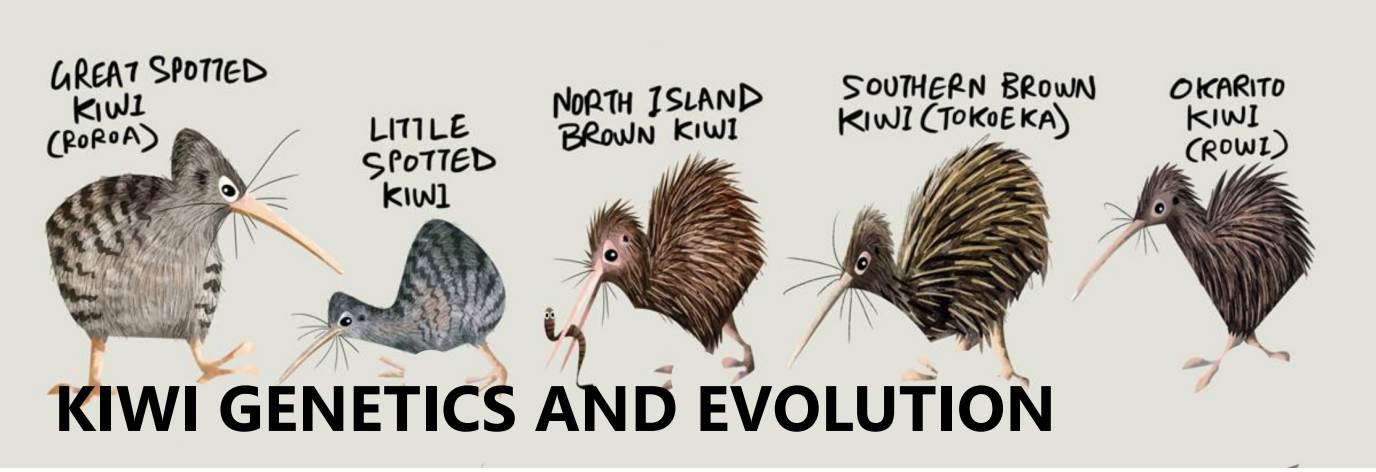


KIWI GENETICS AND EVOLUTION

Photo by Green Humour (https://www.greenhumour.com)

Our national bird is both rare and endangered. We often hear about the conservation of kiwi, but less about how they came to be here and the traits they show. ***Guest author Mike Stone*** *explores the genetics and evolution of kiwi.*

Mātauranga Māori

In Māori tradition, all living things originate from the union of Ranginui (Sky Father) and Papatūānuku (Earth Mother). One of their children, Tāne Mahuta, is seen as the creator and ancestor of creatures and natural resources in the forest. Kiwi fall under his protection and according to many traditions, kiwi used to live in the canopy, not on the ground.

Traditionally kiwi were hunted for food and feathers (used in kahu kiwi ceremonial cloaks). Today feathers are still collected but from birds in captivity, and individuals killed on the roads or by predators. Kiwi are seen as taonga with some iwi considering themselves kiwi kaitiaki.

Our unique icon

Kiwi are endemic and indigenous to Aotearoa. As our islands have been isolated for so long from the other Gondwana landmasses (about 60 million years, m.y.) these birds have evolved many unusual features. They are nocturnal and flightless, with hair-like feathers and beaks with nostrils at the tip, and they make nests in burrows and lay enormous eggs.

Kiwi are adapted to hide from flying predators who hunt by sight, but not terrestrial mammals that hunt by smell. This makes them vulnerable to introduced predators, especially stoats and dogs, so much conservation effort is underway to protect eggs, chicks and adults from these ruthless hunters.

Kiwi eggs are huge compared to the size of the bird. Note the lack of a keel.

The ratite whānau

To fly, birds need to have strong chest muscles attached to an extension on their breastbone, called a keel. Ratites are a special ancient group of birds which have no keel and cannot fly, along with several other complex features. The ratite name comes from the Latin word ratis which means raft, a boat without a keel. Kiwi belong to the genus Apteryx, meaning without wing.

