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Last glacial maximum environments in northwestern Patagonia revealed by fossil small mammals

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ABSTRACT

Comparisons of historical and modern assemblages of mammals can yield important insights into patterns and processes of environmental change. Here, we present the first analyses of small mammal assemblages present in northern Patagonia during the last glacial maximum (LGM). Using remains obtained from owl pellets excavated from an archeological cave site (Arroyo Corral I, levels VII–V, carbon dates of 22,400–21,530 cal yr BP), we generate estimates of the minimum number of individuals for all species detected; these estimates, in turn are used to determine relative species abundances. Comparisons of these data with similar analyses of small mammal remains obtained from a second archeological site (ACoII, levels IV–V, carbon dates of 10,010–9220 cal yr BP) as well as from modern owl pellets reveal pronounced changes in relative species abundance since the LGM. In particular, *Euneomys chinchilloides* and *Ctenomys sociabilis* – the predominant species during the LGM – declined markedly, suggesting a change from open, bare habitat punctuated by patches of wet meadows and shrubs to the more densely vegetated mosaic of ecotone habitats found in this region today. These data provide important new insights into the environmental changes that have occurred in northern Patagonia over the last 20,000 years.

Introduction

Reconstructing historical faunas can generate important insights into patterns and processes of evolutionary change. In addition to revealing temporal changes in the compositions of specific biotas, such reconstructions can be used to draw inferences regarding associated patterns of habitat and climate change. For small bodied mammals, analyses of bones and teeth deposited around owl or raptor roosts represent a particularly direct means of characterizing historical assemblages (Andrews, 1990; Stahl, 1996). Information obtained from such deposits can be used to document temporal changes in multiple aspects of a species' biology, including relative abundance (Grayson, 1983; Terry, 2010a, 2010b), body size (Barnosky, 1994; Hadly et al., 1998), and genetic variability (Hadly et al., 1998; Chan et al., 2005). In conjunction with data regarding a species' current ecology, such analyses can be used to draw inferences regarding associated environmental changes (Barnosky et al., 1996; Hadly, 1996) and, potentially, the causes of biotic change over time.

In South America, glacial cycles are thought to have been critical in shaping habitats and associated biotas (Lessa et al., 2003, 2010), with multiple advances and retreats of ice sheets causing pronounced changes over relatively short periods of time (Heusser et al., 2006). The last glacial maximum (LGM) at the end of the Pleistocene (~23,000–19,000 yr) was the most recent significant expansion of ice on a global scale. In northern Patagonia, the geological nature of this event has been well characterized based on current landforms and other evidence of glacial activity (Porter, 1981; Hulton et al., 2002; Rabassa, 2008; Rabassa et al., 2011). In contrast, the impact of the LGM on the flora and fauna of this region is less well understood, with inferences about paleoenvironments drawn primarily from phylogeographic studies of extant taxa (Turchetto-Zolet et al., 2013). More direct characterizations of biotic assemblages based on fossil data are almost non-existent, with available information limited primarily to analyses of insects and pollen from south-central Chile (e.g., Hoganson and Ashworth, 1992; Moreno, 1997; Heusser, 2003).

With regard to small mammals, a number of Patagonian fossil assemblages have been collected, primarily in archeological contexts (Pearson and Pearson, 1993; Teta et al., 2005; Fernández et al., 2012; Pardiñas and Teta, 2013). Most of these collections, however, are restricted to the Holocene; although a few cover the Pleistocene–Holocene transition, none extend to the LGM. Indeed, the oldest known small mammal assemblage recovered from northern Patagonia (El Trébol archeological site, Neuquén Province, Argentina) dates to only 10,570 ± 130 ^{14}C yr BP (AA-65707) (Hajduk et al., 2004, 2006) and thus does not encompass the last major glacial advance. As a result, the small mammal faunas of this region during the LGM are unknown

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(Tonni and Carlini, 2008; Pardiñas et al., 2011), precluding comparisons of historic and modern assemblages to assess biotic changes over the last ~20,000 years.

Here, we studied a fossil assemblage of Patagonian small mammals from the LGM. The materials examined are from the Río Limay Valley in the Nahuel Huapi region of northwestern Argentine Patagonia, an area that has been the subject of considerable research regarding modern small mammals (Pearson and Pearson, 1982; Pearson, 1984; Monjeau et al., 1997; Pardiñas et al., 2003). Using materials collected from three cave sites in southern Neuquén and Río Negro Provinces, we characterize the taxonomic composition and relative species abundances of the small mammal faunas present at these locations during the LGM. Through comparisons of these data with information regarding the modern mammals of this region, we quantify changes in the vertebrates of this region since the LGM and, based on the ecologies of extant taxa, use these analyses to explore apparent habitat changes over the same time period. In addition to providing the first characterization of a Patagonian small mammal assemblage from the LGM, our data provide new insights into patterns of environmental change in this region over the past ~20,000 years.

Methods

Fossil samples

Small mammal remains were retrieved from the archeological site Arroyo Corral I (ACoI) (Arias et al., 2013; 40°55′52″S, 71°03′19″W [WGS84], 844 m.a.s.l.), located on Estancia La Lonja in Parque Nacional Nahuel Huapi (PNNH), Neuquén Province, Argentina (Fig. 1). The site, which overlooks the Río Limay, consists of a rocky cave composed of two well-developed caverns, each measuring ca. 20 m by 14 m, with a ceiling height of ca. 3 m (Fig. 2). The surrounding habitat consists primarily of precordilleran steppe representing the ecotone between semiarid Patagonian steppe and Andean *Nothofagus* forests. Vegetation in the area is dominated by small shrubs (*Mulinum spinosum*, *Acaena splendens*) and bunch grasses (*Festuca pallescens*, *Stipa speciosa*) and is punctuated by isolated groves of the evergreen cypress *Austrocedrus chilensis* (León et al., 1998; Bran, 2000).

