Title: Fossil Focus: The Evolution of Tree-Kangaroos
Author(s): Christine Janis [*1]
Volume: 3
Article: 3
Page(s): 1-6
Published Date: 01/03/2013
PermaLink: http://www.palaeontologyonline.com/articles/2013/the-evolution-of-tree-kangaroos/

CITATION OF ARTICLE

Please cite the following published work as:

Janis, Christine. 2013. Fossil Focus: The Evolution of Tree-Kangaroos, Palaeontology Online, Volume 3, Article 3, 1-6.

Fossil Focus: The Evolution of Tree-Kangaroos

by Christine Janis[*1]

Ladies and gentlemen, I give you tree-kangaroos. These wonderful animals can, in myriad ways, demonstrate the power of evolutionary biology and geology in explaining the patterns we see in modern ecosystems. Here, I want to show how palaeontologists can piece together multiple lines of evidence to understand the evolutionary relationships of fossil and living organisms.

Introduction:

First, a little introduction to the tree-kangaroos (genus *Dendrolagus*). These small, tree-dwelling ('arboreal') marsupials live in the rainforests of Australia and New Guinea, and belong to the macropod family of animals, which also includes ground-dwelling kangaroos and wallabies. They grow up to about 80 centimetres long, not including the tail, and mainly eat vegetation (see Fig. 1). More than 10 living species are known.

Macropod means 'large foot', and like all members of this group, tree-kangaroos do indeed have big feet (see Fig. 2). They have no hallux, or digit, corresponding to the first digit in other mammals, and their fourth and fifth digits are small and fused together ('syndactylous') to form a grooming claw. The feet are relatively shorter and broader than in terrestrial kangaroos, and have a large, continuous foot pad covered in small bumps that help them to grip. The toes have large, curved claws, rather than flat nails; the ankle joint is modified to allow the foot to be rotated so that the soles of the feet face inwards (ideal for gripping braches); and the tibia (shin bone) is relatively short. Tree-kangaroo arms are proportionally larger and more robust than the arms of other kangaroos, and the hands have pads and claws similar to those on the feet. This combination of longer arms and shorter legs is more like the proportions of a non-hopping mammal than of a terrestrial kangaroo. The tail is not as heavily built as in the hopping kangaroos, and is not prehensile, yet it may be very long: up to 15% longer than the body in some species. It may be used for balance in the tree canopy.

Tree-kangaroos are said to be the only kangaroos that can move their hind feet independently of each other (although other kangaroos can do this while swimming). They have some ability to hop on two feet, but they can also move by bounding on four feet and walking on two, both along branches and on the ground.

The tree-dwelling possums are the closest known relatives to kangaroos, so one might imagine that terrestrial kangaroos evolved from tree-kangaroos in a 'down from the trees' scenario. However, evidence from DNA, anatomy and the fossil record shows that they evolved relatively recently (in the past 5 million to 7 million years), and that their arboreal features have been acquired through modification of the hopping-adapted anatomy of terrestrial kangaroos.

The tree-kangaroo fossil record

Tree-kangaroos are poorly known from the fossil record. Some tooth fragments are known from the Hamilton Fauna, a group of rocks in Victoria, Australia, dating back to the Pliocene epoch, 5.3 million