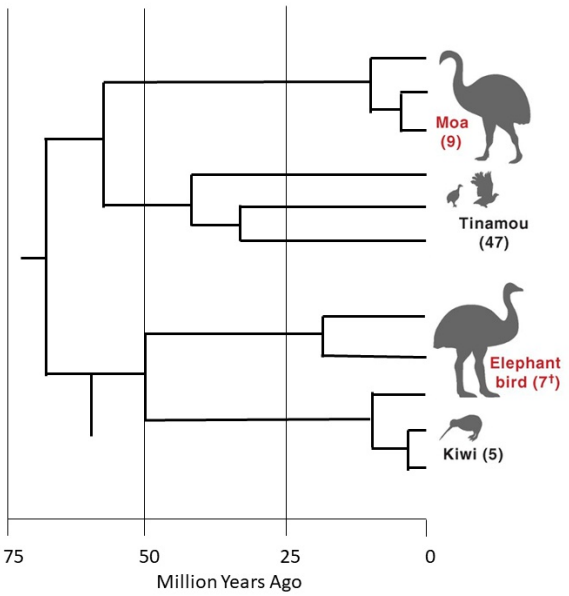
Kiwi are among the smallest of the ratites. Other living birds in this family include ostrich, emu, cassowary, rhea, and tinamou,

all largely Southern Hemisphere species.

Aotearoa is home to more species of flightless birds than any other country, although not all of these are ratites. Our flightless birds include living kiwi, kākāpō, takahē, penguins and weka, as well as extinct moa, adzebills and several flightless wrens.

Ratite evolution in Aotearoa

Using DNA and bone shape from living and recently extinct ratites, as well as species that went extinct much earlier, scientists have built a picture of ratite relatedness (phylogeny) and evolution. When we look at the phylogeny of the ratites we can see that moa are most closely related to the South American tinamou (they descended from a common ancestor) and kiwi are most closely related to the extinct elephant bird from Madagascar (both descended from a common ancestor). However, moa and kiwi are not that closely related.



A phylogeny of four ratites. Red = extinct. (n) = no of species. Adapted from Mitchell 2014.

Due to this phylogeny and the age of the fossils, we know that kiwi and moa ancestors must have flown here. Scientist Nic Rawlence (2021) explains that ancient ratite ancestors called Lithornids arrived in Aotearoa 58 m.y. ago and evolved into a large leaf-eating bird, the moa.

A second Lithornid group, arriving only eight m.y. later, evolved into a smaller bird that ate insects on the forest floor, the kiwi.

Current status

We have five kiwi species, found in different parts of the country, all of which are endangered to some degree.

Helping these species survive includes not only protecting them from predators but also maintaining a high genetic diversity. The greater the variety in their genetic make-up, the more likely the population will survive a change in environmental conditions.

Recent research (Westbury 2022) has told us more about the genetic diversity of four kiwi species. It found that there is very little genetic diversity in the little spotted kiwi and not much more in the Okarito brown; but that the great spotted and North Island brown have greater diversity, consistent with greater numbers (14,000 and 25,000 respectively). There is little information for Southern brown kiwi. Compared to the genetic diversity in other bird species, however, all kiwi are relatively low. So if, for example, they became exposed to avian flu, our kiwi would all be likely to react in a similar way

The genetics of flightlessness

Genes are expressed as traits by the proteins they code for. Gene expression is controlled by other special regulatory genes.

It appears from recent research (Sackton, 2019) that ratite flightlessness is due to mutations in non-coding DNA that regulates gene expression, rather than from mutations in protein-coding genes themselves. Moa have no wing bones at all, but kiwi do, although they are very small. Both birds still have the genes for structures involved in flight, but mutations in the regulatory genes control how many of these flight genes can make their proteins and how much is made.

The genetics of colour

Most kiwi are a shade of brown, providing camouflage on the forest floor from aerial predators. However, there are a few examples of white kiwi, that are rare in the wild.

