

## Early to middle Miocene monsoon climate in Australia

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Travouillon et al. (2012) challenge our interpretation of proxy records (Herold et al., 2011), citing five points for rainforest at Riversleigh and across northern and central Australia in the early to middle Miocene; points that we refute here.

### (1) Cenogram/body mass distribution patterns

Travouillon et al. (2009) were equivocal in assigning some fauna sites to open forest or rainforest using cenograms alone, but using cenograms and body mass distribution (BMD) in combination, they interpreted the majority of the Riversleigh sites as rainforest. Yet, their Discriminant Function Analysis (DFA) of the same faunas identified a mix of open forest (2/6) and rainforest sites (4/6) for the early Miocene, and all five middle Miocene sites as open forest. Thus their own data imply a mosaic of habitats in space and time in the Riversleigh area of northern Australia.

### (2) [and (4)] Obligate rainforest taxa/herbivore dentitions adapted to soft-leaved wet forest ecosystems

The definition of “rainforest” in Australia includes seasonally dry tropical vegetation rich in deciduous trees (Lynch and Neldner, 2000). All types of “rainforest” are rich in soft-leaved taxa and include obligate rainforest vertebrate taxa. The “dry rainforests,” or deciduous vine thickets (DVT), are biogeographically linked to Australian tropical and subtropical rainforests, and not with “hard-leaved” sclerophyll vegetation. They occur where mean annual precipitation (MAP) is 50–150 cm/yr, and are markedly seasonally dry (cf., MAP >200 cm/yr and low seasonality for tropical rainforests) (Greenwood, 1996; Lynch and Neldner, 2000). In saying Riversleigh faunas represented rainforest, Travouillon et al. (2009, 2012) could mean the whole spectrum of Australian “rainforest” from MAP 50 cm/yr to >200 cm/yr.

### (3) “Species diversity comparable with ... rainforest communities in Borneo” / “Diversity could not be maintained ... in narrow strips along rivers or around lakes.”

Guerin and Hill (2006, and references therein) argued that landscapes with a mosaic of habitats will have more species in total than if one habitat was present. Fossil vertebrates in pitfall cave and limestone pool deposits and other attritional or “death-trap” assemblages are a feature of Riversleigh (Bassarova, 2004). In a landscape with multiple habitats, attritional assemblages will potentially sample vertebrate taxa from each habitat, and so their diversity reflects the mosaic.

### (5) “Frog assemblages of sympatric small bubble-nesting myobatrachids collectively indicating cool, aseasonal, permanently wet conditions.”

Myobatrachid frogs are a diverse group found in cool alpine settings in southeastern Australia, as well as in arid and semi-arid environments, with some tropical species producing bubble nests (Littlejohn et al., 1993). “Cool, aseasonal, permanently wet conditions” are contradicted by every

line of paleontological data for the Riversleigh area from the late Oligocene to late Miocene (Guerin and Hill, 2006; Travouillon et al., 2009). Myobatrachids at Riversleigh are not evidence of widespread Miocene rainforests.

Travouillon et al.’s claim that “Guerin and Hill (2006) erroneously presumed that all of Riversleigh’s assemblages were Miocene” is false; these authors clearly stated that Riversleigh spanned the past 25 million years (Guerin and Hill, 2006, p. 717–718). The late Oligocene Riversleigh sites were interpreted as open forest or rainforest, depending on site and method (Travouillon et al., 2009). Whereas late Oligocene and Miocene conditions at Riversleigh may have differed, the correspondence between the vegetation (DVT or “dry rainforest”; Guerin and Hill, 2006) and the mammal analysis for the same time period is compelling for accepting the proxies used.

Travouillon et al. (2012) also cited Lake Eyre Basin faunas as evidence for central Australian Miocene rainforests. Extensive proxy data including paleosols from the Lake Eyre Basin and a newly described flora from Lightning Ridge in New South Wales refute this interpretation (Carpenter et al., 2011; Metzger and Retallack, 2010); unless as argued above, seasonally dry DVTs or forests together with more mesic-evergreen riparian and swamp forests were interspersed with sclerophyll communities.

We recognize the uncertainties in paleoclimate modeling, and the basis for our main conclusion is in fact that the simulated climate underestimates MAP by ~20 cm. Even considering this bias, as well as a CO<sub>2</sub> concentration twice that of the present day, widespread rainforest was not simulated (Herold et al., 2011). In summary, based on the diversity of proxies and the application of numerical modeling, we reiterate our conclusion that it is highly unlikely that “rainforest” (i.e., MAP > 200 cm) occupied large tracts of inland Australia.

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