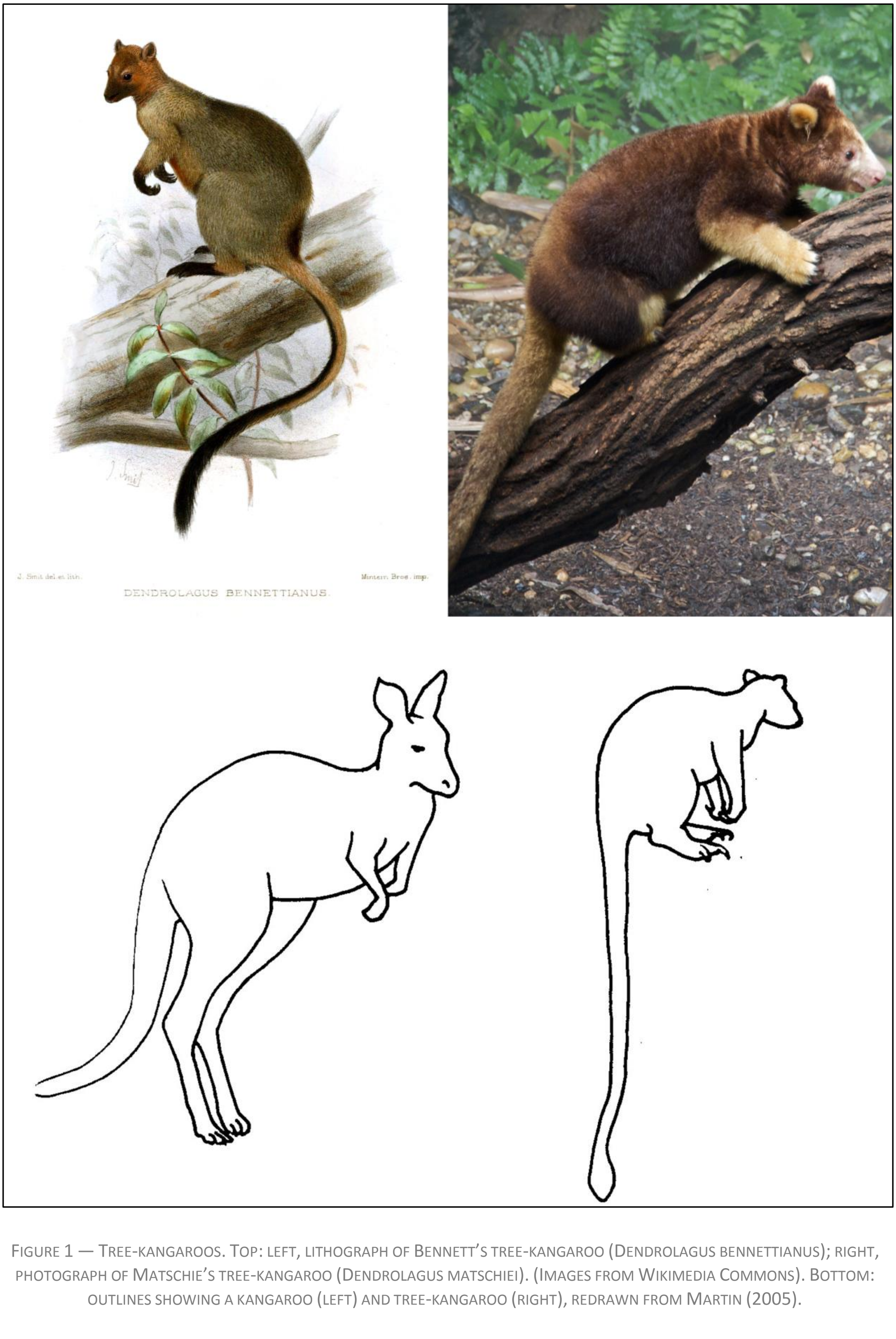

Figure 1 — Tree-kangaroos. Top: left, lithograph of Bennett's tree-kangaroo (Dendrolagus bennettianus); right, photograph of Matschie's tree-kangaroo (Dendrolagus matschiei). (Images from Wikimedia Commons). Bottom: outlines showing a kangaroo (left) and tree-kangaroo (right), redrawn from Martin (2005).

