

Moa's Ark: Miocene Fossils Reveal the Great Antiquity of Moa (Aves: Dinornithiformes) in Zealandia

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ABSTRACT. Fossil eggshell and bone fragments from New Zealand's Miocene St Bathans Fauna indicate that two taxa of giant flightless moa (one weighing 20–25 kg and another much larger than this) were present in Zealandia 19–16 Ma. Contrary to recent suggestions, we conclude that moa have a long history in Zealandia, almost certainly extending to before the Oligocene “drowning”. This conclusion is consistent with biotic evidence from other sources, which indicates a great antiquity of several Zealandian animals and plants.

TENNYSON, ALAN J.D., TREVOR H. WORTHY, CRAIG M. JONES, R. PAUL SCOFIELD & SUZANNE J. HAND, 2010. Moa's Ark: Miocene fossils reveal the great antiquity of moa (Aves: Dinornithiformes) in Zealandia. In *Proceedings of the VII International Meeting of the Society of Avian Paleontology and Evolution*, ed. W.E. Boles and T.H. Worthy. *Records of the Australian Museum* 62(1): 105–114.

Moa (Dinornithiformes) have been central to the debate around the antiquity of the terrestrial New Zealand biota—so much so that their presumed Gondwanan origins have seen the country sometimes dubbed “Moa's Ark” (Brewster, 1987; Bellamy *et al.*, 1990). Although numerous taxa have generally been considered to have dispersed over-water to Zealandia, the biota has long been assumed to include Gondwanan vicariant ancestors of some plants (e.g., southern beech *Nothofagus*), many invertebrates (e.g., velvet worms *Peripatus* and hyriid freshwater mussels), New Zealand

frogs (leiopelmatids), tuatara (sphenodontids) and moa (e.g., Fleming, 1979).

The order Dinornithiformes (superorder Palaeognathae) includes nine Recent species of moa, all of which became extinct about 600 years ago as a result of human hunting (Tennyson & Martinson, 2007; Bunce *et al.*, 2009). Their remains are numerous in Late Pleistocene-Holocene fossil deposits (Worthy & Holdaway, 2002; Tennyson & Martinson, 2007). Moa were very large flightless birds, varying in weight from 9–242 kg (Worthy & Holdaway, 2002; Tennyson

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