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Mammal Extinction at the Pleistocene-Holocene Boundary in South America

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Extinctions throughout the Neogene in South America at species, genus, and even family levels were mostly related to climate and environmental changes. They affected different components of the biota. However, by the late Pleistocene and early Holocene there was an extinction event of extraordinary features, when 100% of the remarkably abundant megamammal species (37 species with body mass over 1,000 kg) and about 80% of the large mammal species (those over 44 kg) became extinct. With the exception of some small mammals, no other animals or plants disappeared. Consequently, the extinction event was distinct from "normal" mass extinctions (see comments in Cione et al. 2003). This extinction has been attributed to climate change, epidemics, or human action, and Cione et al. (2009) proposed an alternative, which they called the "Broken Zig Zag" theory. According to these authors, the distribution and abundance of mammals alternated from wider to narrower ranges, following the cycles of spread and reduction of open-vegetation zones responding to climate changes in the middle and late Pleistocene (see Vivo and Carmignotto 2004). During the cold events, megamammals had a wider distribution. During the warm periods, open environments shrank owing to the expansion of forests. These climatic and faunal changes can be modeled as zig zags. Twenty pairs of changes in temperature from hot to cold and back

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occurred during the middle and late Pleistocene (see Petit et al. 1999), but no extinctions occurred. At the beginning of the current interglacial, when temperatures were rising, moisture increased, and forests expanded; megamammals and many large mammals that had survived for hundreds of thousands of years became extinct, and the "zig zag" was broken. The arrival of humans in South America was the sole new biological or geological event that occurred in the present interglacial period. Consequently, the entrance of humans and their pressure on numerically reduced mammal populations must have been the factor that led to local extinction (extirpation) or total (global) extinction. The different extinction of related species (e.g., between Cervidae and Camelidae, cited by Cione et al. 2009), may correspond to subtle differences in ecological plasticity.

The process of extinction appears to have taken several thousands of years in South America. Politis and Messineo (2008) published six AMS ^{14}C ages from *Megatherium americanum* bone collagen from the site Campo Laborde (37° 00′ 36″ S and 60° 23′ 05″ W), ranging from ca 9700 to 6700 RCYBP. The evidence obtained from Campo Laborde as well as from the La Moderna site (Politis et al. 2003) indicates that some Pleistocene species such as giant ground sloth and some glyptodonts (*Doedicurus clavicaudatus* and *Neosclerocaliyptus sp.*) survived in the Pampas until the early Holocene. Recently, Cajal et al. (2010) proposed that the extinction of a camelid, *Lama gracilis*, can be attributed also to the anthropic action that not only includes the hunt burden but also other factors (i.e., environmental change and ethological changes caused by human presence).

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