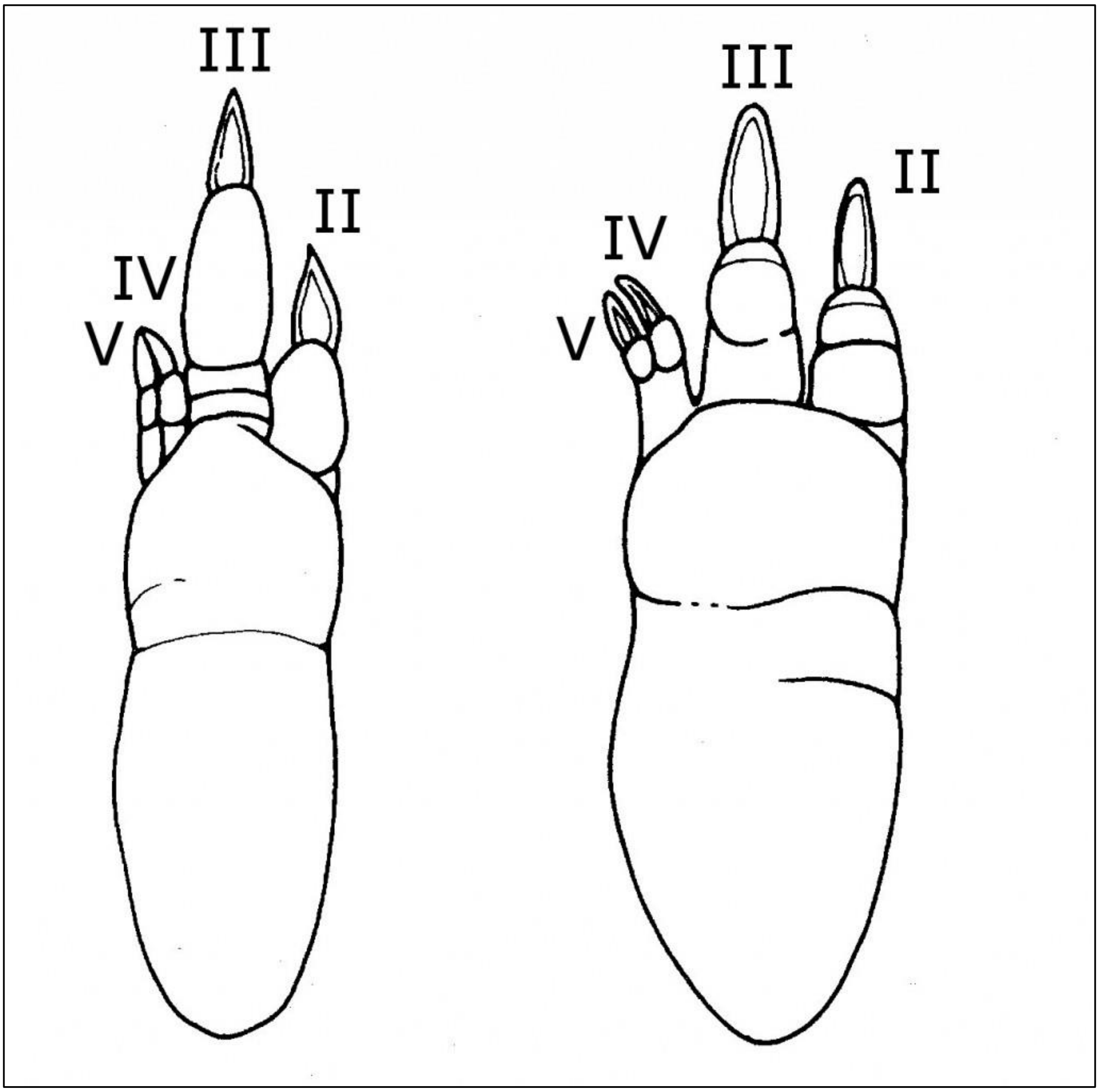

FIGURE 2 — DRAWINGS OF THE HIND FEET OF BENNETT'S TREE-KANGAROO (LEFT) AND DORIA'S TREE-KANGAROO (DENDROLAGUS DORIANUS; RIGHT), REDRAWN FROM MARTINE (2005)

