

With no consensus on tempo and mechanisms in sight, there is clearly a pressing need for further research on Australasian Quaternary extinctions. Our ability to elucidate the causes of these extinctions will grow with improvements in dating methods, an increased capacity to obtain ancient DNA data from poorly preserved samples, and refinement of the estimates of the timing of human colonization.

5. FUTURE DIRECTIONS

Palaeontological research in Australasia is rapidly expanding and evolving. The nature of the research presented at this year’s meeting indicated a clear shift away from systematic descriptions. We are now embracing new analytical techniques and cutting-edge technologies to maximize the information we can extract from the fossil record. However, despite considerable progress, much work remains to be done. Areas that are in particular need of further study include mid-Cretaceous terrestrial vertebrates, Cretaceous–Cenozoic marine vertebrates and Tertiary marine birds.

A key goal is to fill the significant voids (e.g., Eocene–late Oligocene) in the Australasian record during periods of major global events and evolutionary transitions. Continued exploration and a focus on primary collecting will help us not only to characterize past biodiversity, but also to place Australasian taxa in a wider evolutionary and biogeographic context. To this end, continued descriptive and systematic studies of fossil taxa are fundamental to understanding evolutionary histories, palaeobiology, biostratigraphy and extinctions. For example, evidence from the fossil record (deep-time history of lineages and environments) can be used to focus conservation efforts and save species from extinction, as well as to understand the long-term trends associated with climate change cycles.

Palaeontological research has always been and will continue to be highly integrated with other disciplines, providing data that are fundamental to understanding current challenges facing species, ecosystems and life on this planet.

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