

AN UPDATED MAMMAL BIOCHRONOLOGY AND BIOGEOGRAPHY FOR THE PALEOCENE AND EARLY EOCENE OF ASIA

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Paleomammalogists often use a biochronological system of regional Land Mammal Ages (LMAs) to designate intervals of time defined by specific events in the evolutionary history of mammals. In North America and Europe, this biochronological framework is fairly well known and has been partially correlated to the global timescale (Secord et al. 2006; Smith & Smith 2003). The Asian early Paleogene mammal biochronology is less precise, due to our previously limited knowledge of these faunas. Moreover, the endemic nature of these Asian faunas and the few absolute ages available have made the correlation and dating of these faunas problematic. Wang et al. (2007) provided a recent synthesis of the Chinese Paleogene mammal radiations, but Ting (1998) was the last to provide a detailed study of the Paleocene and Early Eocene Asian LMAs (ALMAs). However, in the past decade research efforts have rapidly increased the available data on the Asian faunas, creating the need for a detailed update of the existing biochronological framework and its biogeographical interpretation. Faunal data from Asian early Paleogene mammal sites were analysed with Appearance Event Ordination to obtain a temporally ordered faunal succession. Faunal data and analysis results were studied in detail to define biochronological boundaries corresponding to major faunal turnovers, and to clearly characterise the different ALMAs. The new biochronology allows an improved correlation of ALMAs with North American and European LMAs, and to better

understand the biogeography of Paleocene and Early Eocene Asian mammals.

The poorly known Shanghuan represents the oldest Paleocene ALMA, and is characterised by an assemblage dominated by primitive gliriforms and pantodonts. The following Nongshanian ALMA is characterised by an endemic specialisation and diversification. Especially gliriforms radiate, with the diversification of Anagalidae and Pseudictopidae, the first appearance of the gliriform family Arctostylopidae, and, most notably, the appearance of true Glires, represented by Eurymylidae and Mimotonidae. The poor knowledge and primitive, endemic nature of the Shanghuan and Nongshanian faunas complicates their correlation, but the Shanghuan-Nongshanian boundary is often correlated with the Torrejonian-Tiffanian boundary in North America, and this hypothesis was recently magnetostratigraphically corroborated (Clyde et al. 2008). Both boundaries thus seem to represent independent but synchronous turnovers of endemic taxa, and were possibly triggered by the start of a period of global cooling.

The Gashatan ALMA is characterised by the first appearance of rodents, prodinoceratids and hyaenodontids, all of which supposedly evolved in Asia. However, neoplagiaulacids, nyctitheriids, cimolestids and carpolestids also make their first appearance in Asia during the Gashatan, and represent North American immigrants (Missiaen and Smith 2008). Conversely, during this period Asian mammals were also able to invade North America, with a first wave consisting of arctostylopids and prodinoceratids arriving at the start of Tiffanian-5a, and a second wave consisting of rodents, tillodonts and coryphodontids at the start of the Clarkforkian (Secord et al. 2006). The start of the Gashatan is thus no younger than Tiffanian-5a, but may prove to be even older. Although it is not possible to constrain the exact timing or duration of these migration waves at the start of the Gashatan, available evidence is most consistent with two discrete dispersal intervals approximately 1.3 Ma apart.

The Bumbanian ALMA is characterised by the first appearance of artiodactyls,

perissodactyls and primates, similar to their appearance in North America and Europe at the start of the Eocene, and the Gashatan-Bumbanian boundary is traditionally correlated to the Paleocene-Eocene boundary. Contrasting with dispersal at the start of the Gashatan, dispersal during the Bumbanian seems to have been possible during a more extended period of time and was also possible directly between Asia and Europe (Ting 1998; Smith et al. 2006).

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