Manukura, a North Island brown kiwi, was born in captivity in 2011 at Pūkaha Mt Bruce National Wildlife Centre. Named by Rangitāne o Wairarapa iwi,

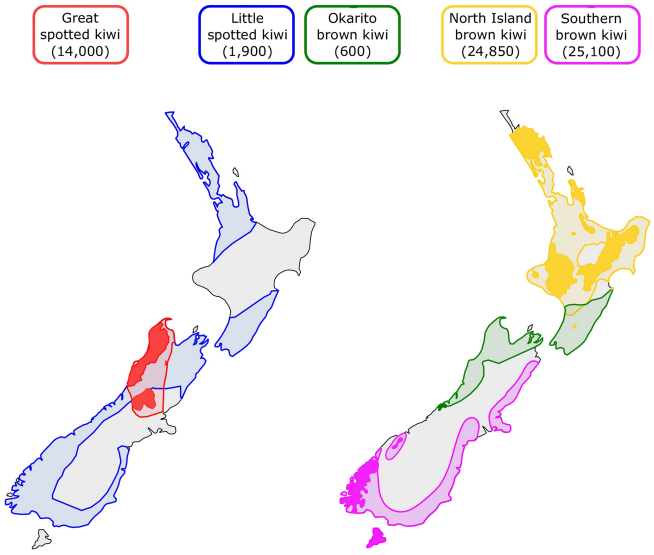
Manukura means of chiefly status. Joy Cowley wrote a children's book about her. Two more white birds were born to the same parents – males Mauriora (sustained life) and Mapuna (precious).

Manukura [Pūkaha]

Both parents of these three white kiwi were moved to Pūkaha from Te Hauturu o Toi Little Barrier Island. In the early 1900s, kiwi that were translocated to this predator-free island included birds with white markings and some fully white kiwi.

These three birds were not albino (a special condition where a total lack of melanin extends to the eyes, making them pink). Rather, the condition in kiwi is called leucism, where there is no melanin in the skin, hair or feathers. Albinos have melanocytes but make no melanin, while leucists have no melanocytes. Melanin is a pigment that gives animals colour and it is made in special skin cells called melanocytes.

The three white kiwi are the offspring of two parents that carry a recessive allele for white feathers. While white colours are seen in the feathers of many different birds, it is a rare trait.



Distribution ranges of the five kiwi species. [Westbury et al, 2022]

Resources useful for the classroom

A pūrākau about 'How the kiwi lost its wings': https://www.tekura.school.nz/assets/te-kura-resources/literacy/ENW314B-how-the-kiwi-lost-its-wings.pdf

A punnet square activity about white kiwi: https://nzmaths.co.nz/sites/default/files/images/KiwiGenetics_Student.pdf

The kiwi genetics unit from BEANZ is available to members.

References

Rawlence, N. (2021) Land of the chonky birds: How and why did NZ have so many feathered giants? BEANZ newsletter term 4.

Sackton, T., et al (2019) Convergent regulatory evolution and loss of flight in paleognathous birds. Science 364 (6435), pp74-78: https://www.science.org/doi/10.1126/science.aat7244

Save the Kiwi: https://savethekiwi.nz

Wikipedia - Kiwi: https://en.wikipedia.org/wiki/Kiwi_(bird)

Westbury, M. et al(2022). Genomic insights into the evolutionary relationships and demographic history of kiwi. PLOS ONE 17(10): e0266430: https://doi.org/10.1371/journal.pone.0266430

This article was improved by critique from Pauline Waiti (Te Rārawa), scientist Associate Professor Nic Rawlence and teacher Linda Haycock.

Ngā Kupu

Kahu kiwi: Kiwi feather cloak
Kaitiaki: Trustee, custodian, guardian, caregiver, keeper
Mātauranga: Knowledge, wisdom, understanding, skill
Taonga: Treasure, something prized
Whakapapa: Genealogy, genealogical table, lineage, descent
Whānau: Extended family, family group; may include friends with no kinship ties.

Source: Te Aka Māori Dictionary