

1856

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NEW ZEALAND ECOLOGY FLIGHTLESS BIRDS

The absence of mammalian predators and competitors in New Zealand, allowed dominant taxa to evolve from other animal groups that were functionally equal to mammals. With the exception of a few oceanic islands, they have no functional or taxonomic equivalent anywhere in the world. Moas were the most significant alternative to mammals on New Zealand, taking the role of the largest dominant herbivores, the same role as large animals such as deer and elephants in other lands.



SEARCH

MOA

After 170 years of controversy over the evolutionary history of the extinct ratite moa, research in 2009 identifies nine species, with three genera and six species in the Emeidae family, two *Dinornis* species in the Dinornithidae family, and one Megalapterygidae species.

Moas are the only species in the Dinornithiformes order, and together with New Zealand's iconic species, kiwi and tuatara, have endemic distinction at order level.

Moas were the dominant herbivore in the New Zealand ecosystem, and another biological peculiarity, which evolutionary scientists relate to the prolonged isolation, size, and geographical complexity of the country, and the scarcity of terrestrial mammals.

New Zealand is Earth's largest oceanic archipelago, and the most distant from any continental land mass, which together with a mixed topography, provided the conditions for natural selection processes that produced varied evolutionary outcomes.



Extinct birds
58 losses since human arrival



Flightless birds

Takahe Kiwi
Kakapo Penguin
Moa Wren



Teal

Auckland Is.
Campbell Is.
Brown teal



Native ducks

Blue duck
Grey duck
Paradise shelduck
Shoveler, Scaup



Penguin

Yellow-eyed
Four crested
Little blue
White-flippered

Rediscovered birds

The remarkable return of five extinct species



Native birds list

273 oceanic, coastal and terrestrial birds



Critically endangered birds

Nine Red List, 26 nationally critical



Extinct giant moa *Dinornis robustus* and *D. novaezealandiae* were the tallest birds on Earth - with the top of their back two metres above the ground.

As Dr Jared Diamond of UCLA points out "... the only approach to moa elsewhere in the world were the elephant birds of Madagascar plus the surviving ratites of the continents, but none of these other groups of very large flightless herbivorous birds radiated to anything like the degree that the moas did ..."

Moas were part of the ratite group which diverged to isolated locations throughout the Pacific. They were a notable early group that have no ridge (keel) on their sternum (breast bone) to which wing muscles are attached in birds that fly.

Ratites are a basal lineage of birds that are

Right: Skull of *Dinornis robustus*. Above: The upland moa *Megalapt* relatively small, weighing 14 to 60 kg, commonly been found in alpine areas known to have occupied steep coasts of South Island. It is the only moa known to have 'down to its' ankles. Image by Peter Schouten. Copyright © Peter Schouten.

Reverse dimorphism - much bigger than male

The extent of reverse sexual dimorphism in some moa is unprecedented among terrestrial mammals with males different in shape than females.

Since the first moa was described this led to confusion with as many species in 20 genera at one time listed by Walter Rothschild in 1907.

At the time eleven moa species were recognised in 2003, three *Dinornis* species showed limited cladistic differences from Owen's description in 1839, they had been separated primarily on their limb bone size.

The first sex-linked nuclear DNA analysis of extinct species showed three forms were one species, whose sex chromosomes were distinctly different. This was a habitat.

3rd

Falcon, Harrier
Morepork
Laughing owl
Haast's eagle

Parrots & Parakeets

Kea
Kaka
Kakapo
5 parakeets

Wattlebirds

Huia
Kokako
Saddleback



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MEDIA NEWS

Moas in decline before humans arrived

"Humans may not be entirely to blame for wiping out moas ... a huge moa population existed in the few thousand years before the arrival of humans ..."

New Scientist
10 November 2004

DNA shows female moa three times size of male

"The mystery of New Zealand's giant moa has been solved at last - she was a female"

New Zealand Herald
11 September 2003

New Zealand's flight path to disaster

"... New Zealand has a better record of the birds that lived over the past 100,000 years than any other area of the world..."

New Zealand Herald
14 January 2003

Feathers to keep moa's toes warm

"Short, stocky and with feathers all the way down to its toes, the upland moa would have been an extraordinary sight ..."

New Zealand Herald

hypothesized to have had a common ancestor 80 million years ago on the Cretaceous southern supercontinent of Gondwana, which subsequently underwent either vicarious speciation as the landmass fragmented, and/or flighted dispersal [Bunce, Worthy, et.al, 2009].

Living members of the ratite lineage include the ostrich of Africa, emu and cassowary of Australia and New Guinea, rhea of South America, and New Zealand kiwi. The extinct giant elephant bird of Madagascar, and fossil *Sylvarnis* of New Caledonia were also ratites.

Morphological radiation of moa appears to have occurred much more recently than previous early Miocene (15 mya) estimates, and was coincident with the accelerated uplift of the Southern Alps just 5 to 8.5 mya [Bunce, Worthy, et.al, 2009].

Periodic bridging of the North and South Islands from lower sea level during glacial periods also influenced dispersal in the Pleistocene within the last 2 million years.

Together with recent fossil evidence, Bunce, Worthy, et.al suggest that the recent evolutionary history of nearly all of the iconic New Zealand terrestrial biota occurred principally on the South Island.

The absence of deep (20 million years) splits in the moa phylogeny suggest that all recent moa species originated from the southern landmass [Bunce, Worthy, et.al, 2009].

A new 5.8 mya estimate for the basal divergence of *Megalapteryx* correlates closely with the rapid phase of mountain uplift during the Miocene-Pliocene [Bunce, Worthy, et.al, 2009].