to 2.5 million years ago, in an area thought once to have been temperate rainforest. A few other remains are known from cave deposits in New Guinea from the late Pleistocene epoch (2.5 million to 0.01 million years ago). Other evidence of Australian tree-kangaroos comes from the late Pliocene and Pleistocene remains of the giant tree-kangaroo *Bohra*, which has a body resembling that of the tree-kangaroos, but a skull more like that of the rock-wallabies (genus *Petrogale*). (Rock-wallabies are the sister group to tree-kangaroos; see Fig. 3.) With a body mass between 30 and 40 kilograms, *Bohra*was around three times the size of the largest living tree-kangaroos, and was probably not as arboreal in its habits, especially given that it is known from areas of southern Australia that were relatively dry during the Pleistocene, such as the Nullabor Plain.

Tree-kangaroos as an example of evolution

So, how can tree-kangaroos be used as a superb example of evolution in action?

1. What better example could we have of a living ‘transitional form’ than the tree-kangaroo? It is not well adapted for its environment, so it is difficult to imagine it having been ‘designed’. Tree-kangaroos are clumsy climbers compared with animals such as monkeys, or even with other marsupials such as possums. Not only is their behaviour clumsy, but their anatomy seems largely unsuited to the arboreal lifestyle. Unlike other largish tree-dwelling mammals, they neither have a prehensile tail that helps them climb (like possums or howler monkeys), nor lack a tail, thus avoiding the problems that one brings (like koalas, sloths and apes). Tree-kangaroos’ tails dangle and can sometimes get in the way of their climbing. Their ankle joints do not resemble those of specialized arboreal mammals, but have clearly been modified from the highly specialized ankles of hopping kangaroos.

