**Phylogeny construction**

Tree topology and divergence dates for living taxa follow Mitchell et al.[1](#_ENREF_1), except that the tree root was positioned between Didelphimorphia and the remaining extant orders following Gallus et al.[2](#_ENREF_2). *Borhyaena* *tuberata* is a member of Sparassodonta, which falls outside crown-clade Marsupialia[3](#_ENREF_3); we have arbitrarily set the divergence of *Borhyaena* as 5 million years before the estimated time of origin of crown-clade Marsupialia. The macropodiforms *Balbaroo nalima* and *Ekaltadeta* *ima* are placed in a polytomy with Hypsiprymnodontidae, Potoroidae and Macropodidae[4](#_ENREF_4). The macropodid *Simosthenurus occidentalis* is assumed to have diverged at the same time as *Lagostrophus* *fasciatus*[5](#_ENREF_5). The fossil dasyuromorphian *Barinya* *wangala* is placed in a polytomy with Dasyuridae, Myrmecobiidae and Thylacinidae[6](#_ENREF_6), whereas the fossil thylacinid *Nimbacinus* *dicksoni* is assumed to have diverged from the recently extinct *Thylacinus* midway between the age of *Nimbacinus*[7](#_ENREF_7) and the time of the Dasyuridae-Myrmecobiidae-Thylacinidae split. The extinct peramelemorphian *Galadi* *speciosus* is assumed to have diverged from the midpoint of the branch leading to crown-Peramelemorphia[8](#_ENREF_8). Divergence dates for fossil vombatiforms are based on *Beck et al*.[9](#_ENREF_9). Three different positions for *Yalkaparidon* *coheni* were tested (following the phylogenetic analyses of Beck *et al.*[10](#_ENREF_10)): stem-diprotodontian (diverging at the midpoint of the branch leading to crown-Diprotodontia), stem-australidelphian (diverging at the midpoint of the branch leading to crown-Australidelphia), and member of Agreodontia sensu Beck *et al*.[10](#_ENREF_10) in a polytomy with Dasyuromorphia, Peramelemorphia and Notoryctemorphia. For all phylogenetic analyses, all three placements for *Yalkaparidon* were tested and results were averaged.

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5 Llamas, B. *et al.* Late Pleistocene Australian marsupial DNA clarifies the affinities of extinct megafaunal kangaroos and wallabies. *Molecular Biology and Evolution* 32, 574-584 (2015)

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7 Woodhead, J. *et al.* Developing a radiometrically-dated chronologic sequence for Neogene biotic change in Australia, from the Riversleigh World Heritage Area of Queensland. *Gondwana Research* 29, 153-167 (2016)

8 Travouillon, K. J., Archer, M., Hand, S. J. & Muirhead, J. Sexually dimorphic bandicoots (Marsupialia: Peramelemorphia) from the Oligo-Miocene of Australia, first cranial ontogeny for fossil bandicoots and new species descriptions. *Journal of Mammalian Evolution* 22, 141-167 (2015)

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