

Early to middle Miocene monsoon climate in Australia

K.J. Travouillon, M. Archer, and S.J. Hand

School of Biological, Earth and Environmental Sciences, University of New South Wales, New South Wales 2052, Australia

Herold et al. (2011) present a monsoon climate model for the early to middle Miocene of Australia, which suggests that widespread rainforest vegetation could not be supported in northern Australia at that time without a major increase in atmospheric CO₂ concentration. They note that this appears to be at odds with the results of Archer et al. (1994) and Travouillon et al. (2009) who argue that early and middle Miocene faunas of, for example, Riversleigh in north-western Queensland are indicative of at least regional rainforest paleohabitats.

The data used as quantitative climate proxies to calibrate Herold et al.'s models require comment. Two northern Australian fossil localities used to derive proxies for mean annual precipitation (MAP) and mean annual temperature (MAT) (Riversleigh's Dunsinane Local Fauna [LF] and the Northern Territory's Kangaroo Well LF) are late Oligocene rather than Miocene in age (Arena, 2008; Megirian et al., 2004). Although Herold et al. evidently accept the interpretation of Megirian et al. (2004) that there was little difference between the late Oligocene and early Miocene, this view is not supported by other analyses. The late Oligocene in Australia, and globally, is widely recognized as a drier, cooler period than the early and middle Miocene (McGowran et al., 2000; Zachos et al., 2001; McGowran et al., 2004).

In the case of the Dunsinane LF from Riversleigh, Herold et al. accept Guerin and Hill's (2006) interpretation of a contemporaneous deciduous vine thicket as a proxy for MAP for the Miocene of northern Australia. However, Guerin and Hill (2006) erroneously presumed that all of Riversleigh's assemblages were Miocene in age despite a long-standing literature demonstrating that these span the climatically very different late Oligocene, Miocene, Pliocene, and Pleistocene (e.g., Archer et al., 1997; Travouillon et al., 2006).

On the basis of their models, Herold et al. suggest that interpretation by Archer et al. (1997) and Travouillon et al. (2006) of extensive early and middle Miocene rainforests in northern Australia may be based on data that derives instead from local, riparian rainforest biotas. They acknowledge that their modeling might have a dry bias, particularly if CO₂ values in the Miocene were a lot higher than present, but conclude that "...widespread rainforest in north Australia is not supported without an arguably unrealistic increase in precipitation" (Herold et al., 2011, p. 5).

Presence of rainforest at Riversleigh in the early to middle Miocene is supported by: (1) cenogram/body mass distribution patterns (Travouillon et al., 2009); (2) numerous obligate rainforest taxa (Archer et al., 1997; 2006); (3) overall mammalian species diversity comparable with that found in lowland rainforest communities in Borneo; (4) lack of evidence in mammalian herbivore dentitions of capacity to consume plants other than soft-leafed taxa typifying wet forest ecosystems; and (5) frog assemblages of sympatric small bubble-nesting myobatrachids collectively indicating cool, aseasonal, permanently wet conditions (M. Tyler, 2007, personal commun.).

That the Miocene rainforest communities are not simply riparian is indicated by the fact that this species diversity could not be maintained for millions of years in narrow strips along rivers or around lakes. Further, absence in these diverse paleocommunities of any arid-adapted taxa sug-

gests they had not yet evolved in Australia, and that the biota documented in the Riversleigh deposits of this age may well be representative of much of northern Australia. Extensive species overlaps (Travouillon et al., 2006) with the early Miocene Kutjamarpu LF from the Wipijiri Formation in the Lake Eyre Basin suggests that similar species-rich forest communities extended into central Australia at this time.

With respect to the suggestion (Herold et al., 2011) that their modeling indicates that grasslands may have been present in central and/or northern Australia at this time, Martin (2006), having reviewed all palynological evidence from Australia, concluded that there is no evidence for grasslands prior to the Pliocene.

We suggest that some aspect of the modeling that led Herold et al. to conclude that the early to middle Miocene communities of Riversleigh were probably either not rainforest or simply riparian localized communities requires closer examination, particularly in the light of the inappropriate proxies that underpin some of the modeling.

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