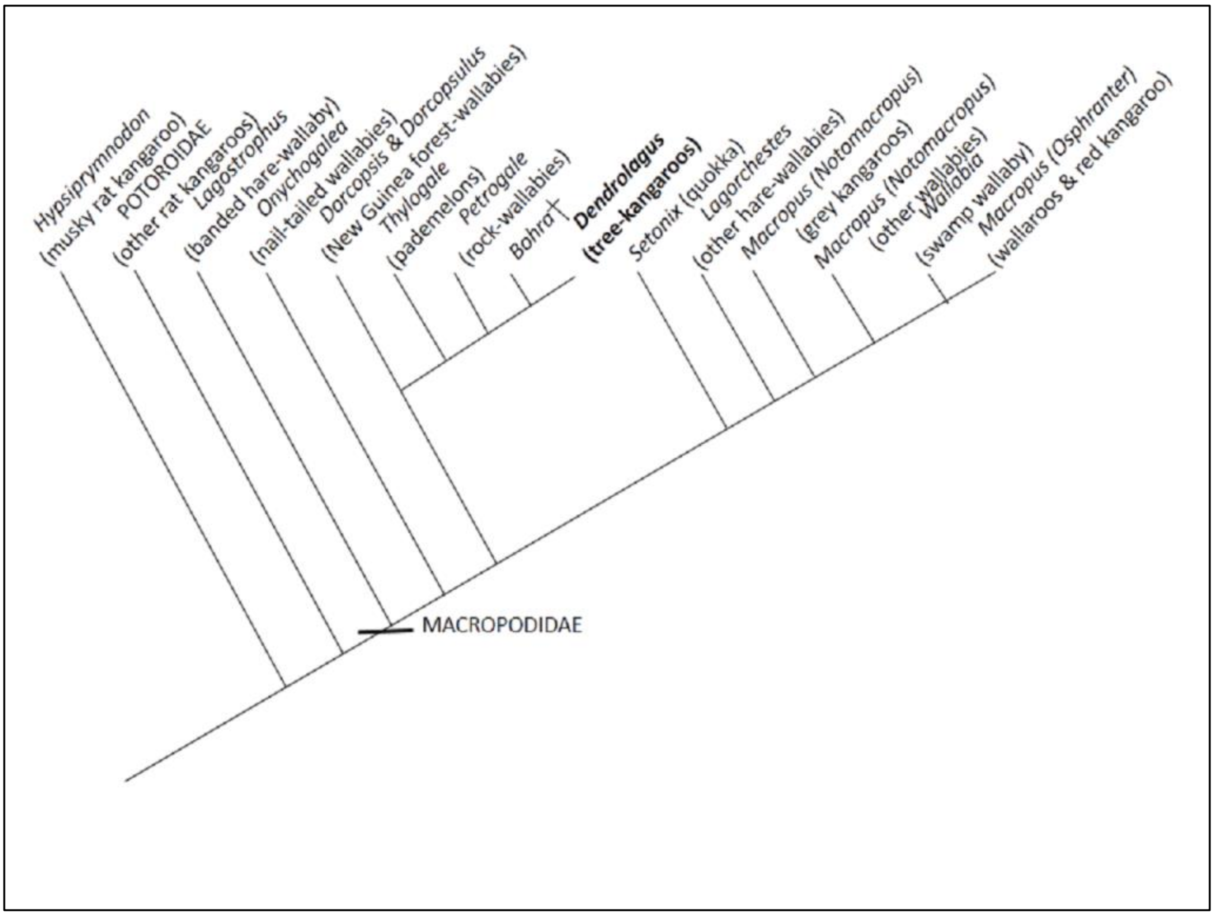

Figure 3 — Evolutionary relationships of the Macropoidea (kangaroos and potoroids). Modified from Meredith et al. (2009); position of the extinct taxon Bohra from Prideaux & Warburton (2010). Note that the anatomy-based phylogeny of Prideaux and Warburton is slightly different from the DNA-based one, but this does not affect the relative position of the tree-kangaroos.

2. What could be a better illustration than one transitional form? An entire series of them! There are close to a dozen species (depending on how you count some subspecies) of tree-kangaroos: two in Australia and the rest in New Guinea. The evolutionary relationships of these animals show that the earliest-evolved forms (the two Australian species and one of the New Guinea ones) that have the least-derived foot anatomy, whereas a couple of the New Guinea species seem to have been modified back again for a more terrestrial existence. This diversity of living forms, showing a range of

progressive adaptations, is counter to the Victorian notion that one species must go extinct after the generation of a newer, 'better-adapted' form.

3. How does such a transitional form develop in the first place? When a creature starts to exploit a new habitat, with no suitable competitors. There were no monkeys in the tropical forests of Australia and New Guinea when the tree-kangaroos first encountered them. There are monkeys on nearby islands to the west of New Guinea, but a boundary called the Wallace Line separates these populations.

The Wallace Line is named after Charles Darwin's colleague Alfred Russel Wallace who was the first person to notice a strange anomaly: New Guinea is closer to many Asian islands than it is to Australia, but the island contains more organisms with close relations in Australia than with relations in Asia. In addition, there is a strange mix of Australian and Asian organisms in the islands between New Guinea and Malaysia, a region now known as Wallacea. One species of tree-kangaroo is found on a couple of the smaller islands to the east of the Wallace Line, but no monkeys are found there.

Evidence from plate tectonics shows that until a few million years ago, New Guinea was further away from Asia, so that immigration of Asian species would have been difficult. During the ice ages over the past few million years, lowered sea levels would have allowed free interchange between New Guinea and Australia, but not between New Guinea and the Asian mainland (because the sea is shallow between New Guinea and Australia, which are basically part of the same land mass, but not between New Guinea and the Asian islands).

DNA data suggests that the tree-kangaroos split away from rock wallabies between 5 million and 7 million years ago, which is about the same time that tree-kangaroos first appear in the fossil record. This date is also a perfect match for evidence from plate tectonics that shows when the northern movements of the Australasian plate brought New Guinea and northern Australia into the tropical zone, establishing new types of rainforest environments that the tree-kangaroos moved into, without competition.

