A Middle Pleistocene Age and Biogeography for the Extinct Rodent *Megalomys curazensis* from Curaçao, Netherlands Antilles

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The extinct oryzomyine rodent *Megalomys curazensis* has been known from abundant but fragmentary remains on the island of Curaçao since 1959. Here we demonstrate an age of 130 000 to 400 000 years before present based on geomorphological context, and propose a biogeographical model for the genus.

**GEOLOGICAL AND GEOMORPHOLOGICAL SETTING**

The Neogene and Quaternary limestones of the northern coast of Curaçao are exposed in an ascending series of five well-defined depositional terraces; Topmost (150-196 m), Highest (90-110 m), Higher (50-80 m), Middle (15-45 m) and Lower (0-10 m) (terminology follows de Buisonjé, 1974, and Stienstra, 1983). Along the south coast, three distinct erosional terraces (Lower, Middle, and Higher) are cut into the Seroe Domi Formation of Upper Miocene through Pliocene limestones (Jackson and Robinson, 1994). The erosional terraces are clearly associated with the depositional terraces (de Buisonjé, 1974; Herweijer and Focke, 1978): on the northern side of the island Late Quaternary high sea levels produced extensive reefal and coastal deposits; on the southern side of the island the same high sea levels produced wave cut platforms (Fig. 2). In each of the three lowermost terraces, erosion by the subsequent high sea level produced a cliff face with a distinct intertidal notch. In addition, the associated high groundwater levels produced distinct episodes of karstification and speleogenesis that are apparent in all the terraces. The red breccia cave and fissure fills bearing the mammalian fossils are located in the Middle and Higher erosional terraces of the south coast; Kueba di Hermanus, the study site, is located in the face of the erosional Middle Terrace (Fig. 2).
The age of the Lower Terrace has been firmly established by U-Th dating of the reef deposits as marine isotope stage (MIS) 5e (∼130 ka; Schubert and Szabo, 1978). Attempts to date the Middle Terrace had been unsuccessful due to problems with coral diagenesis but we have dated by uranium-thorium disequilibrium methods an unaltered *Montastraea annularis* in growth position, collected from the base of the Middle (depositional) Terrace near San Pedro (Fig. 1; Fig. 2 - sample site shown by asterisk). This sample yielded an age of 405 ± 40, -29 ka (by multi-collector, inductively-coupled mass spectrometry; Table 1) and securely places the Middle Terrace (lower unit) in the Isotope Stage 11 interglacial.

These ages on the depositional terraces allow interpretation of the associated erosional terraces, cliff-notch erosion, and speleogenesis. The cliff and intertidal notch in the Lower Terrace of MIS 5e sedimentary rocks is cut by the modern sea; the cliff and intertidal notch in the Middle Terrace of MIS 11 sedimentary rocks is cut by the 5e high sea level, and the Upper Terrace is cut by the former Stage 11 high sea level. Each of these high sea levels has also been associated with cave genesis roughly at the elevation of the former water table and at the intersection of the salt and fresh water following the flank margin model of development (Mylroie and Carew, 2000). The relationships are most obvious on the northern depositional terrace sequences: e.g., speleogenesis during the MIS 5e high sea level produced caves in the face of the Middle Terrace MIS 11 deposits. On the southern coast the erosional terraces cut into the Seroe Domo Formation have a similar relationship to former sea levels; thus, speleogenesis during the MIS 5e high sea level produced caves at the same level. Similarly, speleogenesis during the MIS 11 high sea level produced caves in the Higher Terrace.

**KUEBA DI HERMANUS STRATIGRAPHY**

Deposits of ‘phosphatic breccia’ containing remains of the extinct giant rice rat *Megalomys* occur as a fill in pockets and cavities in the entrance of Kueba di Hermanus, a shallow cave cut into the face of the Upper Terrace (the erosional cliff cut into Seroe Domi deposits that matches the intertidal notch and cliff cut into Higher Terrace deposits by the MIS 11 sea on the northern side of the island), and in the adjacent cliff face. Within the entrance of the cave, the deposit was exposed by blasting during 19th Century phosphate mining activity. This exposure reveals a thick flow-
stone capping the breccia, which in turn buries a substantial stalagmite. Three attempts to determine the age of these speleothems by uranium-thorium disequilibrium dating were unsuccessful, the calcite having been thoroughly leached.

Fortunately, the age of the Megalomys-bearing phosphatic breccias is bracketed, albeit rather broadly, by geomorphological considerations. The deposits do not occur in caves and fissures of the Lower Terrace, and must therefore predate the Last Interglacial, MIS 5e, at ~128 ka. It can be difficult to distinguish the remains of a fossil inter-tidal notch at Kueba di Hermanus (or perhaps halocline cave chamber), so that they must postdate the ~400 ka high sea level stand. The *Megalomys* deposits must have therefore originated between ~130 ka and ~400 ka.

The relationship of the Kueba di Hermanus breccia to the deposits that contained the ground sloth *Pauloecus* and the capybara *Hydrochaeris hydrochaeris* is unknown. The type locality for *Pauloecus* was a fissure-fill exposed by quarrying at an altitude of 150 m above sea-level on the Tafelberg Santa Barbara and it was subsequently destroyed. The capybara site was also on Tafelberg Santa Barbara, at an altitude of 160 m (Hooijer, 1939). Since these sites lay ~100 m higher than the Hermanus site, we presume tentatively that they were contemporaneous with the *Megalomys* breccia.

### Biogeography

The origin of the native West Indian terrestrial vertebrate fauna has been the subject of contentious debate for more than a century, and shows little sign of resolution (see arguments in Hedges, 2001). The West Indian oryzomyine rodents are unusual in this context as they are widespread in their distribution. We therefore reject the scenario in which the ancestral taxon must have been "widely distributed on the South American mainland between northern Columbia and southwestern Ecuador", thereby including the modern range of *O. hammondi*. The Galapagos form has since been shown to be an evolutionarily convergent taxon and moved to its own genus, *Megaoryzomys* (Lenglet and Coppois, 1979), and no evidence has emerged to suggest that *O. hammondi* was ever significantly more widespread in its distribution. We therefore reject *O. hammondi* as the likely progenitor of the Lesser Antillean *Megalomys* spp., and suggest that the ancestral taxon was more likely to have been a small (~40-80 g; i.e. in the range of body masses for extant Caribbean megamomids) rodent on these islands. The evolutionary history of the oryzomyines in the West Indies is one of frequent, over-water colonization events. *Oryzomys antillarum* apparently entered Jamaica from Central America in the Late Wisconsinan (see Morgan, 1993 for a summary of the systematic relationships of *O. antillarum* and its mainland progenitor; McFarlane et al., 2002 provide radiometric evidence of Pleistocene age), requiring two water crossings via the Serranillo Bank. The Lesser Antillean *Megalomys* spp. required multiple 'island-hopping' dispersals to achieve their known distribution. Hershkovitz (1970) proposed that the closest living relative of the *Megalomys* spp. is *O. hammondi*, the largest member of that genus, noting a "cricetine with the size, skull, dentition, and arboreal habitats of *Oryzomys hammondi* could have given rise to all the species referred to *Megalomys*...". However, Hershkovitz's hypothesis is contraindicated by the geographic range of *O. hammondi*, which is limited to the Andes of northwestern Ecuador. Because Hershkovitz (1970) included the Galapagos giant oryzomyine in *Megalomys*, he further postulated that the ancestral taxon must have been "widely distributed on the South American mainland between northern Columbia and southwestern Ecuador", thereby including the modern range of *O. hammondi*. 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LITERATURE CITED