During the austral summer of 2006, a 2-m by 2-m pit was excavated at ACoI (Fig. 2). Digging was completed using hand-held trowels following natural stratigraphic boundaries. Excavation extended to a depth of 280 cm before reaching bedrock. Seven sedimentary levels (labeled I to VII) were identified. All soil removed was sieved in the field using a screen with a 2-mm mesh size. Material collected from each stratigraphic level was placed in a plastic bag and transported to the archeological laboratory in the Museo de la Patagonia in San Carlos de Bariloche (Río Negro Province, Argentina) for final separation and sorting of mammal remains.

Chronology and taphonomy

The small mammal assemblages examined were collected from the three basal levels (V to VII) of the ACoI stratigraphic sequence. Radiocarbon dating performed by accelerator mass spectrometry (AMS) on bone collagen from specimens of Mylodontinae and *Lama guanicoe* contained in these levels generated the following estimates of stratigraphic ages: (1 = AMS Laboratory, University of Arizona; 2 = Oxford Radiocarbon Accelerator Unit, University of Oxford; 2-sigma calibration interval)

Level V: 21,267–19,998 cal yr BP [18,700 ± 260 ^{14}C age BP (AA-75674)[1]]
Level VII: 21,886–21,203 cal yr BP [19,520 ± 100 ^{14}C yr BP (OxA-19478)[2]]
22,108–20,754 cal yr BP [19,410 ± 280 ^{14}C age BP (AA-75675)[1]]

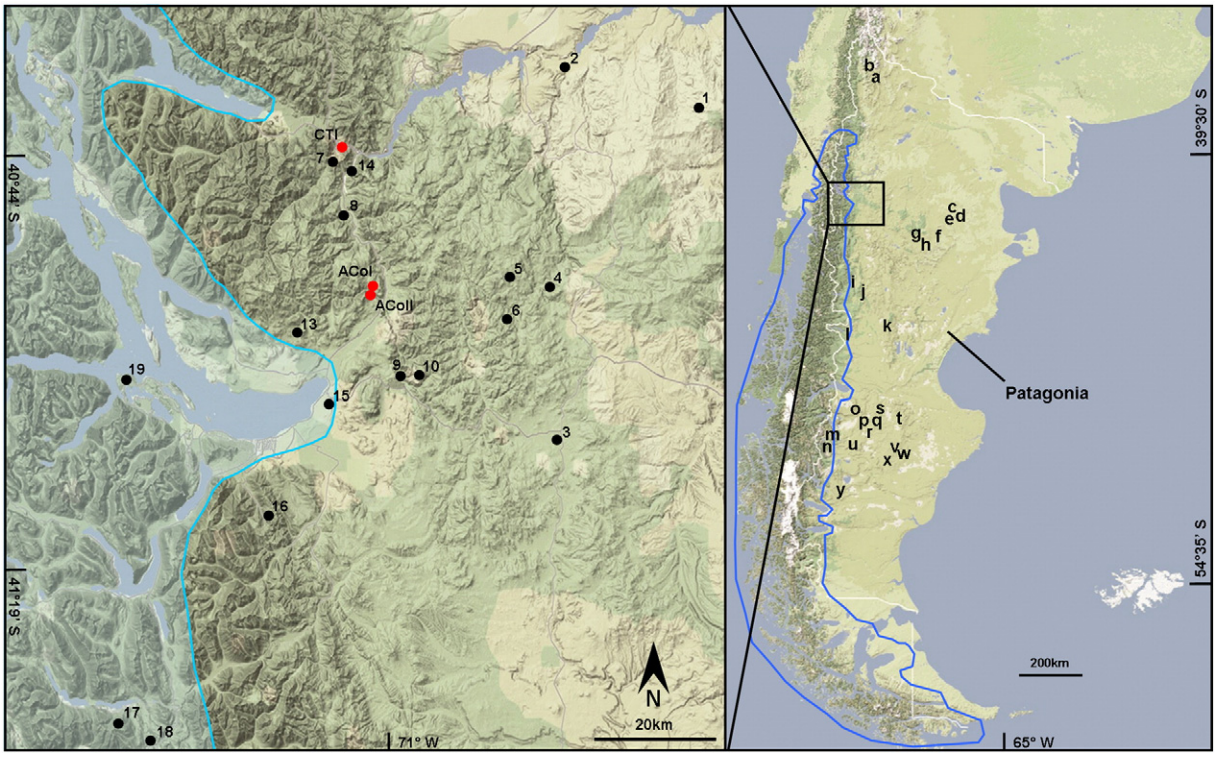

Figure 1. Map of the study area in northern Patagonia. In (A), a detailed map of the Limay Valley region is shown; this area includes the ACoI, ACoII, and CTI sites at which fossil material was collected (red dots) as well as the 19 locations at which modern owl pellets were collected (black dots). In (B), a larger portion of Patagonia is shown, with the 25 locations at which modern owl pellets were collected noted. The blue line indicates the estimated limit of ice sheets during the LGM.