pecially the kiwi, the emu and the cassowary, for the probable habits of the extinct bird. We should also contrast the outline of the moa with a fearful contemporary from South America, the giant terror bird (*Andalgalornis*) which died out about 3 million years ago.

The terror bird compares well in height with a middle-sized moa such as *Emeus*, but the terror bird's large and powerful head, and athletic build, are adaptations for a carnivorous way of life. Different features bring out the opposite in the moa; the small skull and heavy legs and feet of *Emeus* imply an unhurried, herbivorous life.

Only the *Dinornis* moa exceeded the terror bird in size; in silhouette *Dinornis* was also much lighter on its feet than two other of the middle-sized moas (*Pachyornis* and *Eurypteryx*) and could be considered the giraffe moa, although early reconstructions exaggerated its height by articulating the skeleton to maximum effect!

*Pachyornis* was the remarkble heavyweight of the middle-sized moas, but all three types were around 1.3m tall. The smaller moas, sometimes called 'bush moas', were *Anomalopteryx* and *Megalapteryx*. These two genera have a more graceful appearance, and were no doubt more agile than the larger moas. Like *Emeus, Megalapteryx* seems to have been restricted to the South Island.

## Appearance of the moa

Well, what did moas look like, and how did they live? From mummified fragments of *Megalapteryx*, discovered in Central Otago last century, we know that this moa had a downy cover of feathers — with purplish black centres and golden buff edges — from the base of its bill down to its toes. On the examples of the emu, cassowary and kiwi, scientists have supposed that other moas may not have had a complete covering of feathers. Some moas may have had the bare neck of the emu, or the colourful fleshy neck wattles of the cassowary, or the bare lower legs and feet that characterises all three Australasian relatives.

Moa feathers have been found up to 18cm long, and some are double-shafted, that is, have a smaller accessory plume. Like other ratite feathers, moa feathers have lost any semblance of aerodynamic efficiency, and have more of a soft, hair-like quality. 'Stuffed' moas in our museums have been recreated using emu and kiwi feathers over wooden frames. ('Monstrously bad reconstructions', for the most part, according to one paleontologist). Isolated moa feathers have been found with a variety of colourings — a brownish red, white on black, speckled grey and bluish purple — but apart from *Megalapteryx*, there has been no possible identification. Maori legend reports weka and kiwi colourings for some moas, and a tradition published early this century links *Dinornis* to the name *kuranui*, which may be translated as either 'big red' or 'big prize'. Memories of the moa are very vague in Maori oral tradition, however, and at least one story of *kuranui* contains elements suggestive of a lingering image of the extinct NZ eagle.

Feather pits have been noted in some skulls of *Dinornis* and *Pachyornis*, indicating a feather crest, probably sexual, on the top of the head for some moas, although preserved remains of *Megalapteryx* show a reduced, downy covering on the head. Interestingly, in only two cases have moa feathers been found among Maori relics, although bird feathers were especially prized by the Maori. At the British Museum, Sir James Hector discovered moa feathers attached to a taiaha, a souvenir of Cook's voyages. The only moa skin recorded in an archaeological context was a narrow strip of *Megalapteryx* skin, sewn in a cloak of weka skins, found in an Otago burial cave about 1890.

Moas feature with any certainty in only two of the Maori cave drawings which have survived. A particularly impressive group of three bird outlines in the Craigmore cave, near Pareora, South Canterbury, can only be interpreted as moas. The three figures, regarded as authentically pre-European, show a bulky body resting on solid, earth-bound legs and huge feet; a long neck gracefully tapers to a small head held high. One moa holds a leg cocked, as if ready to strike. Though we think of moas as slow, witless creatures, this cave drawing shows a bird capable of defending itself, either from human hunters or in the rigours of mate selection.

These cave depictions are at odds with the prevailing scientific feeling that moas carried their heads forward, with their necks in the more relaxed position of the emu and cassowary, rather than the more erect neck posture of the rhea and the ostrich. However, as National Museum scientist Robin Watt comments, "What's important about the neck of the moa was that it was capable of a vast number of movements," not a surprising development for a wingless, browsing bird.

## Small brains

For their size, moas had quite small skulls, and some were also flattened in appearance. A plaster cast of the brain case of a *Dinornis*, on display in the Canterbury Museum, reveals an impressively small brain, about the size and shape of a small, green pepper. Comparative studies last century on moa skulls suggested a bird with relatively weak vision, but a strong sense of smell. The moa genera differ in the shape of their bills, and in their face muscles. These differences indicate the variety of feeding habits that one would expect, but little work appears to have been done from this approach.

The proportions of moa leg bones and the shape of the moa foot inspired their scientific champion, Sir Richard Owen, to believe that the birds fed largely on fern root, scratching about in the manner of domestic fowls. This was confirmed by Maori tradition, but perhaps in response to leading questions. One of Owen's contemporaries did find in tissue traces a strong case for a powerful middle toe on the moa foot, to support this contention. (Moas actually had four toes, but the first was a hind one, well off the ground.)

Research this century gives a more definite idea of moa diet. From the well-preserved gizzard contents found with individual moa skeletons in the Pyramid Valley swamp, North Canterbury, as well as other places, has come a clear picture of the moa as a bird with broad tastes, but a special preference for twigs. Gizzard samples from *Dinornis, Emeus* and *Euryapteryx* showed a predominance of twigs from a variety of woody plants, with some seeds, fruits and leaves. In one typical *Dinornis* gizzard, Colin Burrows, botanist at the University of Canterbury, found that short pieces of twig made up over 90% of the content: 'The twigs were not counted but it is estimated that there were several thousand pieces of *Olearia* stem and many hundred *Coprosma* twigs.'

This interest in twigs is unusual among birds, but probably extended to the other moas as well. Under a limestone overhang in Takahe Valley, in Fiordland, in 1949, Dr Robert Falla and Ken Miers found moa dung preserved with the remains of *Megalapteryx*. "Falla thought this dung to be human at first," recalled Ken Miers in 1985. "But when he broke a piece of it in half, there was a big, characteristic coprosma twig in it, at least 1cm long and about the thickness of a glasses stem".

Despite the Pyramid Valley gizzard material, which came to light over 1939-1940, and although a twiggy matrix in gizzard residues had been noted as early as the 1880s, leading moa scientists of the 1940s and 50s (notably Duff, Oliver, Falla and Archey) placed a greater stress on the role of grasses in moa diet, and so located the birds on the grassy plains of New Zealand. These plains have been deforested for only a few centuries, but a whole generation of New Zealanders has grown up with the impression that the moas were restricted to a grassland habitat. The evidence suggests quite the contrary.

## Not grassland birds

Moas were primarily birds of the forest and scrub. Only a thousand years ago virtually all of lowland New Zealand was forest-covered, or scrubland, and correspondingly moa remains have been found everywhere: from the dunes near Cape Reinga to Mason's Bay in Stewart Island. Though not common, moa relics have also been found on the volcanic plateau in the North Island. Bones have been discovered on Great Barrier Island, but on no other island. Off Wellington's western coast — an extensive lowland up until ten thousand years ago — moa bones have been dredged up twice in recent years.

European settlers last century often commented that in areas of inland Otago and Canterbury, moa bones were amazingly abundant on or near the surface of the ground, and that some bones were surprisingly fresh. In both islands, moa gizzard stones can still be found. These stones, often quartzose and sometimes semi-precious, remain after all other trace of the bird has decayed. Collectively, these gizzard stones can weigh up to 3kg, and because they usually relate to the local geology, scientists have supposed that the moa, unlike the emu, was not a migratory