Other divergence estimates are 5.3 mya for the mean Dinornithidae/Emeidae taxon split, 1.45 mya for *Dinornis*, 1.9 mya for *Pachyornis*, 1.8 mya for *Anomalopteryx/Emeus* plus *Euryapteryx*, and 1.35 mya for *Emeus/Euryapteryx*.

The tallest bird on Earth

The largest females of extreme sexual size dimorphism were 150% the height of males. [Bunce, Worthy, et.al, *Dinornis* weighed between 80 while males were only 40 to 9

The stout-legged moa *Euryapteryx* was considered to be two species recently, because of the difference in female which weighed 40 to 1 the weight of an ostrich, and the male weighing between 12 and

Moa eggs were normally cream colored however, some light green and blue have been found. The eggs of 13 species were 24 centimetres (9.5 inches) long, and the largest egg that found has a capacity of 4,302 centimetres (1.8 cubic feet), 1/3 the capacity of an average sized chicken

The fastest known extinct megafauna

The descendants of the original moa proliferated and developed diversely during millions of years of isolation in New Zealand, until the arrival of humans

Moa had only one natural predator, Haast's eagle *Harpagornis moorei* eagle ever known with a wingspan of 1.5 meters and talons as big as tiger

But life in a bird's paradise could not last and after millions of years moa species ended up in Maori cooking pits as their habitat was destroyed by

Holdaway and Jacomb explore the moa population of low elevation by an initial population of 100 coupled with the habitat loss caused by them. Conservative analysis of medium human population growth and minimal rates of habitat removal of the two main islands, and the resulting cropping rates.

The total population of all species of moa at the time of human settlement was small, and only consumption of one year old was considered. It is known that consumption of moa was considerable, but was ignored

Moas, like most long-lived birds, were vulnerable to any increase in predation. When subjected to a low level of predation, moas required an increase in births to maintain

.....
"... human hunting and destruction drove nine species to extinction less than a century after Polynesian settlers.

20 June 2002

Swamp yields moa haul in historic dig

"Palaeontologists working in North Canterbury will not know the extent of the biggest collection of swamp moa and other extinct or rare species until the end of the year."

New Zealand Herald
9 July 2001

Extinct bird in 'ground breaker'

"The DNA of extinct birds has shed new light on formation of Southern Hemisphere continents"

BBC NEWS
7 February 2001

The largest moa, the two female *Dinornis* species were the tallest birds on Earth - 6 feet tall at the top of their back. Paleoecologists no longer think the giant long necked moa normally stood erect (as shown right it would have reached 4 m [13 ft] in height). It is now thought that moa had a more horizontal neck posture, however, it could have reached up to 3 metres to graze on trees. Skeletal remains show that they were built like some dinosaurs.

A female *Dinornis robustus* weighed 275 kg (600 lb), less than the extinct elephant bird *Aepyornis maximus* of Madagascar that weighed 1100 lbs, but was much bigger than all other ratites. The largest living bird in the world today is the African ostrich which reaches a maximum weight of 114 kg (250 lb). Some individual Mantell's moa *Pachyornis geranoides* were a mere 17 kg, reaching up one metre, and with a back height of 0.5m, about the size of a large turkey.



Image: Frederick William Frohawk 1861-1942, *Dinornis ingens* 1906. Permission of the Alexander Turnbull Library, National Library of New Zealand, Te Puna Matauranga o Aotearoa must be obtained before any re-use of this image.

Moa were the only avian species in the world without any vestige of a wing. They also had no tail. The junction of a small scapulocoracoid bone, formed from the fused scapula and coracoid, is where the wing humerus was at an earlier evolutionary stage.

Formerly, morphological data defining the ratite family tree, suggested kiwi were closely related to moa by ten skeletal similarities. It was thought that kiwi and moa had the same ratite Gondwanan ancestor from which all ratites developed flightlessness, and co-existed but dispersed separately within New Zealand.

This supports the argument of arrival of moa and kiwi by a land connection prior to the late Cretaceous, before New Zealand broke off from Gondwana.

Moa were the world's only avian species without any vestige of a wing.

Genetic research has concluded that kiwi evolved from a Gondwana ancestor, that along with South American rhea and New Zealand moa diverged early in their evolution.

This places kiwi in the same group as Australia's emu

Zealand ..."

Even without habitat loss that have occurred during the extinction the most conservative analysis: moas were extinct within 160 years of arrival.

Revised radiocarbon dating of campsites, place the earliest Maori hunters, Polynesians who were in New Zealand, in the 13th century.

The archeological record clearly shows moa bones were suddenly missing from campsites and Maori middens in the 13th century. The short period during which they were eaten out of existence is the geological time of moa life.

In a commentary on the study Diamond claims that in New Zealand, Madagascar and many Pacific islands would deny that the first arrival caused mass extinction, and the question is how fast it occurred. The study shows that moa extinction was the only cause. It was fast and was mainly by hunting.

Dr Ross MacPhee, a mammal curator at the American Museum of Natural History, who has studied ancient records says "there is no way of interpreting the record other than that it had to be virtually overnight ... this is an instance of overkill, of blitzkrieg."

Moa extinction was more rapid than the extermination of large prehistoric mammals such as mammoths, ground sloths, mastodons and that some scientists think was caused by hunters in a North American b... 13,000 years ago.

The predators that depended on moa, which included saber-toothed cats, cheetahs, maned lions, wolves and short-faced bears are thought to have become extinct in 400 years.

and cassowary, and African ostrich, and probably flew to New Zealand about 40 million years ago.

Kiwi have vestigial wings, whereas moas had no wings whatsoever, indicating earlier divergence and the possibility of moa walking into New Zealand. Without ancient fossil evidence, the mystery of when moa became flightless, and how they reached New Zealand will be keenly debated.



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