

even in the difficult topography of this region, a variety of moas lived and flourished. The scientists who excavated the Mt Owen cave also commented on the rugged landscape of the surrounding country. Similarly, a very large collection of subfossil moa bones have been discovered in the last few years in caves in the jumbled limestone of the Oparara Valley, near Karamea. The remains were part of a special National Museum study, led by Dr Millener.

Moa enthusiast Bill Hartree discovered over 40 moa nesting sites in the steep hill country of the Wairarapa and Hawkes Bay, and was able to identify *Anomalopteryx* nests from bones adjacent. He found evidence for only a single egg, in scoop nests usually protected from the weather by an overhang or rock shelter. Dr Millener states in his Oparara report that some moa species probably nested in caves, and there is good evidence for this. Other records from last century indicate moas also nested out in the open. Geologist Alexander Mackay, as one example, briefly records his finding 'a moa's nest', in the 'western districts of Nelson', probably in 1879. The nest held the remains of a chick, and was open to the weather. In the open country of Marlborough, too, large quantities of eggshells have been noted.

Millener's doctorate suggests that *Pachyornis* used the dunes of the Far North as nesting sites. Moa eggshell fragments are common in many coastal dunes around New Zealand, but at Tokerau Beach they can be found in "phenomenal quantities", according to Brian Reeve, "with carpets of eggshell where the sand has blown out." Eggshells are usually cream coloured, although some bleaching is common when exposed to the weather. Some olive green pieces have been found in other localities. Half of a dark green egg, the first discovered, was recently excavated from a nesting site in the Upper Rakaia Valley, in Canterbury. Identification of eggshell to species is very rare, because a direct association with identifiable bone is required, but in single locations this has been accomplished with *Euryapteryx* and *Emeus*.

Over a dozen moa eggs have been uncovered whole, and sometimes in perfect condition. They have been found mainly in river silt or sand deposits, as well as in early Maori burials. Of course moa eggs are large — about 18 hens' eggs in average volume — but not proportionately larger than a kiwi egg. *Dinornis* eggs measure up to 27cm in length, but they in turn would be overshadowed by the egg of the elephant bird. A specimen in the British Museum is a colossal 75cm in girth, with an estimated liquid capacity of over nine litres.

Although Hartree uncovered mainly single-egg nests, other evidence points to moas also laying more. When one unbroken moa egg was discovered in a small cave at a Southland quarry in 1920, 'the others were broken in the nest' he wrote in a 1947 *Weekly News*. The bones of four chicks were found underneath a perfectly preserved *Dinornis* skeleton in alluvial deposits in Central Otago in 1864, but this intriguing fact was mentioned only in

passing by the discoverers. Along with the bones of the parent, these relics were quickly dispatched to England.

Male on the nest

This adult moa was undoubtedly a male, as the task of incubation and care of the young is delegated to the male in all three surviving Australasian ratites, and is also the main domain of the male ostrich and rhea. Kiwi, cassowary and emu males are smaller than the females, and are dominated by them, so it seems likely that moas were similar. Kiwis usually lay two eggs, and cassowaries average three to four, but emus lay as many as nine eggs. These birds having evolved in a more competitive and predatory environment, we can assume that moas survived with smaller broods, perhaps not even reproducing every year.

Incubation times for the moa's living kin give a good idea of gestation in the extinct bird. As for emu and cassowary, eight weeks' gestation would be a likely length for the moa, with the male leaving the nest only occasionally, to feed or eliminate. The chicks would be mobile not long after hatching, as they would have to forage for themselves.

After their initial mobility, the development of young ratites can proceed at a more leisurely pace, relative to flighted birds, as there are not the same pressures to become airborne.

40-year life span

The life span of a moa may have been forty years or more, such longevity being common with large birds with low reproductive rates and few enemies. Not that life for the moa in primaeval New Zealand was without danger or hazards. The extinct NZ eagle *Harpagornis* and the extinct large NZ harrier *Circus* were quite possibly a threat to the ungarded young. It is also possible that the weka preyed upon moa eggs, as it is claimed to do on little spotted kiwi eggs on Kapiti Island. Moa eggs were relatively thin (2mm maximum) for their size, and ungarded no doubt presented an attractive meal to the opportunist weka.

Other hazards to moas were floods (although their ratite cousins are surprisingly competent swimmers), slips and fire, not to mention volcanic eruption. Hector counted thirty-seven moa skeletons on the surface of the ground, in a small area between a steep mountain side and Lake Wakatipu, in 1862. He attributed the find to the onslaught of fire, but a snowstorm could also be an explanation. Maori legend supports Hector's interpretation: the fires of Tamatea were an ancestral event held chiefly to blame for the decimation of the moas.

Despite their ability to negotiate very difficult terrain, moas were frequent victims to pot-holes, and had an amazing propensity for bogging themselves in swamps and mudsprings. "It would be hard to imagine a creature more beautifully adapted to becoming mired, than a moa," said Dr R. C. Murphy, an American scientist involved with the 1949 excavations at the Pyramid Valley swamp. Nineteenth

century naturalists were staggered by the sheer numbers of bones that could be retrieved from a very small area of bog, and contrived all sorts of theories to explain them. In one deposit in the Maniatoto, 400 birds were estimated in 1874 to have been trapped in a crescent-shaped area measuring only 12m from point to point, and about 5m at the widest.

In many of these swamp deposits, the geography is strikingly similar, with the remains concentrated in particular spots, at the foot of ridges and spurs from higher ground. Over the years, moas had become bogged, either in crossing to the other side of the swamp, or while trying to drink. The chemistry of most of New Zealand's swamps is unfavourable for the preservation of moa bones, but in localities such as Pyramid Valley, the remains of a great variety and number of animals, not only moas, have been perfectly preserved.

Whose tracks?

The siting of these swamp discoveries corroborates other evidence from a few other locations that moas had their own tracks through the forest and fernlands. In the Taupo area (1975) and Hawkes Bay (1963) researchers reported the excavations of compacted paths of heavy footed creatures from long ago. Two of these former trackways were traced down slopes to watercourses, while a third wound its way through a former swamp. The cassowary is known to make habit paths, and it seems likely that moas were obliged to form and retain easy access through the forest and forest margins. The difficulties of making a way through such vegetation were quickly noted by New Zealand's early European explorers. Who knows if the old Maori tracks mentioned by European bushmen and surveyors were in fact first formed by human feet at all? Kakapo keep paths too, and the effect in an area where their populations were undisturbed was remarked on by the men of the survey ship *Acheron*, while exploring the southern sounds in 1852. From the many criss-cross trails they came upon, the *Acheron* men at first thought they were near a Maori village.

What is clear from this review of moa's ark is that in their heyday moas were a very tangible part of the New Zealand landscape. While the birds were perhaps well dispersed through the endless forest — population densities are very hard to reconstruct — we should imagine, from their remains, a country where the big birds were always somehow or somewhere in evidence. If not the birds themselves, then their calls, or their heavy footfalls in the litter of the forest floor, or their footprints on river banks and estuaries, or their abundant droppings. Their easy dominance in the life of the forest continued for age after age, but what seemed for always was not forever. 🦜

This article summarises my moa research to date. I would be grateful for any unpublished material regarding the moa, such as manuscripts or old newspaper clippings, and these can be addressed to me at PO Box 602, Nelson.

Barney Brewster.