4. Why are there are so many species of tree-kangaroos in such a relatively small area? This is exactly what one would predict as a result of frequent breaking apart and rejoining of forest habitats over the past couple of million years, when ice ages in the higher latitudes were accompanied by drying and loss of forest habitat in the tropics. Such fragmentation in the African and South American tropical forests is well documented as the driver of increased speciation during the Pleistocene, and the number of tree-kangaroo species in New Guinea echoes the diversity of African monkeys and Amazonian tropical birds.

5. Science relies heavily on consilience: it tests whether a result is accurate by checking whether multiple lines of evidence lead to the same result. In that spirit, a type of evidence completely separate from the fossil record throws light on the evolution of tree-kangaroos: genetic studies show that the closest relatives of the tree-kangaroos are the rock-wallabies (genus *Petrogale*). The most arboreal rock-wallaby today is the Proserpine rock-wallaby, *Petrogale persephone*. Now, surprisingly (or perhaps not), the genetic evidence shows that the Proserpine rock-wallaby is the most basal of the *Petrogale* group of a dozen or so species of rock-wallabies, so it is closest to the common ancestor of the tree-kangaroos and rock wallabies.

It can be tempting to think that palaeontologists and biologists might simply look at what fossils are found where and when, and deduce evolutionary history from that. But I have detailed here several separate, independent lines of evidence about tree-kangaroo evolution. Issues such as the divide of the fauna and flora across the Wallace Line (with the absence of monkeys in New Guinea) and the makeshift arboreal anatomy of tree-kangaroos are observations in today's world that remain entirely independent of any evolutionary interpretations. Yet these, and other facts such as the evidence from plate tectonics, genetic studies and fossils, all fit together into a coherent evolutionary perspective on the distribution and anatomy of tree-kangaroos.

Further Reading:

Aplin, K. A., Pasveer, J. M. & Boles, W. E. 1999. Late Quaternary vertebrates from the Bird's Head Peninsula, Irian Jaya, Indonesia, including descriptions of two previously unknown marsupial species. *Records of the Western Australian Museum.* Supplement **57**, 351–387.

Eldridge, M. D. B. & Close, R. L. 1997. Chromosomes and evolution in rock-wallabies *Petrogale* (Marsupialia: Macropodidae). *Australian Mammalogy* **19**, 123–135. doi: 10.1071/ZO9890351

Flannery, T. F., Rich, T. H., Turnbull, W. D. & Lundelius, E. L. 1992. The Macropodidae (Marsupialia) of the early Pliocene Hamilton local fauna, Victoria. *Fieldiana: Geology, New Series* **25**, 1–37.

Martin, R. 2005. *Tree-kangaroos of Australia and New Guinea*. CSIRO Publishing. ISBN: 9780643090729

Meredith, R. W., Westerman, M. & Springer, M. S. 2009. A phylogeny and timescale for the living genera of kangaroos and kin (Macropodiformes: Marsupialia) based on nuclear DNA sequences. *Australian Journal of Zoology* **56**, 395–410. doi:10.1071/ZO08044

Meredith, R. W., Westerman, M., Case. J. A. & Springer, M. S. 2008. A phylogeny and timescale for marsupial evolution based on sequences for five nuclear genes. *Journal of Mammalian Evolution* **15**, 1–36. doi:10.1007/s10914-007-9062-6

Prideaux, G. J. & Warburton, N. M. 2010. An osteology-based appraisal of the phylogeny and evolution of kangaroos and wallabies (Macropodidae: Marsupialia). *Zoological Journal of the Linnean Society* **159**, 954–987. doi:10.1111/j.1096-3642.2009.00607.x

[1] Department of Ecology and Evolutionary Biology, Brown University, Providence, RI 02912, USA.