The Lost Giants of Tasmania

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New evidence reveals that megafauna survived in Tasmania until soon after a land bridge across Bass Strait enabled humans to cross from the mainland.

Australians think of Tasmania as our largest island, isolated from the mainland by the often stormy waters of Bass Strait. While this is true for the past 14,000 years, during glacial periods in the Earth's history – when ice sheets in the Northern Hemisphere expanded greatly and sea levels around the world fell by up to 130 metres – the emergent floor of Bass Strait provided a land bridge between the "Apple Isle" and continental Australia. The most recent connection started about 43,000 years ago, instigating a chain of events that have had dramatic repercussions for Tasmania's ecology.

By 43,000 years ago humans had already colonised most regions of mainland Australia for many millennia, but the island to the south remained unoccupied. However, the new land bridge presented the first opportunity for people to walk across to Tasmania.

It has generally been thought that these first Tasmanians never encountered the large indigenous "megafauna" that are now extinct but had once roamed the island, because none of their bones or teeth has been found at archaeological sites. But a new paper published in the *Proceedings of the National Academy of Sciences of the USA* challenges this conventional view by revealing that at least some of the megafauna survived until shortly after initial human arrival. The recent disappearance of the iconic Tasmanian tiger, or thylacine, continues the sad legacy of 40,000 years of human-induced extinctions on the island.

Tasmania's megafauna were not as diverse as those on the mainland. There were only six species of marsupial and one species of monotreme (*Megalibgwilia*), the latter being similar in shape and size to the long-beaked echidna of New Guinea.

Among the giant marsupials were the half-tonne *Zygomaturus trilobus*, which is often described as a "marsupial rhino" and is closely related to the mainland *Diprotodon*. The equally formidable *Palorchestes azael* was similar to a ground sloth.

The giant browsing kangaroos included two short-faced species (*Metasthenurus newtonae* and *Simosthenurus occidentalis*) and the long-faced, long-necked *Protemnodon anak*. These giant roos weighed between 100 and 150 kg.

All of these Tasmanian herbivores shared the island with the carnivorous "marsupial lion" *Thylacoleo carnifex* – the largest mammal predator in Australia.

The oldest archaeological site so far discovered is Warreen Cave, which is located in the Tasmanian Wilderness World Heritage Area in the south-west of the island. Radiocarbon (^{14}C) ages of up to 40,000 years have been obtained for artefact-bearing deposits in this cave, but stone tools were also found in the deeper undated deposits, making it likely that people first arrived in Tasmania soon after the land bridge emerged 43,000 years ago.

Hundreds of thousands of bone fragments have been studied from archaeological excavations in Tasmania. However, Chris Johnson of James Cook University points out that less than 1% of these are from the first 4000 years of human occupation.

If there was only a brief overlap of people and megafauna on the island, then it is perhaps not surprising that the remains of the last-surviving giant marsupials have proven hard to come by at archaeological sites, especially when the vagaries of fossil preservation are also taken into consideration. In the younger levels of the Tasmanian archaeological sites, where fossils are more abundant, the absence of megafaunal bones supports the view that any coexistence of humans and megafauna must have been brief.

So when did the Tasmanian megafauna finally die out? This deceptively simple question has been hard to answer for many of the same reasons as apply to the mainland. The long-term survival of fossils is capricious, and their discovery is commonly serendipitous, so the chances of finding the remains of the last-surviving individual of an extinct species are miniscule.

These difficulties are magnified by the technical challenges of directly dating fossils to determine their age. Although a variety of dating methods are now available to palaeontologists and archaeologists, each method has a restricted scope,

The skull of a giant browsing kangaroo (*Protemnodon anak)* from Mount Cripps. An OSL age of about 36,000 years was obtained for sediment grains that had intruded after death into its nasal cavity, and radiocarbon ages of about 41,000 years were obtained for fossil bones of two individuals of this late-surviving species. Photo: Queen Victoria Museum and Art Gallery

both in terms of the applicable time range and the types of materials that are suitable for dating.

In this latest study, which involved scientists from Australia and the United Kingdom, two different dating methods were used. For the Tasmanian sites that fell beyond the reach of ^{14}C dating (which currently extends to about 50,000 years ago), optically stimulated luminescence (OSL) dating was applied to deposits in which the fossil remains of megafauna were found.

OSL dating has been used previously on mainland Australia to show that the megafauna probably became extinct about 46,000 years ago, but this method is not suitable for direct dating of bone or tooth. Instead, it can indicate when an animal died by measuring the time since the sediments in which skeletal remains are buried were last exposed to light. For this approach to be reliable, the bones must be found in their correct anatomical (articulated) arrangement – that is, in the position that the animal died.

Pleisto Scene Cave, situated in the north-west corner of Tasmania, contained articulated remains more than 120,000 years old, and fragments of younger megafauna were found at other sites, most notably in the caves beneath the rainforest-clad Mount Cripps. Here, well-preserved specimens of *Protemnodon anak* were discovered in 2000 by members of the Savage River Caving Club while exploring a labyrinth of tunnels.

The Mount Cripps megafauna were found lying on the cave floor and wedged in rock crevices, and included the remains of three giant roos. These precious fossils are now stored in the collections of the Queen Victoria Museum and Art Gallery in Launceston, and curated by Craig Reid.

In a darkened laboratory at the University of Wollongong, sediment grains were scraped out from deep inside the nasal cavity of one of the skulls, and sand-sized grains of quartz were isolated and purified for OSL dating. These grains had entered the skull after death and had thereafter remained hidden from light, so the OSL age of about 36,000 years is the shortest possible time since the death of this animal.

However, a more accurate fix on its age was obtained by directly dating the collagen extracted from the megafaunal bone. Initial estimates of between 34,400 and 38,000 years for two of the Mount Cripps individuals were obtained at the University of Wollongong by Chris Turney using conventional methods of bone preparation.

