Small mammal community change during the Last Glacial Cycle

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Abstract

Research into two Pleistocene aged small mammal bone deposits of the Naracoorte Caves National Park and World Heritage Area has revealed the role of climate thresholds in shaping faunal communities. The study sites were from Wet Cave and Blanche Cave, each providing large fossil samples suitable for looking at a past mammal community and to examine if and how it changed over time. The aims of the research were to measure how much change occurred within a mammal community over time and to see if that change corresponded to climate change. As the two cave deposits span a similar time period they also provided a rare opportunity to test the robustness/repeatability of the trends measured in the fossil records.

Introduction

The Naracoorte Caves are recognised as a globally significant fossil locality, containing multiple sediment and bone deposits that provide 'snap shots' of local environmental conditions and animal diversity in relation to cyclical climate changes over the last c. 500,000 years. One of the unique features of the Naracoorte Caves fossil locality is that in some cases, more than one fossil deposit is available for a period of time, providing multiple sites from which to draw evidence about the past.

A focus of palaeontological research at the Naracoorte Caves has been Australia's iconic megafauna. A number of megafauna species were first described from fossils found at the Naracoorte Caves and numerous studies have provided insights into the timing and potential causes and processes associated with their extinction in the Late Pleistocene, c. 50,000 years ago (Roberts et al., 2001; Prideaux et al., 2007; Macken et al., 2012).

Bone deposits of the Naracoorte Caves also contain or in some cases, are largely composed of the remains of small body-sized animals. The latter resulted from the accumulation of owl pellets under roosting sites in caves. Research at the Naracoorte Caves has shed light on the diversity of small-body sized animals of the Naracoorte region through the Pleistocene (e.g., Smith, 1971; 1972) and in a number of studies, small-mammals were used as a basis for reconstructing past environmental conditions (McDowell, 2001; Laslett, 2006).

The research presented here was completed as part of my PhD studies with Flinders University under the supervision of Drs Liz Reed and Gavin Prideaux and involved a study of small mammals from deposits in two nearby caves within the Naracoorte Caves National Park and World Heritage Area: Wet Cave and Blanche Cave. Bone deposits in these caves were targeted specifically to analyse the effects of climate change through the last glacial cycle on the local small mammal community. Previous work on the studied assemblages revealed that they covered similar time periods, both spanning the last glacial cycle, c. 500,000 to 10,000 years ago, contained large samples of bone material and were both accumulated by similar means (owl pellet), making them ideal for the research question (McDowell, 2001; Laslett, 2006). They also presented an opportunity to examine if the results from one deposit were replicated in the other, providing a test for the robustness of the observed trends. By establishing a chronology for the two sites at the level of both sedimentary units and layers, I was also able to examine how the timescale at which a deposit is studied can influence the detection of ecological change.

Methods

Sedimentary units and layers of the Wet and Blanche Cave deposits were correlated with each other based on a statistical analysis of their radiocarbon ages (Macken et al., 2013). The sedimentary units provided a coarse timescale from which to analyse change through the deposits. Sedimentary layers provided a finer timescale.

All diagnostic small mammal remains (maxillae, dentaries and teeth) from the two study sites were identified and were used to generate counts for the number of individuals of each species for each unit and layer of the two sites. A range of ecological metrics for measuring the characteristics of the small mammal community were calculated from the specimen data. These were: species richness (how many different species for each sedimentary unit/layer); composition (what species made up each sedimentary unit/layer); rank-order abundance (what

was the least to most abundant species in each sedimentary unit/layer) and species proportions (what is the relative abundance of each species in each sedimentary unit/layer). These metrics were examined in both deposits and compared between deposits. For statistical treatment of the data please refer to Macken and Reed (2014).

Results and Discussion

Results are presented here only for the analysis of species richness. For results across the other metrics please refer to Macken (2013) and Macken and Reed (2014).

Species richness for each sedimentary unit compared between Wet and Blanche Caves was found to be statistically similar, suggesting that both sites provided comparable information about the small mammal palaeocommunity through the last glacial cycle from the Naracoorte region.

In relation to climate change effects, there was no detectable change in species richness at the coarse timescale. This finding is consistent with studies of older deposits which found no change in the number of species during earlier phases of climate change (Moriarty et al., 2000; Prideaux et al., 2007). By comparison, a significant decline in species richness was detected at the fine timescale and occurred from 17,100 to 16,700 years BP.

Comparison with a sea-surface temperature record (derived from core collected from the Murray Canyons; Lopes dos Santos et al., 2012) revealed that the decline in species richness at this time did not coincide with the commencement of climate warming following the last glacial maximum, but instead lagged the onset of warming by c. 1,000 – 3,000 years. It appears to have instead been associated with sea-surface temperatures warming beyond 16 degrees C. Of note is that the temperature curve shows that sea-surface temperatures had not exceeded 16 degrees C for the previous c. 30,000 years.

Conclusion

Our findings suggest that it was not warming per se that drove changes in the local small mammal community during the Pleistocene, but warming beyond a temperature threshold that hadn't been exceeded for millennia. It is also significant as it is the first evidence for significant community-level change in response to climate change from the Naracoorte Caves. It challenges an assumption that the extreme cold and arid conditions of the last glacial maximum drove large-scale faunal change in Australia (McDowell et al., 2013). Instead, our results suggest that the small mammal community of the Naracoorte region was not affected by the cooler climate phases of the last glacial cycle, but responded to temperatures exceeding a threshold level for the community.

Our results also show that the timescale at which the deposits were studied did affect the observed pattern of faunal change. At the coarse timescale, variation in species richness was 'smoothed out,' suggesting that there was no change through the last glacial cycle. By comparison, the finer timescale enabled shorter term fluctuations to be detected, revealing a significant ecological perturbation in the decline in the number of species in the Naracoorte area during the warming phase. Of note is the observation that species richness increased again following the decline, revealing an ability of the community to recover from disturbance.

While future work is required to determine the relationship between the small mammal community change and other climatic and palaeoenvironmental factors (e.g., rainfall, vegetation and land temperatures and seasonality), the observations from Wet and Blanche Cave emphasise the role of thresholds in contributing to perturbations in ecological communities. In particular, understanding threshold points for modern communities may be more important than modelling responses to generalised climate warming.

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