Techniques for ^{14}C dating of bone have improved tremendously in the past few years, and Tom Higham of the University of Oxford used a molecular ultrafiltration method to isolate the original components of the bone and remove more modern contaminants that could otherwise make the ^{14}C ages appear too young.

The ages of between 40,900 and 42,900

The fossilised remains of the last of Australia's giant kangaroos were discovered in the caves beneath the rainforest-covered slopes of Mount Cripps. Photo: Craig Reid

years for the same two specimens confirmed the survival of the Tasmanian megafauna to the same period as human arrival on the island. The ultrafiltration method also showed how less rigorous chemical preparation of ancient bones can produce inaccurate ages, especially when approaching the practical limits of the ^{14}C method.

The coincidence between the last appearance date for Tasmanian megafauna and the first appearance date for humans echoes the pattern observed for many islands around the world – namely, that mass extinctions shortly follow human colonisation.

In his best-selling book *The Future Eaters*, Tim Flannery of Macquarie University advocated direct human involvement in megafaunal extinctions in Australia through hunting. This latest study strengthens claims for human hunting of the megafauna because the main alternative mechanisms for extinction – climate change and/or vegetation burning – can be largely discounted for Tasmania.

Eric Colhoun of the University of Newcastle has eliminated both of these candidates after extracting pollen grains and charcoal particles from the sediments deposited on the bed of Lake Selina, which is situated close to Mount Cripps. He found that the regional vegetation remained remarkably stable between about 65,000 and 15,000 years ago. Herbs dominated throughout this period, in the middle of which people arrived and the megafauna disappeared.

Importantly, vegetation changes associated with the last glacial cycle were recorded in earlier portions of the Lake Selina sequence, but the Tasmanian megafauna appear to have survived these climatic fluctuations without any loss in species diversity.

This result repeats findings across southern mainland Australia by Gavin Prideaux of Flinders University, who investigated sites spanning the last several glacial–interglacial cycles. Prideaux and colleagues discovered that the megafauna were resilient to climate change. Populations fluctuated in size in response to local conditions, but species diversity did not diminish with each successive cycle. Species composition remained essentially stable for the half-million years leading up to the time of human arrival and then collapsed catastrophically – and, from a geological perspective, instantaneously.

The most common objections to the notion of human hunting of the megafauna are that prehistoric technology

was inadequate for the task, and that no megafauna "kill" sites have been found. But a recent study by Barry Brook of the University of Adelaide and Chris Johnson neatly provides a solution to both of these mega-riddles. Using a demographic population model that allows for variable human and megafaunal densities, hunting efficiencies and harvesting strategies, they found that the selective hunting of just one or two juvenile megafauna per 10 people each year would be sufficient to exterminate such slow-breeding species within a few centuries.

By targeting juveniles at this remarkably low rate of exploitation there would have been no need for "big game" hunting equipment, and few (if any) megafaunal bones would be preserved at archaeological sites. The period of overlap of humans and megafauna would have been brief, the proportion of megafauna bones in the deposit would be small compared with those of other animals hunted throughout the year, and weathering processes may tend to discriminate against the preservation of smaller (juvenile) bones in favour of larger (adult) bones.

The Tasmanian study provides a further important message for current and future studies of the Australian megafauna. Sites containing articulated remains can be reliably dated using a variety of well-established techniques, including OSL dating of the burial sediments. However, sites that do not contain bones in articulated anatomical position run the risk of yielding erroneous ages if direct dating of skeletal remains is not carried out. It is commonplace for bones to be reworked from their original resting place to another location, perhaps many tens or hundreds of millennia later.

Certainly much valuable information about a deposit and its contents can be gleaned through a detailed understanding of the stratigraphic context and other forms of field and laboratory analyses. But in the absence of direct dating of the fossils there will always be lingering concerns that the disarticulated remains are not truly contemporaneous with the materials used to infer their ages (typically charcoal fragments recovered from the same levels).

Direct dating of megafauna has received only limited use in Australia, partly due to the considerable technical challenges and the potential pitfalls. Previous attempts at ^{14}C dating of collagen from megafauna bones, prepared using conventional procedures, have been reviewed recently by Richard Gillespie of the Australian National University and Barry Brook. All ages were rejected as unreliable.

However, other materials and methods have recently been investigated. Gifford Miller of the University of Colorado used amino acid racemisation and ^{14}C dating of eggshells to show that *Genyornis newtoni* – an extinct giant, flightless bird – disappeared abruptly from central Australia about 50,000 years ago, coinciding with a reorganisation of the vegetation communities in these arid and semiarid regions.

For the giant marsupials, the combination of electron spin resonance and uranium-series dating offers renewed hope of obtaining reliable, direct ages for bones and teeth. This approach, led by Rainer Grün and Steve Eggins of the Australian National University, has been applied to sites throughout southern Australia, revealing that many deposits contain reworked fossil teeth.

An artist's reconstruction of the half-tonne *Palorchestes azael*, which is similar to a ground sloth and is sometimes described as a "marsupial tapir". The diet of this extinct browser included tough plant material and possibly tree bark. Illustration: Peter Schouten

Intriguingly, none of the large number of mainland sites investigated by Grün, Miller and colleagues has yielded the remains of megafauna younger than about 40,000–50,000 years. Tasmania fits this same pattern, with the giant kangaroos of Mount Cripps persisting until about 41,000 years ago and then disappearing suddenly from the fossil record.

The common theme in both of these continental and island settings is the extinction of the megafauna soon after human arrival. If this ecological catastrophe were the result of low levels of hunting of juveniles, then the approaching extinction would have been virtually imperceptible to the people responsible for it – a poignant reminder of our current environmental crisis.

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